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BAECULA battle Geographic Information System

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Abstract

Purpose:
This contribution explains the procedure followed for the construction of GIS applied to the study of the archaeological scene of a battle.
It is about the Baecula Battle, that took place in 208 b.C.in the frame of the second Punic War, near to the village of Santo Tomé (Jaén), that faced the Carthaginian army commanded by AsdrubalBarca, with the roman Army commanded by Publio Cornelio Escipion "the African".
The CAAI (Iberic Archaeological AndalusianCenter), along five field works stage, since 2006 until now, have made a job of investigation based on the low level prospection of the artifacts located in the battle area.

Method:
The methodology used has a land survey phase, consistent in a surface scanning based in a 106 transect system, divided in 3453 square parcels, which cover 40 hectares. In this area was registered the ceramics artifacts detected in each square parcel and then the 6123 metallic rests found with magnetic prospection was geolocated by GPS. During the laboratory phase, took place the identification and classification of the materials.
All of this archaeological and geographical information has been integrated to make up a geographical database, been those register the one that link with the battle, implementing with all the available cartography to help the analysis tasks.

Result:
The operation of the GIS and it application to cartographic analysis techniques has improved the knowledge of the battle development, from the movements of troops through the areas with mayor tacks concentration (that cover the sole of the roman shoe), to the zones where took place the different stages (the assembly of the roman army, fight face to face, etc…). By the way have been done another study of the density of Iberic ceramic artifacts, that together with the presence of nails of the shelter tents, has provide an important indication to locate the zones where the roman and the Carthaginian army placed their camps.

Discussion & Conclusion:
In any case, it confirms that the application of the GIS in the battle scene of Baecula, bring us positives results.

1 Introduction

The Andalusia Iberic Archaeology Centre, between the years 2001 and 2003 the location of the conflicts corresponding to the second Punic war that took place in the high Guadalquivir river [1] was reviewed. Between then, we can found the Baecula battle, which location was questionable, even when it was usually located nearby the city of Bailén (Jaén) by different authors.

This location was discard and proceeded to find the real location of the battle with the the support of two resources:

- The wide knowledge of the chronologies of the settlements in the high Guadalquivir by the research team.
- The descriptions made of the event in the classical sources: Histories of Polibio [2] and History of Rome since its foundation of Tito Livio [3], that give some topographic references, that could be contrasted in the field.

Thanks to this investigation process, the real location of the Baecula battle was found in the province of Jaén, specifically in the council of Santo Tomé, occupying the Albahacas hill. This orographic unit take about 1700 has of approximate area, and presents the maximum elevation of 678,043 m. over the sea.

Fig. 1Baecula battle localization.

2 OBJECTIVES

The main objective of this project is to know the investigation of the different phases of the Baecula battle.

For this, once the battlefield was located, the archaeological works began along, five field works stage since the year of 2006 to 2010. The employed methodology consist in a scan of the surface leaning in a 106 transects, subdivided into 3453 grids, in a total area of 40 has. In this surface, have been collected the ceramics rests in each grid, and georeferenced with GPS the 6123 metallic rests founded by the magnetic survey with metal detector. Lately, in the laboratory phase, was made the identification and classification of the materials.

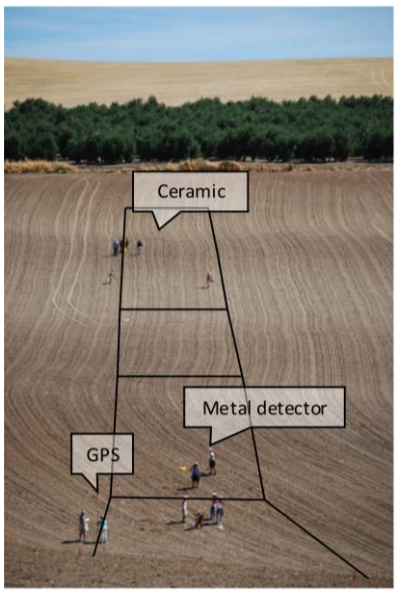


Fig. 2Surveymethodology, georeference and register in the Albahacashill.

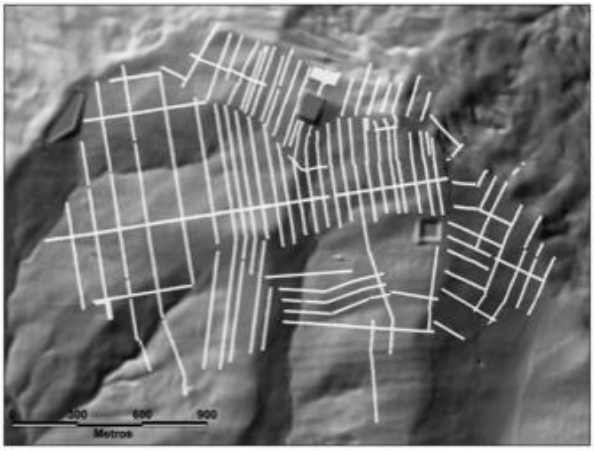


Fig. 3ProspectedTransects in Albahacas Hill.

As result of the accumulated volume of data and the wide surface they occupied in the field, rise the idea of storage them into a Geographic Information System, performing the storage of the data in a efficient way, enduring and versatile, because it allows an easy way to share information between investigators, that in other case can do easy queries with no need to have knowledge of the GIS technology, as affirm Conolly [4], sometimes is enough organizing the data in a efficient way to generate new ideas about the past. But the most important thing is the fact of having a geographic database that allows the application of cartographic technics that shown the data from points of view impossible to do with other methods.

3 GEOGRAPHIC INFORMATION SYSTEM

3.1 GIS DESIGN

There are so many definitions of what is a Geographic Information System (GIS), in this case we base on the one proposed by Felicisimo [5]: “Group of computer software, hardware and peripherals that transform geographical reference data, into information about sites, special interactions and geographical relations between the fix entities or the dynamics that have and space in the natural or builds environments”.

In the case of Baecula GIS, the software used was Geomedia Professional versión 06.01.02.04 (Intergraph Corporation), geographical reference data should be the ones that comes from the micro survey, among others, that in this case occupied the natural site of hill of the Albahacas and its area.

We have two remember that the spatial database of a GIS is the digital representation of the reality and to took place is necessary to hold on a data model [6]. Exists two basics models in what lies every Geographical Information System: the raster model and the vector model.

In the case of the survey in the hill of Albahacas the data makes a vector GIS, composed by spatial elements with geometric character, like the point or the area and with

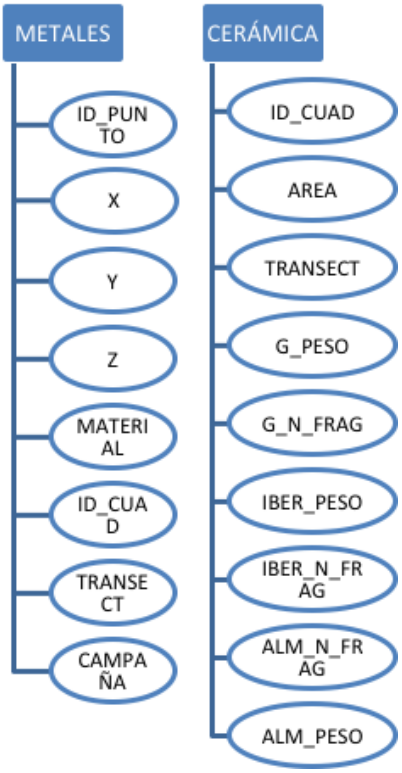
thematic attributes joined, which are manage from tables joined to the concept of relational database, just as we explain forward.

At the time of building a Geographical Information System, we began with a group of georeferenced data, we have to make a database, to do this we used the entity-relationship model, that describe the real world through entities related between then, and for this, used three basics elements : the entities, the attributes and the relationships [7].

Basing on these elements, it is possible to build the database, into different models, depending on the type of information, which is going to be used. One of this models is the relational, the one used in this case.

In a relational database, the data are store in tables (one for each entity), where the rows represents the registers and the columns the attributes. Each register is unique, and it is specifically identifiable, through one of the attributes, called primary key. Also the entities and the tables that represent them are joined between relationships with different order. Although the basics theoretical of this model are more extensive, perhaps was more illustrative to build the entity-relationship diagram for the data coming from the Albahacas hill, that compose the main body of the GIS.

The most relevant objects of the survey were by side the metallic elements founded, and in the other hand, the ceramics fragments collected. Each other, generate almost one point type entity, in first case, and an area type in the second case, and also it will have a set of attributes associated, with one of them been the primary key, the “Id_punto” in metals case and “Id_cuadrícula” for the ceramic. In the entity-relationship diagram, the entities are represented by rectangles, and their attributes like ellipses. For the relationships between entities diamonds will be employed, In this case, the relationships between CERAMIC AND METALS entities, will be 1 to N (because one grid can have N metallic elements) .



Tab. 1Entity-relationship diagram.

4 DATA INCORATION TO THE GEOGRAPHIC INFORMATION SYSTEM

In the implementation of the GIS and once the database is made, the next step is the implementation, which consist in storing the available to fill the database, following the model that was employed in its design.

In other hand we have the spatial information, obtained or by the measuring of GPS points linked to metals, or digitizing the grids in which where ceramics artefacts were collected.

Then, to finish the storing process, it is necessary to add the thematic attributes to each of the spatial entities.
For the point type metals entities, some of the attributes will be:

- MATERIAL. This field have a primary approach of the kind of material found, like tacks, Nails, etc.
- ID_CUADRICULA. Have the grid identification where the point belongs.
- ID_TRANSECT. Have the “transect” identification where the point belongs.
- CAMPAÑA. Its about a numeric field, with the date of the field works stages in which were collected the material that belong to this point.

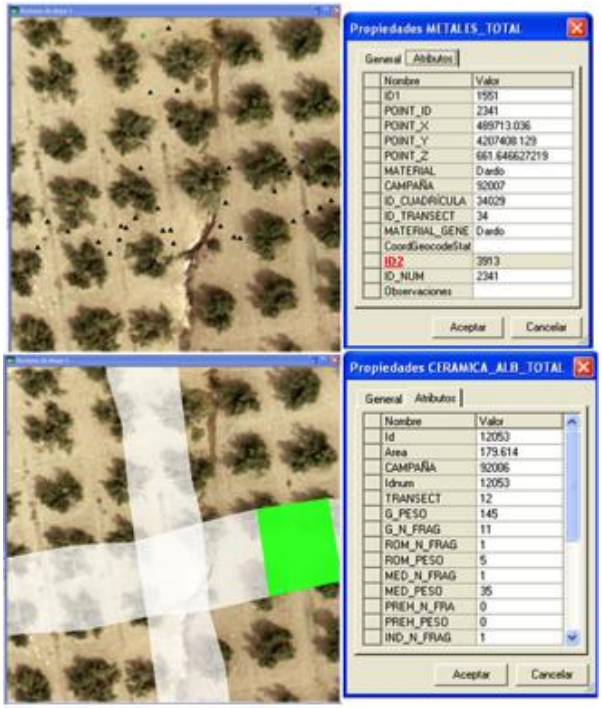


Fig. 4Attributes and entitiesexample in GIS.

For the area type CERAMICS entities, the attributes will obtained of the generated file of the ceramics collected in this grid after the laboratory phase. The variables considered was the number of artifacts and the weight, for each grid, linked to four chronologic horizons: prehistoric ceramic, Iberic, of the high imperial roman, and finally the ceramic between medieval periods, modern and contemporary. Also, based in the thickness of the artifacts, should be added one variable indicating how many of then correspond with storage containers, and then should be linked with field works stages.

5 ANALISYS AND APLICATIONS

Once the database is created, and the available information was implemented into the system, the GIS is ready to help us in the analysis tasks.

One of this tasks consists in the elaboration of thematic maps that had been a still are a very important instrument for the archaeological investigation and divulgation [8], in this way the possibilities that a GIS offer to obtain specific cartography are very valuable because allows to represents, not only places, but amounts too, and combine different variables in only one map.

In this way, one of the Jobs made was to quantitative classification of the ceramics artefacts, specifically the Iberic ceramic densification (which is joined to the historical moment of the battle), it should understood like the number of artefacts in a square meter of this period. The study of the spatial distribution of this variable should have much interest, because the mayor concentrations could be applied to zones where the field stages of both troops established.

For the representative result of the intervals chose in the final map, is necessary to know the variable distribution, elaborating the frequency histogram [4]

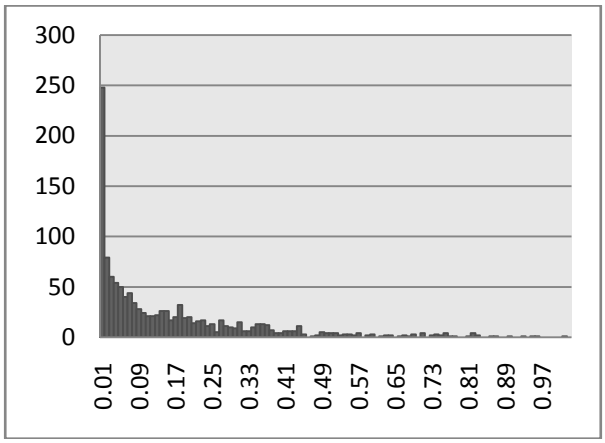


Fig. 5Histogram of density of Ibericceramicartefacts.

The graphic inform us of the biased distribution, and so the best thing is to use a geometric progression, to the exponentially increase of the ranges of classes (X1, X2, X3, etc.) using the next equation:

$$X^n = \frac{H}{L} \quad (1)$$

Where “n” is the number of intervals, “H” and “L” is the highest and the lowest value respectively.
With this method we get to subdivide the low values, and enrich the representation, because the variability is shown, instead of letting it in a back plane in only one category.
The results obtained with this process are very positive, because the place with highest concentration, are found in the highest part of the hill, and it is surrounded by a step embankment, just as it is described in the classical texts. The localization of the campsite in this zone, should be considered with others signal as a confirmation like it will be shown later.

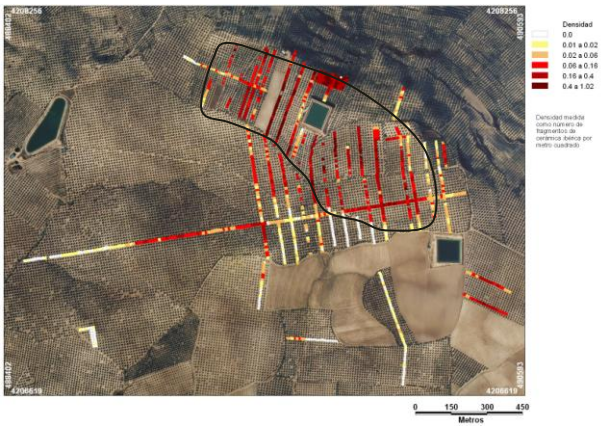


Fig. 6 Grid classification about Iberic ceramic density.

So, like we have updated the METALS entity, queries can be done about attributes of the different elements found. For example, the nails employed for setting up the tents of the troops should be found nearby the campsite, in the

perimeter established in the last figure. So it is as can be check in the next figure.

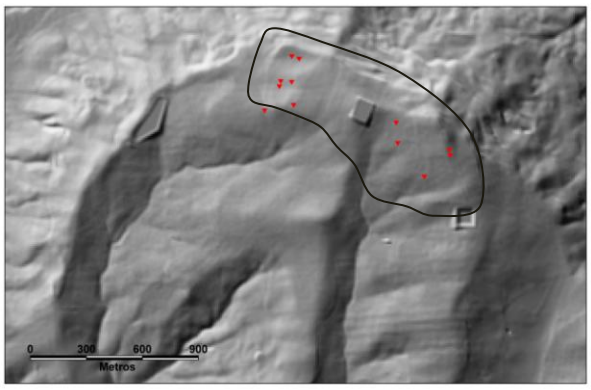


Fig. 7Tentsnails location.

Another important metallic element found in the Albahacas hill, have been the tacks of the sole of the roman sandals and that gave off easily of them when they advance with a sort step, or walk up through steep slopes. Thanks to the sampling made in the looking of this elements in concrete, can be determined the access way to the hill that the romans troops followed under orders of Escipion. Those data were also stored in the GIS, and it can be seen in the next figure, and also determine the formation of the roman troops just before the attack.

Fig. 8Tacks.

Fig. 9 Roman Sandals (Caligae).

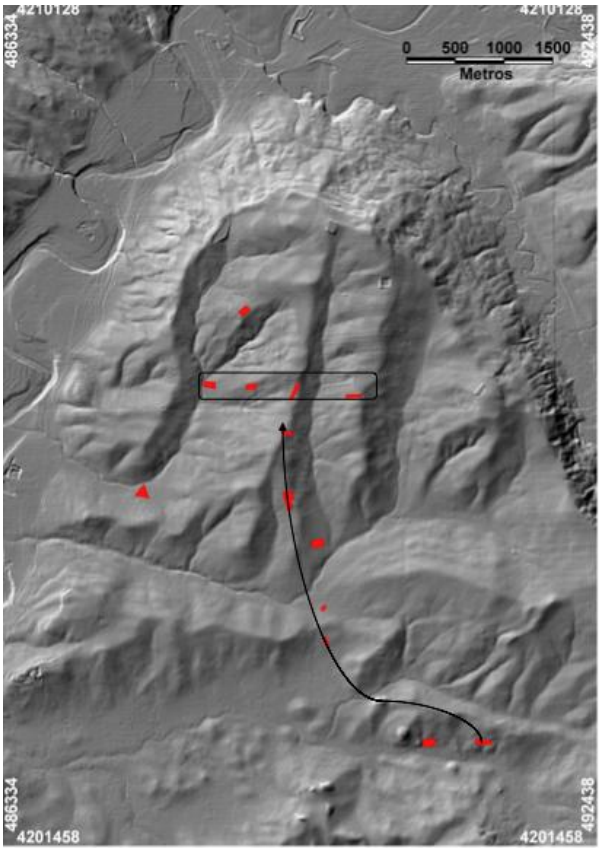


Fig. 10 Access way to the hill and formation of the roman troops just before the attack.

When the situation of the roman troops can be determine and also the position of the Carthaginian campsite, the next challenge consist in determine the troops movements during the course of the battle.
Tito Livio [3] describe this movements as follow:
"Then Escipion orders to the winners to jump into the centre of the battalion, distribute with Lelio the rest troops and order to surround the hill by the right side until find a low slope way of coming up to the hill; he describing a little arc by the left side, and is released over the enemy flank."
To confirming these facts in the field, it was employed the tacks spatial distribution within the battle field, by Geomedia utilities, a new attribute is created, that indicates the number of tacks in a grid, and influence areas was made with proportional diameters to the value of the attribute, integrating so the cartographic technic of the gradual symbol.

The result is shown in the next figure, and confirm so accurate all we have described by Tito Livio [3]. The central axis S-N can be note associated to the advancement of the light infantry, and the complete turn of Escipion in the left flank. Also can be seen the arriving of Lelio to the east side, in default of conforming this doing more surveys in the south side.

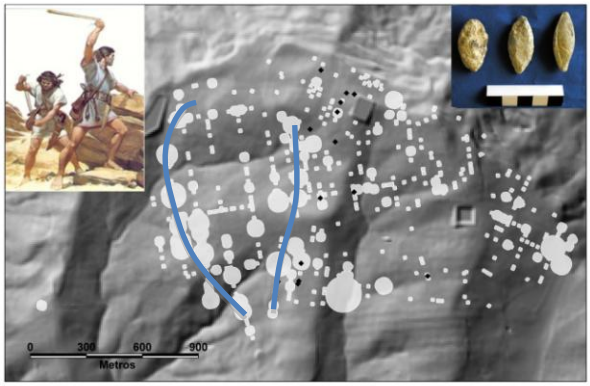


Fig. 11Troopsmovements and slingersprojectiles location.

A way to confirm the centre line joined to the movement of the light infantry is superimpose a second element. Through the classics text, it is known that the roman infantry suffered the attack with throwing weapons from the Carthaginians. Between those we can find the slingers, whose lead projectiles have been found during the surveys, in the sites of the next map, marking a axis near to the advancement of the infantry.

Finally, of the three roman faces, converge in the campsite, where should took place the final battle “melee fighting”, and then should be found the rest of the weapons of this kind of fight: spears and javelins.

Once again the use of the GIS is very important, confirming the scene of part of the final Baecula battle.

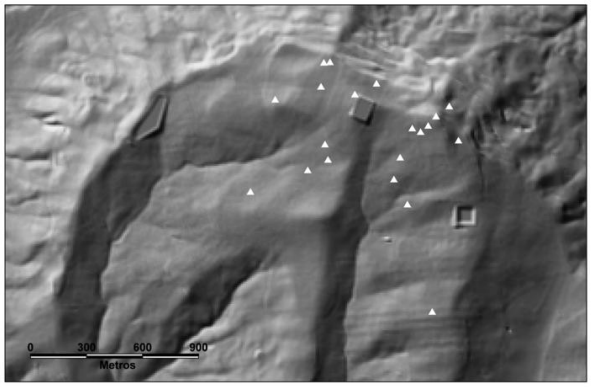


Fig. 122Spears and javelins location.

6 CONCLUSION

This project of creating a Geographical information System of the Baecula battle have need of the share of different disciplines: archaeology, GIS, cartography, but apart of this it is about a project that is still alive, and it is necessary to continue adding information and new data becoming from the analysis made with the different data, this process will carry us into an evaluation process in a high level each time and more complex, and will involve others disciplines, like the statistics analysis. As any other GIS, the implementation and actualization process of the database, gave rise its construction.

About the analysis process, it is required to have scientific rigor, as we have said in the firs paragraph, it is necessary following with investigation and studying the performance of the different algorithms founded in the different GIS software the possibility of it application to spatial data get in the battle scene.

In any case, it confirms that the application of the GIS in the Baecula battle scene, bring us positives results. First of all allow us to storage the archaeological data into a organized and georeferenced way, because for the archaeologist is so important of a piece finding as the spatial context where it appear, and an appropriated tool for this context study are the GIS applications and the analisys they allows.

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