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Radiography of an Iron Age hillfort: non-invasive archaeology in the settlement of Villasviejas del Tamuja (Botija, Cáceres)*

Radiografía de un castro de la Edad del Hierro: arqueología no invasiva en el asentamiento de Villasviejas del Tamuja (Botija, Cáceres)

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ABSTRACT

The aim of this paper is to present the progress that has been made in the study of the hillfort of Villasviejas del Tamuja (Botija, in the province of Cáceres), based on a combination of non-destructive techniques. The possibility of cross-referencing the results obtained with different geophysical methods (magnetometry, georadar and electric tomography) raises the opportunity to formulate a reliable diagnosis on the spatial organization of this site. The most relevant results are described, and their contribution to a general interpretation of the urban structure and morphology of domestic spaces is analyzed. This information is contrasted with previously available excavation data and its framing is analysed within the existing knowledge on this type of settlements. In addition, elements of interest about the diachronic evolution of the site are added, which are relevant in relation to the hypotheses formulated about the impact of the Roman conquest. Ultimately, the potential of this type of research strategy for the study and revaluation of large and complex archaeological zones is considered.

RESUMEN

El objetivo de este trabajo es proporcionar un primer avance del estudio del castro de Villasviejas del Tamuja (Botija, provincia de Cáceres) a partir de la combinación de técnicas no destructivas. La posibilidad de cruzar los resultados obtenidos con diversos métodos geofísicos (magnetometría, georradar y tomografía eléctrica) plantea la oportunidad de formular un diagnóstico fiable sobre la organización espacial de este enclave. Se describen los resultados más relevantes, y se valora su aportación para una interpretación general de la estructura urbana y la morfología de los espacios domésticos. Esta información es contrastada con los datos de excavación previamente disponibles, y se analiza su encuadre dentro del conocimiento actualmente existente sobre este tipo de asentamientos. Asimismo, se añaden elementos de interés acerca de la evolución diacrónica del sitio, que son relevantes en relación con las hipótesis formuladas acerca del impacto de la conquista romana. En última instancia se pondera el potencial de este tipo de estrategias de investigación para el estudio y revalorización de zonas arqueológicas grandes y complejas.

Key words: Iron Age; Protohistoric Urbanism; Non-destructive methods; Geophysical survey; Extremadura; Iberia.

Palabras clave: *Edad del Hierro; Urbanismo protohistórico; Métodos no destructivos; Prospección geofísica; Extremadura; Península ibérica.*

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1. INTRODUCTION

It is a well-established fact that, during the Second Iron Age (4th to 1st centuries BC), hillforts became a fundamental type of habitats in extensive parts of the central and western parts of the Iberian Peninsula. Today there is a consensus on assigning these settlements a fundamental role in the structuring and exploitation of the territory and in the control of communications and exchange routes. It has been assumed that these sites are essential in order to explain the development of social complexity of these communities within this geographical and temporal scope.

However, the archaeological record of these settlements is overwhelmingly limited to the definition of their walled enclosures and their defensive architecture, with very few examples in which we have a minimal idea of their intra-mural spatial organization, let alone the configuration of their domestic spaces. Many conditioning factors have led us to this situation. The most important one is obviously the high cost of large scale excavation work, as well as the problem of preserving the exhumed structures. The maintenance needs of this type of intervention often lead to a management model that is difficult to sustain. Such large and complex archaeological sites therefore require action to combine their value as a cultural resource with their long-term conservation.

In this context, the growing introduction of non-invasive methods offers a very promising alternative. The adoption of standards in the use of these procedures has become widespread and consolidated as a full-fledged discipline (Campana and Piro 2009; Schmidt *et al.* 2015). In recent years there has been a growing implementation of this type of research in the Iberian Peninsula. However, with regard to the environment of the case study dealt with here, most of the published experiences correspond to other periods, such as Recent Prehistory (Márquez and Jiménez 2013) and especially the Roman world (Corsi *et al.* 2012; Álvarez Martínez *et al.* 2014; Mateos *et al.* 2014).

Nevertheless, with regard to the settlements from the Second Iron Age there was an almost total absence of precedents[1]. This was a great chance that encouraged us to launch in June 2017 the *MINARQ* project (Minimal Invasion in Archaeology), the first results of which are presented in this paper. Our main aim is to rely on the potential of non-destructive methods, as a way of obtaining knowledge for the study, protection and valorisation of archaeological sites. The previous link between the Institute of Archaeology and the hillfort of Villasviejas del Tamuja, raised the opportunity to turn this site into an open laboratory to test these procedures.

The team includes researchers from the Institute of Archaeology, the University of Extremadura and the Centre for Scientific and Technical Research of Extremadura (*CICYTEX*). We are putting together the efforts of specialists in geology, geophysics, remote sensing, archaeological survey and the application of geospatial technologies. Thanks to these combined efforts, we have been able to launch a research programme with two main fronts. On the one hand, a plan for geophysical survey that includes both magnetic and geoelectric methods and Ground Penetrating Radar (GPR). Their results are the main focus of this article. In addition, we have implemented a battery of remote sensing methods (thermal and multispectral imaging, LIDAR, and photogrammetry). With the combined analysis of all these results we hope to achieve a more complete knowledge of our case study in two main dimensions. First, we seek the widest possible coverage to help us understand the internal structure of the settlement. We hope to track different typologies of built spaces, and contrast the hypothesis of the existence of open areas within the enclosures. Secondly, we are looking for clues that help us to understand the diachrony of a site that was occupied for three centuries. Methods such as GPR and electric tomography can provide us with clues about the urban layout prior to the final stage, as well as the impact that the Roman presence had on the continuity of the settlement. Ultimately, we hope that this information can provide relevant data on the degree of planning, demography, functional specialization of certain areas and about the variability of domestic spaces.

2. THE STUDY CASE

The hillfort of Villasviejas del Tamuja is located in the province of Cáceres, about 25 km southeast of the capital and in the municipality of Botija. The surrounding area is characterized by a domain of meadowland with scrub and pasture, mainly used for livestock farming (the *dehesa* landscape). In this sense the archaeological site is a peculiar element in its environment, as historically it was an area used purely for agriculture, until the farmland was abandoned over the last few decades (Fig. 1).

The settlement comprises two enclosures with a total area of about 7 ha. The largest is located to the north (Fig. 2A) with a surface area of 4.7 ha. The natural defences offered by the Tamuja river and the stream of Verraco are reinforced by a ditch and a wall flanked by towers and bastions. Enclosure B is locat-

[1] It is important to note that there are initiatives still underway, such as the Transvettonia Project (Ref. MINECO: HAR2015-65994-R), which as we will see is closely connected with this study.

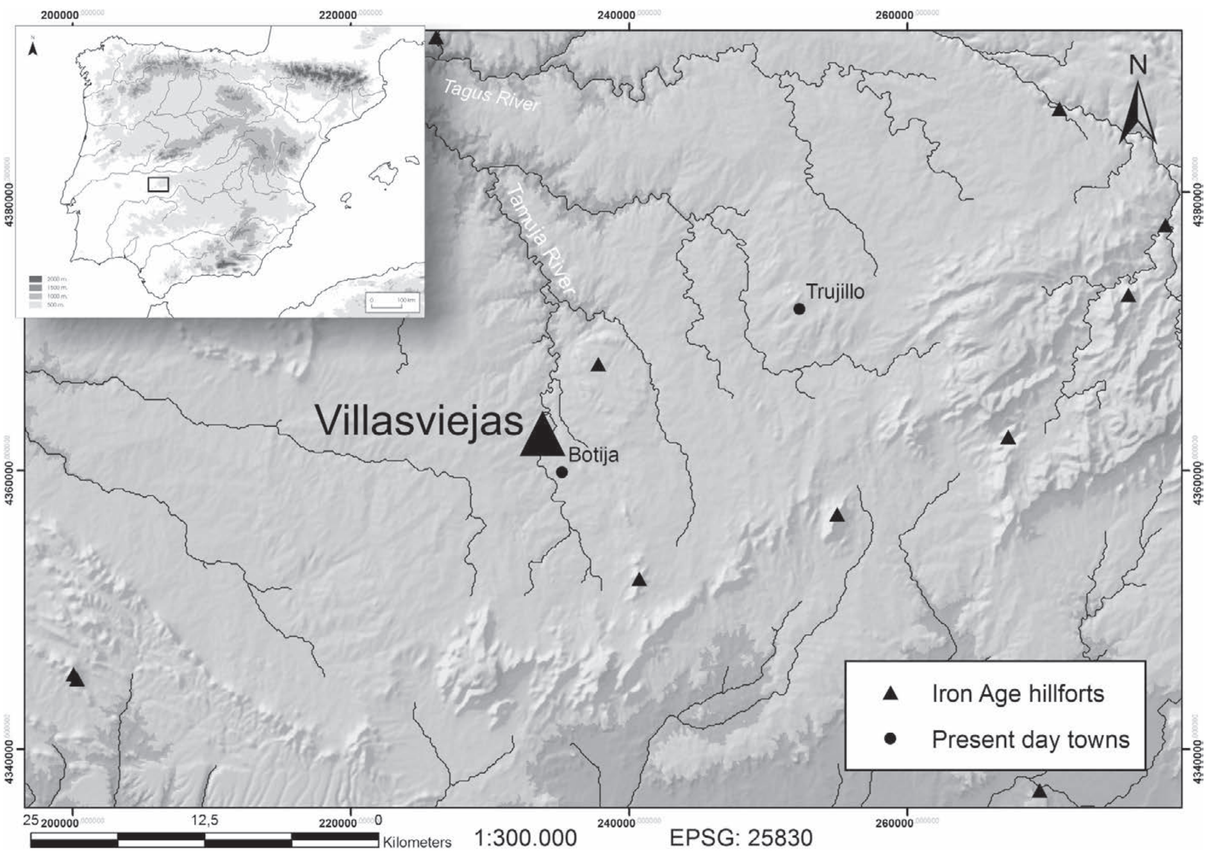

Fig. 1. Map showing the location of the Hill Fort of Villasviejas del Tamuja (Botija, Cáceres) in the Iberian peninsula.

ed to the south of the previous enclosure and is somewhat smaller (2.4 ha). It is also protected by a walled perimeter reinforced by towers that stand out in its Southwest and Northeast corners, as well as by a 10 to 12 m wide moat that closes off its entire South and West flank until it connects with the gorge of the Tamuja River. It is located in a higher position than A, the majority of whose interior it actually overlooks, and is the only point in the entire settlement from where it is possible to have medium and long-distance control over the surrounding area.

Archaeological exploration of Villasviejas dates back to the mid-19th century, with the reactivation of mining activity in the area (González Cordero and Heras 2009). However, systematic research in the hillfort began in the 1960s, with excavations carried out by Dr. Francisca Hernández. This author was the main responsible for continuous study of the site over more than 30 years. This long activity included the excavation in several points of both enclosures (Hernández *et al.* 1989), the systematic surface survey of the surroundings (Hernández *et al.* 2009), and above all a complete record of three necropolis associated with the settlement (Hernández and Galán 1996; Hernández and Martín Bravo 2017). The excavations carried out by the University of Extremadura should also be mentioned, although they were only partially published (Ongil 1991). The last archaeological interventions carried out in 2007 were oriented to prepare the site for public visiting within the framework of the Master Plan designed jointly by the University of Extremadura, Complutense University of Madrid, and the Institute of Archaeology. All this previous research has provided us with extensive knowledge of the site. We know that human occupation in Villasviejas can be traced back to at least the 4th century BC, although it is only over the following three centuries that the extensive walled settlement took shape, and which continued to be occupied until the early stages of Roman domination.

Based on our current knowledge, Villasviejas is considered as a representative case on a regional scale of the forms of occupation during the Second Iron Age. From the point of view of a cultural ascription, the site has been traditionally framed in the southern limit of the territory of the *vettoni*. This was one of the peoples that occupied the western area of the *Meseta* (plateau) of the Iberian Peninsula according to the vision of the Roman conquerors (Álvarez Sanchís 1999; Salinas de Frías 2001). Nevertheless, because of its geographical location, features of other neighboring cultural areas like *Lusitania* or the *Baeturia* have been identified (Hernández and Galán 1996: 108).

As most of the hillforts in the area, Villasviejas is located at a secondary elevation near a main watercourse. The aim of this lesser topographical prominence of Second Iron Age sites was to obtain better conditions of habitability, and was compensated by the increasing complexity of the defensive structures. As far as the surface area is concerned, these settlements would have typically covered an area of between 1 and 2 ha. Therefore, Villasviejas would be within a small group of 6.5% of the 54 hill forts catalogued by Martín Bravo (1999: 204), but far from the four that are known which cover 10 ha or more, and even more than the 60 ha of Ulaca (Álvarez Sanchís 1999: 120).

It is important, however, to bear in mind that the 7 ha of our case study correspond to the total surface of the two walled enclosures. We are not certain that both were occupied simultaneously before their final stage of development. In fact, there seems to be a tendency on a regional scale for larger enclosures to be associated with more advanced historical contexts, already under Roman domination (Martín Bravo 1999: 265). The same phenomenon occurs with regard to the complexity of the defensive systems, something of which Villasviejas would be a good exponent (Berrocal 2005). It seems clear that the definitive abandonment of the site occurred during the first decades of the 1st century BC. However, a particularly controversial aspect of its historical evolution is that of the nature of its occupation in this final stage. Evidence of a military presence at this time has led to disagreement regarding the degree of continuity and the type of interaction between the indigenous population and the Romans. The team that has excavated on the site for a longer time defends the idea of a community gradually transformed by an external influence (Hernández 1993; Hernández and Martín Bravo 2017: 322), while other authors have emphasized the sudden transformation involved by the conquest, speaking of a true "re-foundation" of the site by the Romans (Heras 2018).

In spite of these antecedents, our knowledge about the urban structure of the hillfort was logically very limited, since the excavations carried out only represent 1.2% of the total surface of both enclosures. However, unlike many other settlements in its surroundings, Villasviejas offered ideal conditions for conducting a non-invasive archaeological programme. Prolonged agricultural use has kept most of the site deforested for centuries, favouring the formation of a large flattened platform. In addition, previous excavations revealed the reduced stratigraphic depth of the upper area of Enclosure A and the shallow depth of the wall foundations in the rest of the site.

3. METHODS

Today, in order to provide a robust diagnosis of buried structures through a geophysical exploration, it is imperative to provide the results of multiple methods. Each one responds to different properties of the elements of the subsoil, and therefore offers distinct and complementary images. However, their implementation entails very different timescales, which conditions the ability to explore large areas in a uniform way. In the case of Villasviejas, available methods allowed us to explore the subsoil in two main dimen-

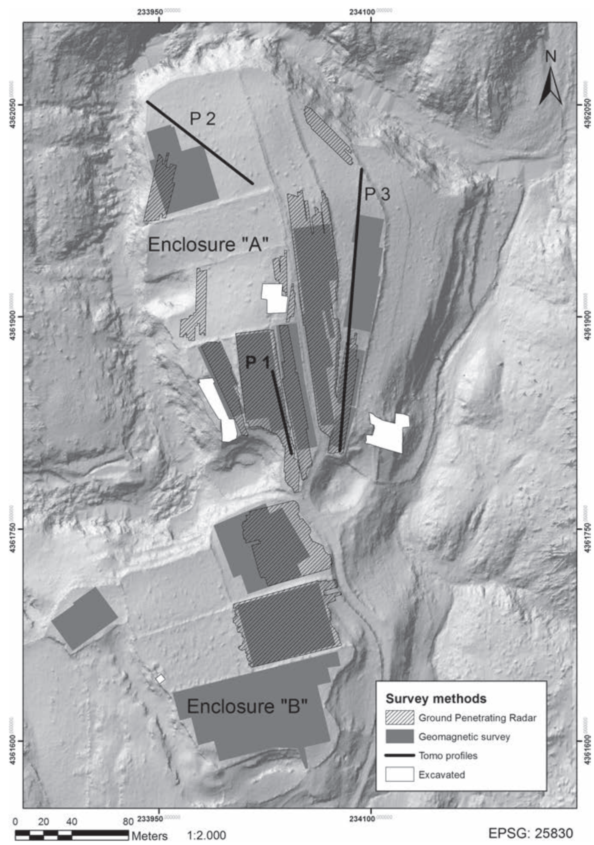

Fig. 2. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Boundaries of the prospected areas, indicating the different methods used: Electrical resistivity tomography; Ground-penetrating Radar; Geomagnetic survey. Coordinate System: UTM ETRS89 H30N.

sions. On the one hand, especially thanks to geomagnetic survey, we are carrying out a "radiography" that gives us an open area understanding of the structure of the site. On the other hand, thanks to the GPR and the tomography, we obtain something very similar to a Computerized Axial Tomography Scan, which provides us with a vertical reading to evaluate the diachrony of the site (Fig. 2).

In order to calibrate the relative effectiveness of each method, it is essential to characterize the environment in which we are working, as it is decisive in the response of the sensors. From a geomorphological point of view, the area is within the Trujillo-Cáceres peneplain (Tena 2010), a result of the prolonged erosion of the materials of the Schist-Greywacke Complex. These are mainly slates, whose resistivity values have already been studied in nearby areas with the same substrate (Tena 2008). This information has been very useful for the interpretation of the tomography. These slates are affected by a primary schistosity in a mainly N-S direction and angles close to the vertical in the northern zone of the enclosure, constituting natural cliffs that delimit the hillfort. The dip is less pronounced towards the south, based on the data observed in the outcrops of the Tamuja riverbed and slope of the enclosure. The lateral continuity would indicate that the layout of the slates would have formed the original base of the settlement, forcing a terraced layout adapted to the outcrops.

As for the archaeological contexts, we have the information provided by the excavations carried out in both enclosures. The predominant building material was provided by the local geology: slate slabs interlocked with mud, forming masonry plinths between 50 and 90 cm wide. Occasionally, granite blocks were used to reinforce corners and thresholds. The floors are normally made of flattened earth, although the use of the bedrock itself as a base has also been documented, levelling with slate, ceramics and adobes, and slate slabs (Ongil 1991: 250; Hernández and Martín Bravo 2017: 272). There are other details to take into account for the interpretation of the results of geophysical survey. Nearby structures are often adjoined with very narrow gaps between them instead of sharing party walls. Inside the rooms is usual to find auxiliary elements, like benches or ovens, made with the same fabrics and materials. In addition, we find superimpositions that coincide in their orientation, creating the false impression of double walls, reinforcements or subdivisions. As for the walls, they are mostly made of rammed earth or adobe. This is a very favourable factor for the detection of the structures, as the presence of accumulations of collapsed stone inside the rooms would have introduced a considerable amount of noise in the reading of the data.

Fig. 3. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). View of one of the sectors excavated by the team of Dr. Francisca Hernández showing the shallowness of buried structures (in colour in the electronic version).

Finally, the processes following the abandonment of the hillfort also had a positive influence on the visibility of the structures. The defensive walls have acted as a large container for archaeological deposits, and their subsequent division into crop fields has slowed down the erosive activity that is so apparent in the weak soils of the surrounding landscape. At the same time, centuries of tilling have led to the formation of soils with a matrix of sand-clay lithology. The action of light ploughs has removed the most superficial levels, so that most of the structures are only 20/30 cm from the surface, another factor that helps in identifying them clearly (Fig. 3).

3.1. Geomagnetic survey

The magnetic prospection is by far the method that has allowed us to explore a greater surface of the hillfort. To date we have covered a total of 3.1 ha, which represents 26% of the total prospectable surface of the site. This work has particularly favoured Enclosure B, with 44% of its prospectable area compared to 39% of Enclosure A.

The equipment used was a Grad601 fluxgate gradiometer from Bartington (Bartington and Chapman 2004; Himmler *et al.* 2008; Schmidt 2008). Most of the time it was used in grid mode, adapting the grid to the variable dimensions of the land plots. The usual configuration of the equipment has been with an interval of 2 lines/m and density of 8 samples/m. We have experimented in some sectors to compare the results with a denser data collection (4 lines/m). It creates a more nuanced image of magnetic variations, but we have not seen significant differences in the quality of the information provided.

The data was processed with the Terrasurveyor software. Basic corrections were made to the errors derived from data collection: stripping, staggering, and occasionally filters to correct noise problems. Once exported to a GIS environment, we worked with the range of values of the tables in order to explore their distributions and maximize the detection of traces of archaeological interest. Thus, from a semi-automatic classification of the average values of magnitude for each type of identified element, we have elaborated an intermediate layer between the raw data and a final interpretative reading that would be visually more understandable.

The range of values associated with different types of buried features and anomalies has been classified as a series of discrete categories: positive and negative peaks, wall foundations (certain or probable) and thermo-altered surfaces. Within the latter group, we have differentiated between possible pavements, burnt and possible combustion structures (kilns, fireplaces). From this reading layer, a visual interpretation has been made, combined with the use of contours generated at different magnitude intervals, crossing the three types of information. The result has been vectorized offering an interpretative synthesis of the data obtained by magnetic prospection.

3.2. GPR

The GPR (Conyers and Goodman 1997; Conyers 2012; Goodman and Piro 2013) has been the second most used method in the survey of Villasviejas, with a total of 1.4 ha covering extensive areas of both enclosures. A total of 316 transects have been carried out, providing a total of 3.476 georadar sections of various lengths. The work was carried out at the end of June, in extremely hot, dry conditions.

The equipment used consists of a Stream X multichannel antenna (IDS Georadar - Hexagon Geoystems). The nominal frequency is 600 MHz with a disposition of 12 dipoles with a polarization in HH and VV. In each pass, 11 georadar sections are obtained with a spacing of 8 cm for a footprint width of 88 cm. The horizontal distance calibration is determined using the odometer of the equipment and a taking of points of beginning and end of each transect by means of a differential GPS of sub-centimetre precision. The horizontal resolution is around one scan every 4 cm.

The data has been processed with the GPR-Slice software. The objective of the adjustments has been to minimize the abundant background noise and to amplify the signal containing significant data. Depending on the area, the velocity of the medium can be quite variable, but an average of around 10.3 cm/ns of constant velocity has been assumed for the ground with a dielectric coefficient of 9. With the data from the processed GPR sections a series of slices around 10 cm thick was generated, without any overlap between them. Finally, the interpolations generated from the sections were exported to a GIS working environment in order to compare this data with the other layers of information.

3.3. Electrical resistivity tomography (ERT)

Electrical tomography provides the distribution of the electrical resistivity of subsoil materials, either along a profile (2D) or for a three-dimensional volume (3D) (Dahlin 2001). Its implantation in archaeological studies is fully established (Teixidó *et al.* 2013; Nowaczinski *et al.* 2015; Kvamme 2018). The equipment used in this study is the ABEM Terrameter LS resistivity meter with 90 electrodes.

The work plan carried out in Villasviejas had two objectives: on the one hand, it was proposed to create long profiles that crossed both enclosures longitudinally and transversely, with the intention of assessing

Type/name	Distance between electrodes	Description
Profile / P1	0.5m	Roll-along length= 60 m depth= 6m
Profile / P2	0.5m	Roll-along length= 90 depth= 6m
Profile / P3	1 m	Roll-along length= 200 m depth= 12 m
Square C1	0.5m	Spools: 2×21 Nº profiles=12 Distance between profiles= 0.5 m Depth: 4 m Size: 20 m × 5m

Tab. 1. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Technical specifications of Electrical resistivity profiles (see fig. 6). Square C1 corresponds to the small area explored with pseudo-3D method.

the stratigraphic deep and the relationship between the archaeological deposits and the geological base. To date, three of these profiles have been carried out, all in Enclosure A (P1, P2 and P3, see summary of their features in table 1). On the other hand, pseudo-3D studies were considered, consisting of data collection with a grid composed of 12 profiles spaced 0.5 m, with an electrode interval of 0.5 m. This type of register adds a horizontal reading to the previous one that makes it possible to appreciate the layout of the buried structures. Using this procedure, so far it has only been possible to explore an area measuring 20 x 5.5 m in the central part of Enclosure A (Square C1 in Tab. 1).

The data has been processed with the RES2DINV and RES3DINV inversion programs from Geotomo Software. Finally, georeferencing and integration in GIS environment was carried out. In the case of pseudo-3D, we also assessed the quality of the resistivity surfaces at various depths using different interpolation methods.

4. RESULTS

Thanks to the integrated work with various geophysical methods, in a short time we have accumulated a wealth of information on the internal organization of the settlement. Making effective use of these data is a challenge that first requires evaluating each source separately, and then combining them all together.

4.1. Geomagnetic survey

The most notable feature of the geomagnetic survey results is the high contrast between the values corresponding to the target structures and the filling deposits between them. The former is almost always negative, while the latter show a higher degree of magnetisation. As we already pointed out in section 3, this good result has been extremely favored by the building technique and the absence of collapse deposits of stone and roof tiles. There is also a very limited

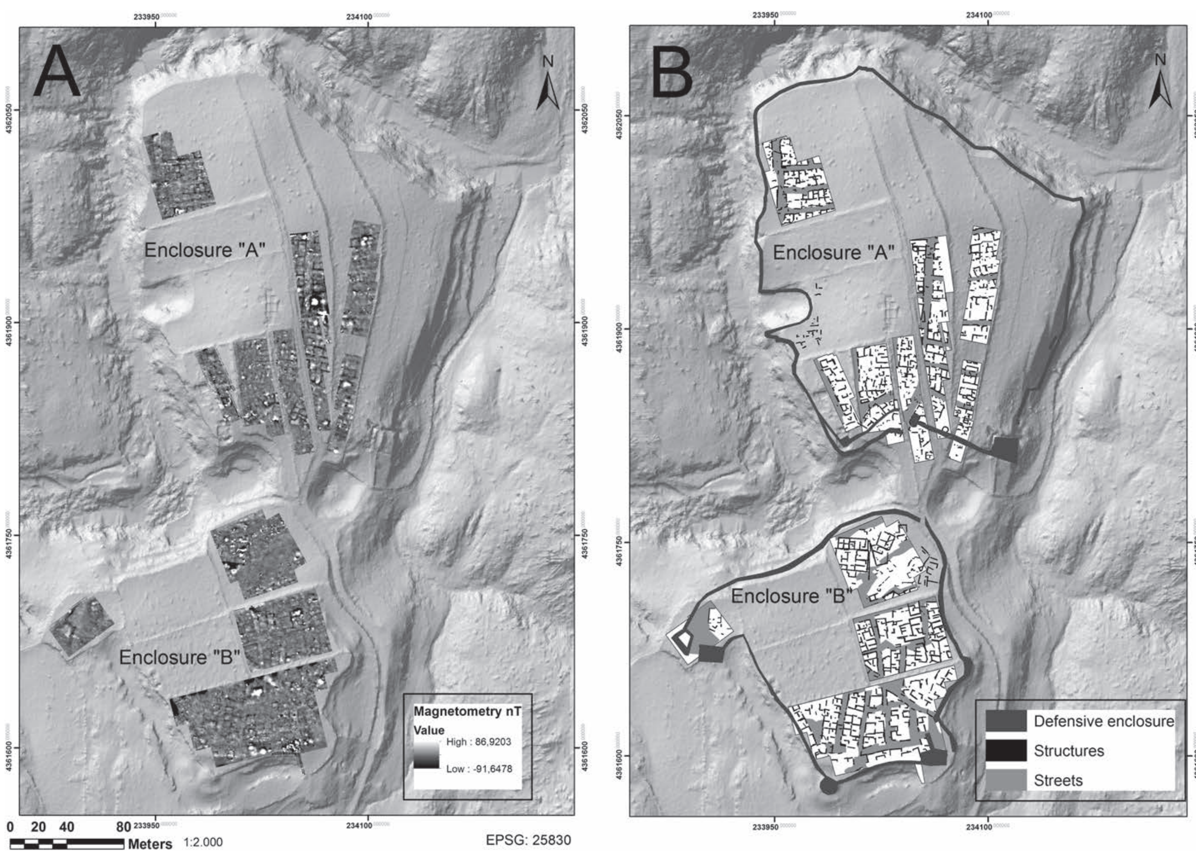

Fig. 4. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Results of the magnetometry from both enclosures: A original data; B reading and interpretation.

presence of dipole anomalies, which generally correspond to modern alterations (wire fences, residues, pieces of agricultural machinery, etc.), thermo altered areas or the presence of buried metallic elements. In general, the range of values is quite limited and with little background noise. This favours the clear detection of elements of less magnetic susceptibility, which would otherwise be masked by the extreme values. Distortions caused by the presence of bedrock outcrops can only be seen at some points in the higher zone. On the contrary, as we descend towards the lower points of the prospected zone, the stratigraphic power is greater and this type of anomalies are attenuated. The terraced arrangement of the boundaries of the landplots has favoured this process (Fig. 4).

4.2. GPR

As a whole, the result of the GPR survey returns an image of the buried structures with abundant noise, which makes their interpretation difficult. The dielectric coefficient of the walls is estimated to be between 7-10 mS/n with a mean propagation velocity of 9.5 - 11 cm/ns, and that of the soils is estimated at 6-13 mS/ns and a propagation velocity around 8 cm/ns. Therefore, the contrast between the two media is relatively low and in some specific cases can be similar, although sufficient to obtain reflected energy. With the antenna used, a critical zone around 4 cm is estimated, meaning that walls with a wider width can be detected. The investigation depth was around 1.1 m except in areas of metamorphic rock, where anomalies up to 2.3 m were detected.

In Enclosure A there is a major contrast between the hyperbolas[2] produced by the buried walls and the soil surrounding them. The signal that we identify as collapses of structures is very localized, and there are few stones or soil disturbances. The wall anomalies are detected from an estimated depth of 0.26 m to 0.98 m. The lower contact of the soil with the geological level has not been detected except in the southern part, at a lower topographical level, where the hyperbolas could be related to the internal structures of the metamorphic rock (Fig. 5).

Enclosure B is where we find a greater background noise, with a large number of isolated hyperbolas that indicate the presence of areas with landslides and removals, masking the detection of possible structures. On the other hand, the layout of the wall on the east side of the enclosure is clearly visible, forming a group of hyperbolas with large dimensions in both width and height. In the central zone, the alignments of the urban structures are detected with different degrees of clarity. The walls have hyperbolas between 0.2 - 1.1 m. There are anomalies close to the surface that present wave reverberation that is typical of a metallic element, probably related to modern livestock activity. Horizontal reflection anomalies have been detected that coincide with transects parallel to walls. In the lower part of this enclosure, an inclined reflection has been detected below the hyperbolas of the walls, which could be due to the lower contact of the soil with the rock at the geological level at a depth of between 0.6 - 1.2 m. It forms a valley some meters wide, oriented along a northeast-southwest axis. The deepest anomalies in these sections are related to the internal structures of the metamorphic rock, diaclases and altered internal fractures. In the slices at different depths a small variation of orientation of the structures has been detected, one along a north-south axis and walls at about 0.18 m, and another along northwest-southeast axes and walls at 0.31 m.

4.3. Electrical resistivity tomography (ERT)

As it was described in 3.3, we carried out three long profiles (P1 to P3) in the A Enclosure in order to get an extensive transversal reading ot ER values across the site. Results (Fig. 6) show clearly the boundary between the geological base and the archaeological deposits, located at a maximum depth of about 3 m in the case of profile P1 and 1 m for P2. The error in the inversion process is very low, being equal to 1.9 % for profile P1 and 0.95 % for P2 (Fig. 6).

Profile P1 shows three zones of anomalies, located at distances between 9 - 16 m, 18 - 28 m and 38 - 60 m from the origin of the profile. The first is located between 1 - 2 m deep from the surface and could correspond to a wall. The second, located at a depth between 1 - 3 m, is the one with the largest dimensions and highest resistivity values. In the magnetic susceptibility map these two anomalies are not shown, probably because they are at a greater depth. The third anomaly to highlight in the profile is the most superficial, located at a depth between 0.2 - 2 m. This feature shows a narrow correlation with the values recorded by the magnetometer, and may correspond to wall foundations (Fig. 7). Between 30 - 38 m, areas with low relative resistivity are detected, where the most noteworthy is the one located below 35 m. A relative maximum is also observed at 31 m, which coincides with a maximum of magnetic anomaly. On the other hand, between 48 - 60 m in length, structures located between 0.2 - 0.8 m have been detected that seem to have a certain degree of collapse since they present lateral

[2] A hyperbola is the set of all points in a plane such that the absolute value of the difference of the distances between two fixed points stays constant

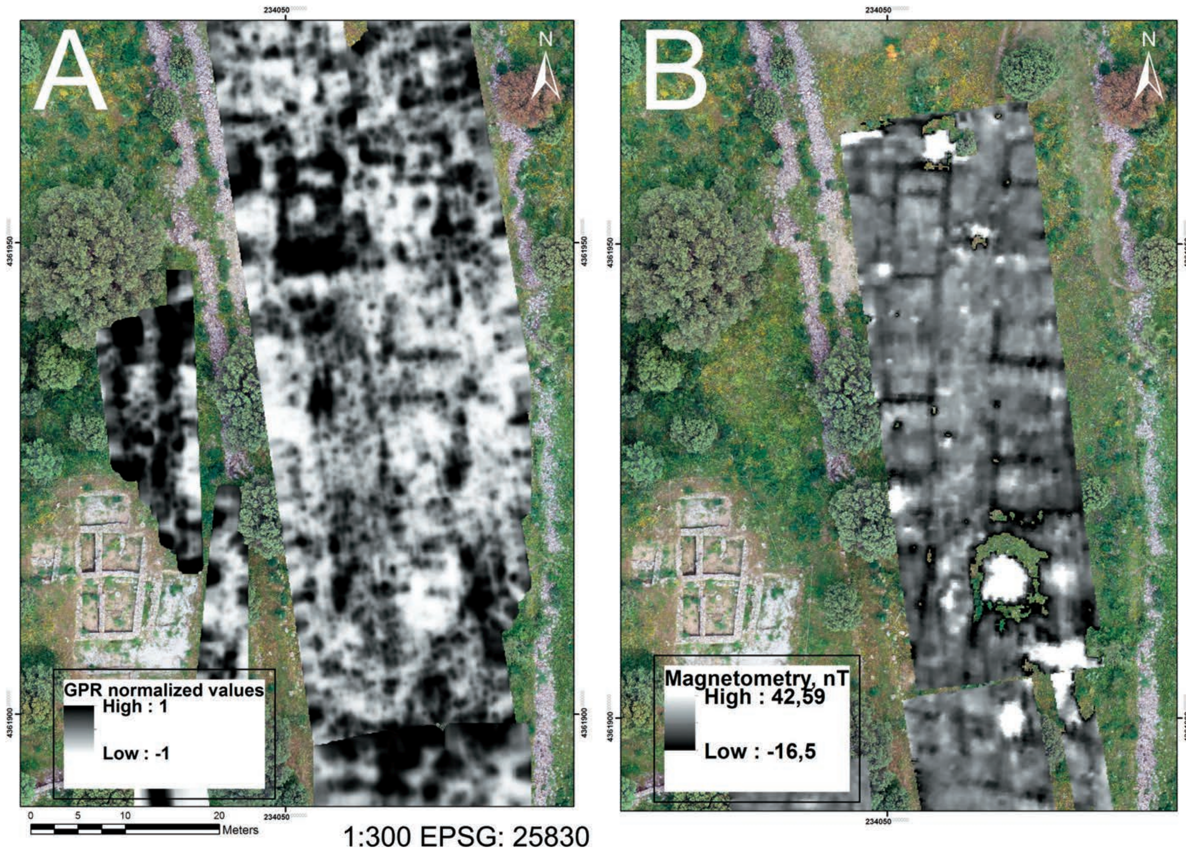

Fig. 5. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Results of Ground-penetrating Radar survey: A central area of the Enclosure A compared with the magnetometry resuls for the same area B (in colour in the electronic version).

variations. Comparing it with the map of magnetic anomalies, it can be deduced that they may be the remains of walls combined with a surface that was used for some type of purpose. Between approximately 38 - 48 m, high resistivities are detected that are possibly associated with thicker stone masonry structures than in the previous case. Their roof is between 0.2 - 0.5 m and increases with the slope, while the base reaches 2 m in depth, and also increases with the slope.

In profile P2, the layer of archaeological interest is shallower than in the previous profile. The first anomaly to be highlighted is between 16 - 44 m from the origin of the profile, highlighting a body centered on the most excavated 32 m in the geological base, which could correspond to some type of infrastructure. A second anomaly is located between 48 - 55 m and is the one that presents the highest resistivity values of the entire profile, which may correspond to a wall. Between 65 - 89 m there are heterogeneous resistivities that seem to be grouped in a surface and conductor section corresponding to filler material, with two anomalies standing out that are centered on the 73 m and 85 m, some 2 m long and around 0.5 m thick.

The P3 profile was traced from south to north along almost the entire length of enclosure A (200 m long). Its purpose was to evaluate the distribution of the archaeological level and, above all, to study the geological characteristics of the area at a greater depth. Therefore, the distance between electrodes is 1 m, reaching a maximum depth of about 12 m. Figure 6 shows the result of the inversion, with a final error of 0.99 %. A dotted line indicates the limit of the layer of archaeological interest, which is at a maximum depth of about 3 m. Between 13 - 30 m from the origin of the profile, anomalies similar to those of the P1 profile (located about 40 m to the west) between 18 - 28 m can be observed. These could correspond to the granite wall. This coincidence in the anomaly of very high resistivity in identical sections of the two profiles, indicates that the data are reliable and valid to interpret the deepest levels explored. Below the archaeological level, the layer corresponding to the substrate of slate

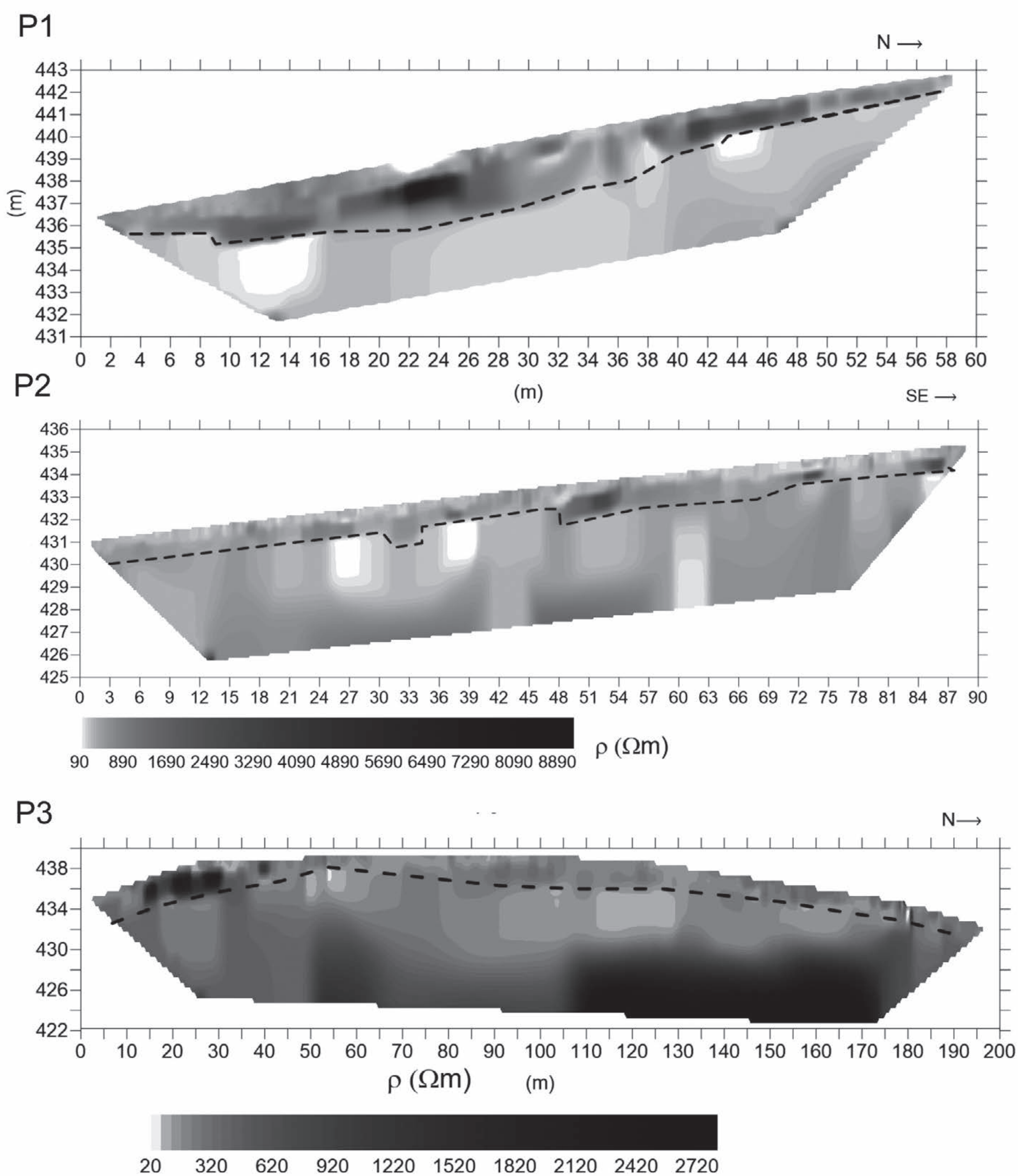

Fig. 6. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Tomography profiles made in Enclosure A. The dotted line indicates the contact surface between the archaeological deposits and the geological substrate.

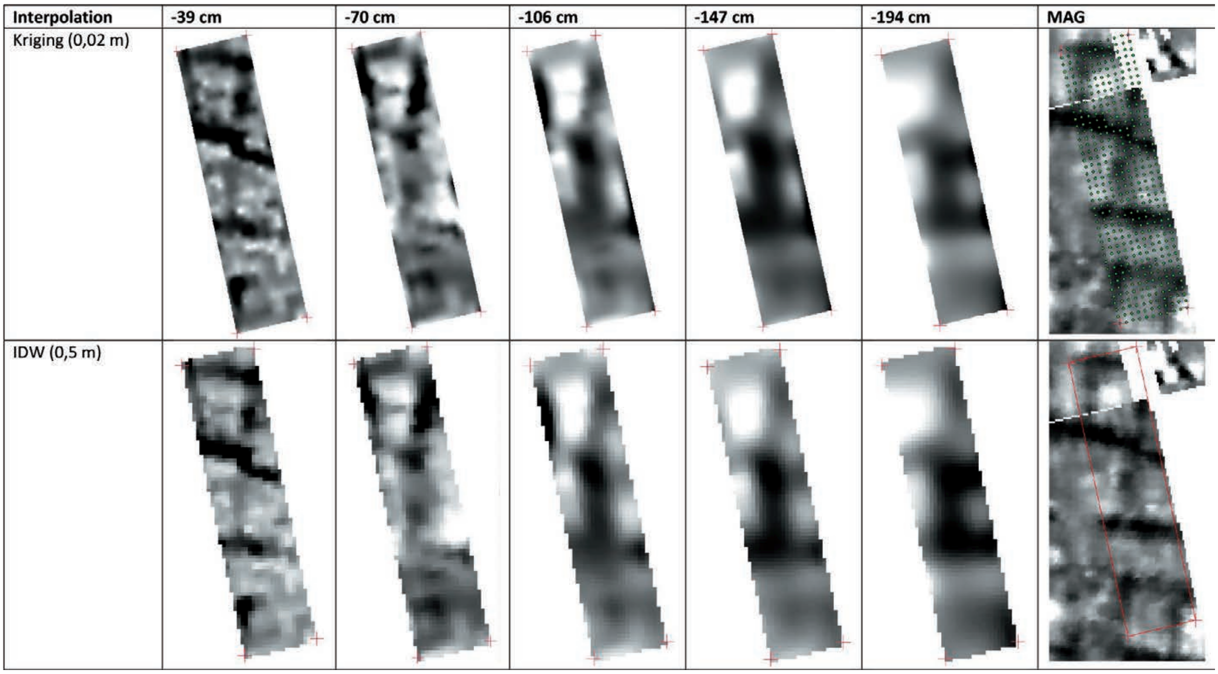

Fig. 7. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Comparison of the interpolation by Kriging and Inverse distance weighting (IDW) of the pseudo-3D tomography values at several depth intervals. Left column: overlay of the results with the magnetometry data (MAG) from the same zone.

materials of the Schist-Greywacke Complex can be differentiated, and below this unit, from 7.5 m deep, highly resistive materials appear, with dome morphology and resistivity values that gradually increase towards the nucleus. We propose the hypothesis that this discordant presence could correspond to a granitic intrusion that would provoke a contact aureole, determinant of the gradual increase of resistivity values.

Regarding the results of 3D tomography, although the exploration covered a very small area, a high potential for the future is evident, as it provides interesting data for the quantitative comparison of the results provided by different sensors. As may be seen in Figure 7, there is a high contrast that clearly differentiates structures with higher resistivity values. The correspondence with magnetic anomalies is very close. The tomography study allows us to situate the maximum depth of the latter at 1.7 m.

5. DISCUSSION

5.1. General remarks

The joint analysis of the large volume of data obtained with different sensors reveals the existence of numerous correspondences that reinforce the validity of the hypotheses proposed regarding the presence of buried elements. This can be clearly seen in the urban pattern of Enclosure A, where the high values of electrical resistivity coincide with the low magnetic susceptibility bands corresponding to the structures and with the anomalies registered by the GPR.

An illustrative example of this correspondence can be seen in the front of the defensive wall at the southern side of Enclosure A. In this area, the layout of the ramparts in their W and E corners was known, but the accumulation of plough soil from agricultural work had masked the presence of the wall and the location of the main entrance to the enclosure. The magnetometry (Fig. 8A) made it possible to trace the line of the wall throughout this section, also revealing the presence of an open space flanked by a 6.7 x 6.3 m structure with walls 1.5 m thick, which we interpreted as a stronghold defending the entrance. On the other side of this access, the magnetometry image was confused, and it was suggested that there was a recess in the rampart to create a funnel-shaped entrance. However, the data provided by the GPR and profile 1 of the tomography (Fig. 6P1; Fig. 8B and 8C) recorded a strong anomaly just 5 m west of the entrance, which would indicate the presence of another built mass. This would surely indicate the existence of a second tower

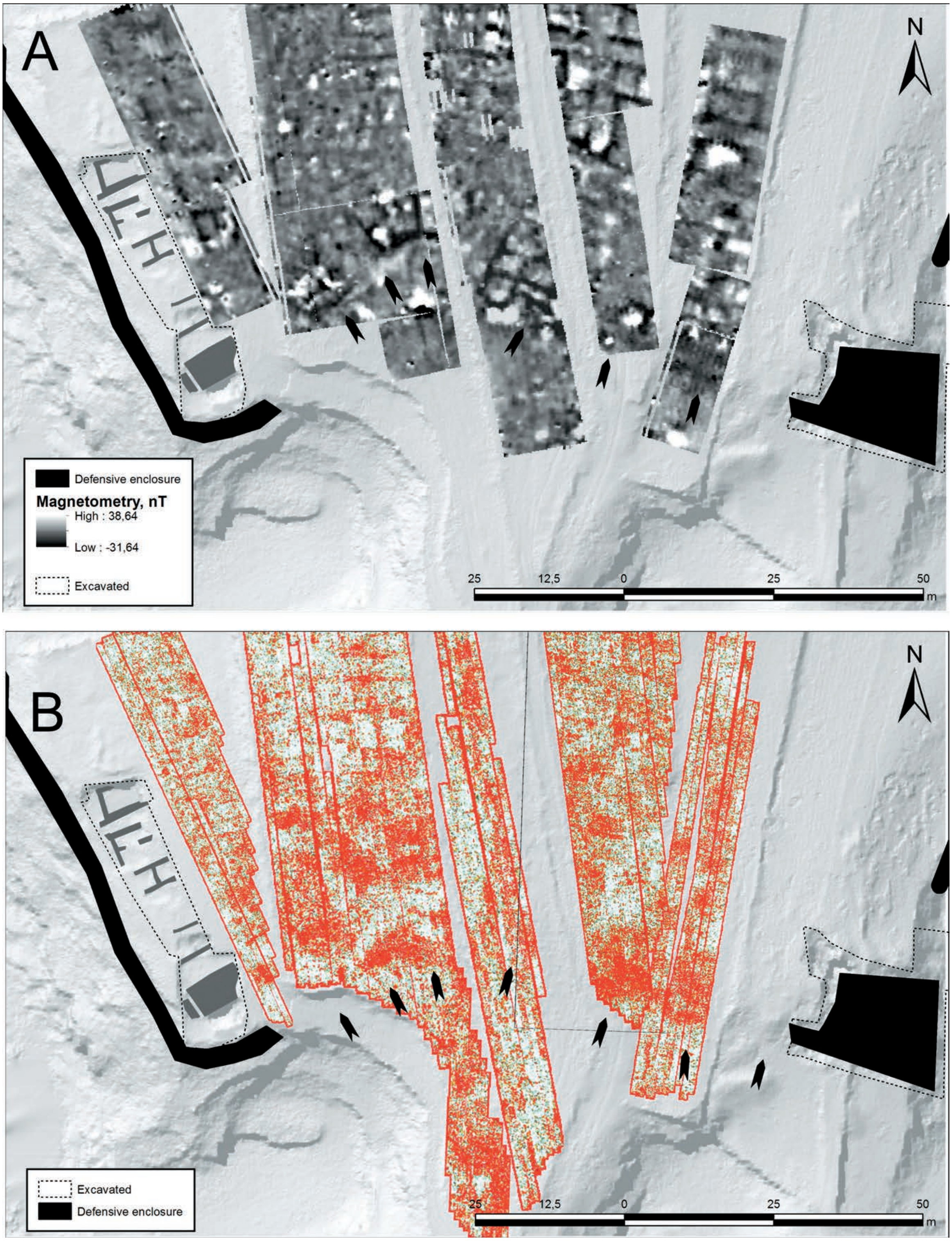

Fig. 8. Hillfort of Villasviejas del Tamuja (Botija, Cáceres). Comparison of the results from A magnetometry, and B Ground-penetrating Radar, which raises different hypotheses regarding the layout of the wall (indicated by black arrows) and the entrance to Enclosure A (B in colour in the electronic version).

flanking the main door, and may be offering us clues about modifications made to the southern face of the defensive wall.

At the same time, this variety of methods provides us with new information where only one or more sensors are capable of recording buried features. A good example of this is the information provided by the GPR in Enclosure B. On the one hand, it has made it possible to delimit a good section of the inner face of the rampart in an area where its layout was more dubious. On the other hand, thanks to magnetometry we were considering the idea that at least 1/3 of the enclosure lacked a dense framework of structures as typically found in A. As we have seen, in this sector the GPR defined a shallow depression oriented from the SW-NE that would correspond to an open space, probably a passageway, which we can therefore characterise three-dimensionally.

5.2. The internal structure of the walled enclosures

Beyond these partial valuations, the comparative work using the sensors makes it possible to create an overall image of the internal organization of the settlement. In this sense, the two enclosures have both similarities and differences.

In Enclosure A, the largest one, is evident a greater organicity and adaptation to the topography. Open spaces are scarce. It is possible to distinguish a series of large longitudinal axes adapted to the shape defined by the walled perimeter that organize the circulation in an N-S direction. The principal one, outstanding for its width (up to 6 m) and rectilinear layout, divides the enclosure in two halves. This main street runs parallel to the slope, and seems to connect directly with the main entrance to the enclosure, as we saw in the previous section. We can affirm that urbanistically this formed the backbone of the entire complex. A secondary axis runs along the western side of the settlement. As we will see for the B Enclosure, we never find circulation areas between the defensive wall and the building blocks, as the existence of constructions attached to the inner face of the rampart has been confirmed in several points. We do not know whether the eastern side would have been symmetrically organized in the same way. In this area, the geophysical readings were hindered by a series of terraces created by the segmentation of agricultural land, although it should be noted that these may be the fossilised remains of the original stepped design of the hill fort.

Based on these longitudinal axes, a series of secondary streets run in a general E-W orientation, but do not transverse them at right angles. Their widths vary between 3.5 - 4 m, forming blocks of 11 or 12 m in width. This information is consistent with the

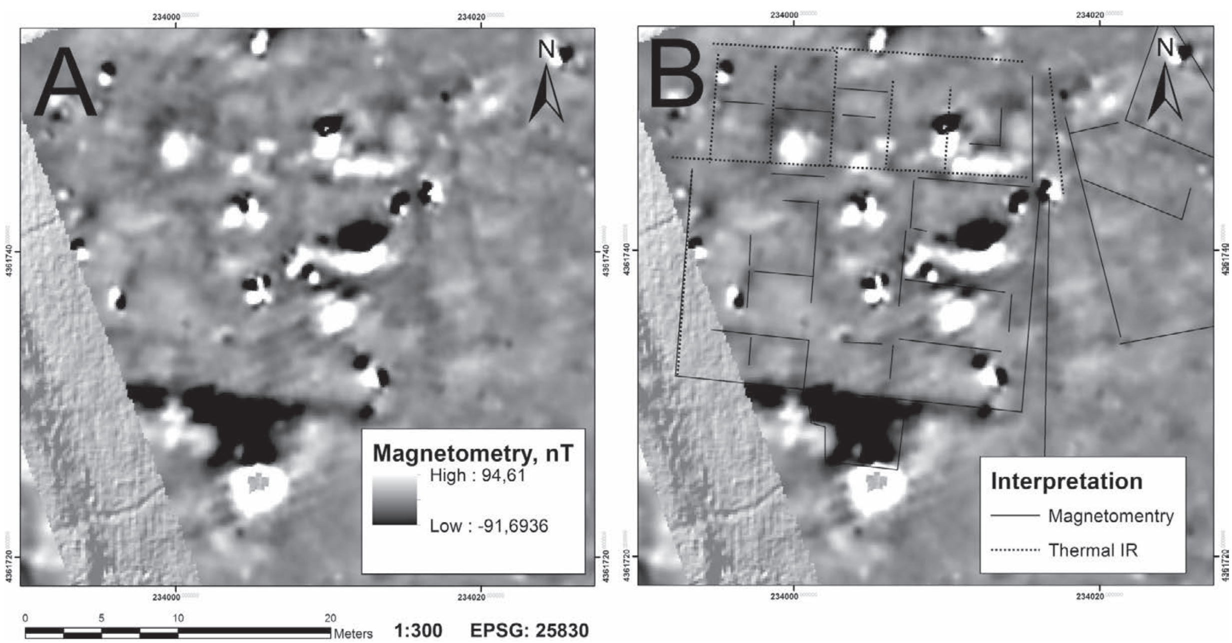

Fig. 9. Possible Italic-type structure in Enclosure B of the hillfort of Villasviejas del Tamuja (Botija, Cáceres): A Original data; B Reading and interpretation.

dimensions of the block of houses excavated by Dr. Francisca Hernández, which would have been flanked by two of these roads. In several points it can be seen how these blocks are structured forming two alignments of houses facing two streets. In any event, despite the good contrast, we cannot venture much more regarding the internal organization of the houses. This repetitive scheme seems to break up in some areas, forming alleys that lead to small squares. This suggests the presence of more extensive and compartmentalized dwelling units beyond the basic module of some 30 m^2 defined in the hillfort itself (Hernández *et al.* 1989: 157)

In the case of Enclosure B, although the entire southern half contains a dense urban layout, we can see a large, unstructured space in the area next to the northern boundary of the walled perimeter. No major roads have been found, and all of the streets are narrower (between 3 and 4 m). Although their design is also very straight, there is more diversity in their size and layout. Here, too, we repeatedly find structures attached to the entire inner face of the wall. It has also been possible to identify one of the entrances of the enclosure, corresponding to the Northwest angle. Although the existence of a tower at that point was already known, we can now define in detail a large trapezoidal defensive structure with an internal compartmentation that allows us to hypothesize that it had an upper room. This bastion would have flanked a gate of 7 m wide. All these data lead us to propose that, while Enclosure A was the result of the evolution of a previous urban plan, Enclosure B was formed from the aggregation of independent structures. Some of them, due to their regularity and design, suggest an ex novo implementation, as discussed in the following section (Fig. 9).

5.3. Temporal evolution of the hillfort

In the few areas that have been excavated, the superimposition of structures clearly indicates that the urban layout we have documented correspond to the final stage in the life of the settlement, dated to the beginning of the 1st century BC. In Enclosure A, the compact and regular distribution indicates a high level of urban planning. However, in its south-eastern side we can see narrower and more irregular streets, and more heterogeneous dwelling units. As a whole, it could be suggested that the urban structure of the 4th - 3rd centuries B.C would have been partially maintained, preserving its orientation. The evolution of the street network and domestic structures came about either as a result of superimposition (documented in areas excavated by I. Ongil and, to a lesser extent, by Dr. Francisca Hernández) or by the adjoining of walls that ended up defining the street layout, something that is especially apparent in the central and highest area of the enclosure.

A separate issue is the diachrony that the excavations have revealed in the evolution of the defensive system. It has been suggested that some attachments and superimpositions to the rampart would denote a loss of its functional and symbolic role, to the point of proposing a “refounding” of the hillfort after the Roman conquest (Heras 2018: 465). This matter requires a detailed analysis that goes beyond the limits of this work. We will only note that geomagnetic survey has clearly revealed a main entrance to the enclosure that is well articulated with the rest of the urban layout.

As for Enclosure B, we will focus on the characteristics of three isolated buildings located at its N and S sides. The first (Fig. 9) forms a SW-NE oriented quadrangular block measuring approximately 23 x 23 m, formed by three rectangular sections around 8 m wide, subdivided into several elongated rooms between 3.7 - 5 m wide, which are arranged around a central space that seems to act as a distributing corridor. This regular and symmetrical arrangement seems to have been devised in a unitary way. Here we propose its similarity with the Italic architectural model of the Late Republican tripartite houses and granaries pointed out by Moret (1999: 64-65) for the “fortified houses” and *castella* from that period in the Iberian Peninsula. The presence of several fragments of *tegulae* on the surface could be indicative of the type of roof used for these buildings.

The other two buildings are located in the southwest end of the enclosure, in an area where the geophysics reveals the presence of a less dense urban layout, with blocks of structures and streets that are perfectly visible (Fig. 10).

Both groups form compact block , with a total width of about 10 m, divided into 2 batteries of square rooms with dimensions of 4.5 x 4.5 m in one case and between 5.2 - 5.8 m each side in the other. They have a SW-NE orientation and are placed in parallel, with a straight street with a width of about 4 m between the two. Further west, a third body with very similar characteristics would have been attached to the inner face of the defensive wall. Once again, the extreme regularity in the layout of the floor plan and the homogeneity in the dimensions of the spaces invite us to consider them as non-domestic structures with a specialised function. In this case, the search for analogous examples leads us to review the excavations carried out by Schulten in the Numantine Roman camps, in particular the structures corresponding to phase III of Renieblas (Dobson 2008). Although with

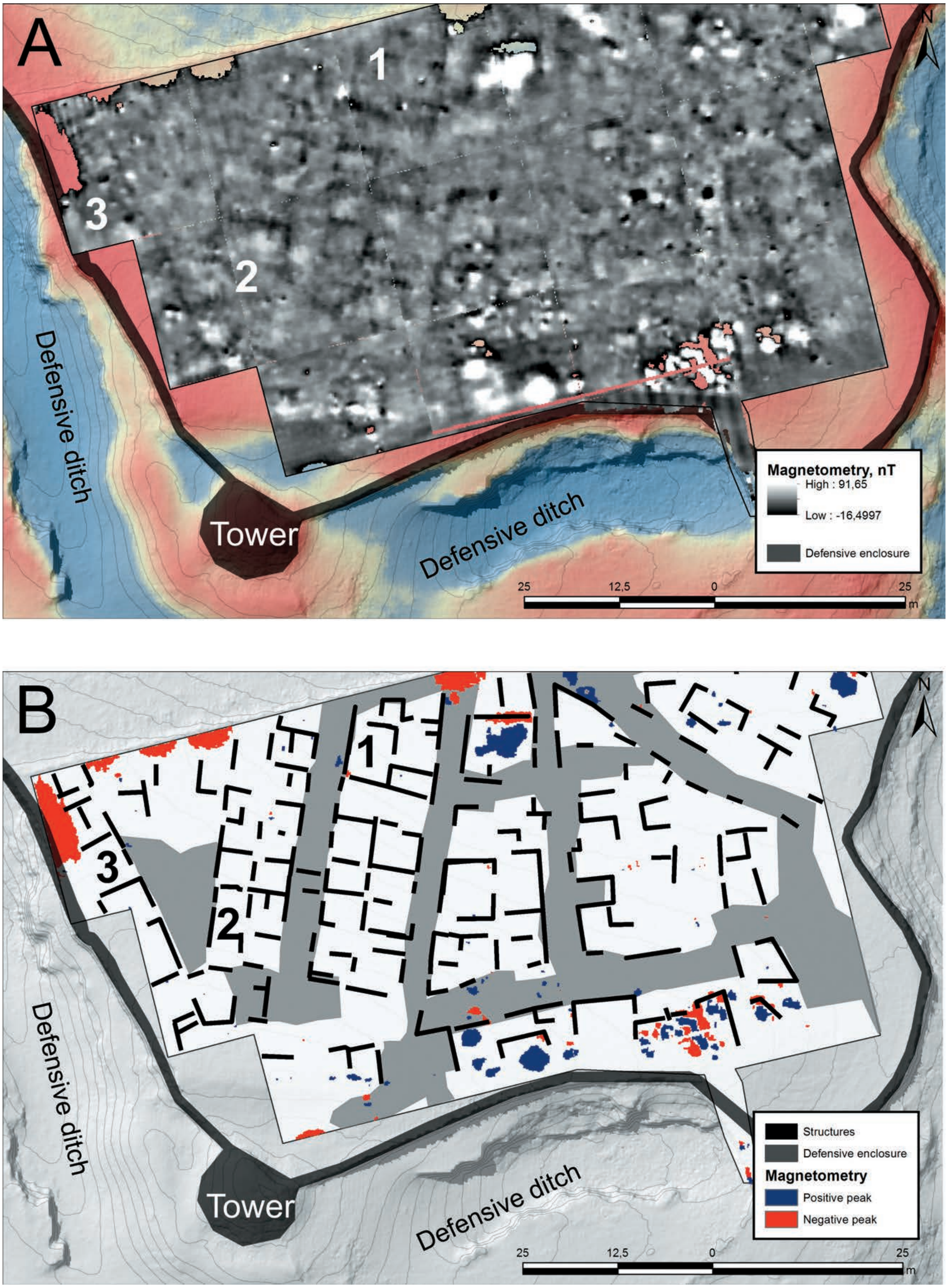

Fig. 10. Geomagnetic survey from the southern end of Enclosure B of the hillfort of Villasviejas del Tamuja (Botija, Cáceres): A Original data; B Reading and interpretation. 1-3: structures interpreted as possible military barracks (in colour in the electronic version).

less clarity, we can also see similarities in the structures of the much closer case of the Roman camp of Cáceres el Viejo, whose chronology coincides with that of the last occupation of Villasviejas (Abásolo *et al.* 2008). We therefore propose the hypothesis that they could have been the barracks of a permanent military encampment. Although we do not yet have a direct confirmation through excavation, just 20 m from these traces we have one of the test pits excavated by Dr. Francisca Hernández, where the material recovered points towards a level of occupation dating from the beginning of the 1st century BC (Hernández *et al.* 1989: 26 *et seq.*)

We can therefore see in this Enclosure B some elements that would point towards the presence of Italic structures, possibly of a military nature, during the Late Republican period. This is not the first time that this idea has been raised (Esteban and Sánchez 1988), an aspect that needs to be explored in detail elsewhere. The presence of imported materials in the two parts of the settlement is overwhelming. In addition, the funerary record of the necropolis of Romazal I has provided an important collection of grave goods with weapons and other elements that strongly point towards an Italic presence in the final stage of the life of this settlement. The discussion about the identification of Villasviejas as the coining center of the mint of Tamusia should not be ignored in this sense (Blázquez Cerrato 1995, 2014). It's purely Celtiberian character has given rise to the hypothesis of the presence of contingents from the eastern Meseta displaced by the Romans within the framework of the armed conflicts of this period (Sánchez Moreno 2017: 68-69). Although all the known coins have a clear geographical concentration in the regional environment of Villasviejas, it is no less true that none of them comes from excavation contexts in the site itself. The question that will have to be evaluated is the type of interaction between the local inhabitants, Celtiberians and the Romans that is revealed by this complex palimpsest.

5.4. Villasviejas within the context of the protohistoric urban development of the Peninsular Southwest

Finally, it is worth assessing to what extent the knowledge gained in the case of Villasviejas will help to improve our knowledge of the urbanism of Iron Age fortified settlements in the western part of Spain's *Meseta*. A common element throughout this wide area from the period in question is the widespread appearance of new settlements, which has been interpreted as evidence of the expansion of a new socioeconomic model (Álvarez Sanchís 2003: 106-111). This question has been in the research agenda since the late 1980s (Almagro 1994: 13). However, the empirical basis from which this debate has developed has barely expanded in all this time.

This fact is especially striking with regard to the immediate context of our case study: the Northen part of the region of Extremadura. Although the defensive enclosures are relatively well known, with the exception of La Coraja (Aldeacentenera, Cáceres) no significant excavations have been carried out in the area, so we still lack any information about the internal organization of these hillforts (Almagro 1994: 16). Without leaving the cultural sphere of the Vettones, the situation is slightly better in the case of El Raso de Candeleda (Fernández Gómez 1986, 2011), which is today the hillfort with the largest excavated area in the region. Unlike Villasviejas, its adaptation to a rough topography dominated by granite outcrops determines the way in which the houses are grouped together.

We seem to find a similar arrangement in the case of Ulaca, in Avila, where, despite the small area that has been excavated, there are signs that would suggest a spatial differentiation of various activities and the basic articulation of the axes of circulation. The model of spatial organization in this large settlement differs considerably from that observed in Villasviejas, as the dwellings are not grouped into compact blocks, but are instead scattered without a uniform orientation with well-defined public spaces. In the case of the Cogotas hillfort, as in Villasviejas, a series of houses attached to the interior face of the wall have been documented, forming compact clusters. However, the presence of large granite outcrops inside the enclosure would have made it impossible to develop a regular urban layout, as in the case of Ulaca (Álvarez Sanchís *et al*. 2008) or El Raso. On the other hand, there is a similarity with our case as regards the identification of spaces for rubbish dumps, spaces used for working, and other structures outside the walls, as can be seen from the area around Enclosure A (Hernández *et al*. 1989: 66). Another of the most outstanding cases in the area of Avila is La Mesa de Miranda (González-Tablas 2008; López García 2012). Thanks to recent work we have a more detailed record of the structure of the houses. However, and despite the fact that here the topography would be more propitious for creating a well-organised urban scheme, as is the case in Villasviejas, we lack any information that could help to corroborate this hypothesis (Fig. 11).

If we move towards the northern limits of the Vettones region, the situation is similar to that in Extremadura. We have some recent excavations in several hillforts (Benet and López Jiménez 2008) but, as a whole, there is still a total lack of knowledge regarding th e urban layout and the organisation of domestic space.

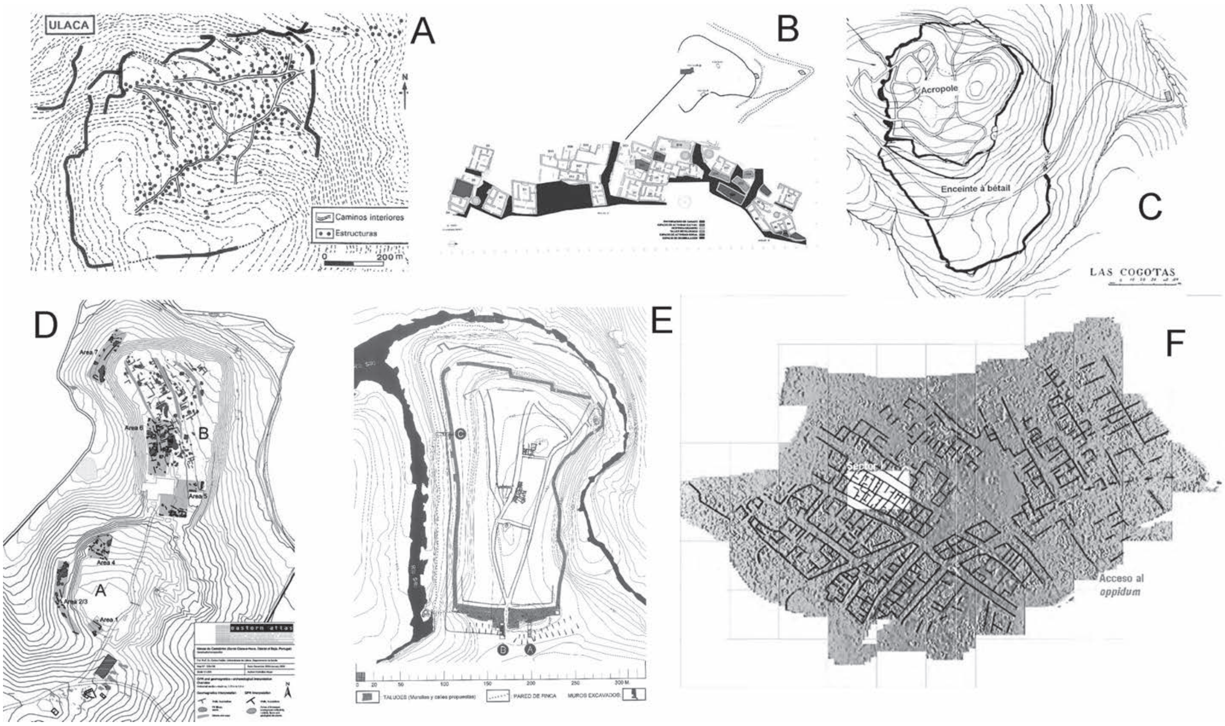

Fig. 11. Ground plans of fortified Iron Age settlements whose layout is known (on different scales): A Ulaca (Álvarez Sanchís 2011: fig. 25); B El Raso (Rodríguez Hernández 2018: fig. 4.28; C Las Cogotas (Bonnaud 2005: fig. 5 after Cabré 1930); D Mesa dos Castelinhos (Guerra and Fabião 2010: fig. 4); E Capote (Berrocal 2007: fig. 2); F Santorcaz (Contreras *et al.* 2014: fig. 6).

As far as the southern *submeseta* is concerned, especially in the Tagus river basin, few sites are known to any great extent. In the case of Cerro de la Gavia, in Madrid, it was possible to excavate a street with a curved outline, which crossed the village from north to south, starting from a possible entrance. An urban plan of compact blocks and two main axes adapted to the topography was identified (Morín *et al*. 2007). In turn, the excavations and geophysical surveys carried out in the village of El Llano de la Horca (Santorcaz, Madrid) have revealed a more complex layout, organized around a central square that was accessed from the entrance to the village and a series of radial streets that spread out from it (Contreras *et al*. 2014). Despite having been explored to a lesser extent, the case of Cerro de la Mesa (Alcolea de Tajo, Toledo) offers the image organized around several main axes[3].

Towards the South, within the pre-Roman *Beturia*, there are equally few references for a comparison. In the province of Badajoz, one of the few cases with open-area excavations is the hillfort of Los Castillejos de Fuente de Cantos. Unfortunately, the documentation published to date does not a detailed picture of its internal organization. More illustrative is the case of Castrejón de Capote (Berrocal 2007: 258). Its location and adaptation to the topography is similar to that of the A Enclosure of Villasviejas, with a series of longitudinal axes that start from an access defended by an "entrance fortress". However, in this case the perpendicular roads are mere alleys, compared to the wider ones in Villasviejas. On the other hand, the excavation has provided indications that the street network was modified after the Roman conquest, blocking off squares and densifying the built space. Another settlement with occupation after the Roman conquest is the oppidum of Hornachuelos, in Ribera del Fresno (Badajoz). Excavations within the walled perimeter have revealed the layout of two parallel streets, adapted to the topography and framing regular blocks of adjoining rectangular houses (Rodríguez Díaz 1991).

Finally, we have an equally incomplete understanding of the internal organization of Iron Age settlements in Portugal, especially in the centre of the country. Although we have evidence of sites that are chronologically similar to Villasviejas, such as Segovia (Bargão 2017) or Cabeço de Vaiamonte (Fabião 1996)

[3] This pattern has begun to be revealed thanks to the data provided by the georadar and magnetometer readings as a part of the Transvettonia project, and is still being studied.

there is no data on the distribution of streets or houses. In the south of the Alentejo region, the site of Mesas do Castelinho offers more information about its urban layout. The record of its Enclosure B is particularly of note, revealing the extensive restructuring of the space, dated by its excavators to between the end of the 2nd century and the beginning of the 1st century BC (Guerra and Fabião 2010: 472). The straight layout of the roads, organising a dense network of constructions, offers a close resemblance to the urban structure that we defined in Enclosure A of Villasviejas.

In conclusion, in the light of the cases that have been evaluated, we can contextualize the urban design detected in Villasviejas del Tamuja in two different scenarios. In the first place, Enclosure A offers the image of a housing pattern that evolved over time, becoming denser and more complex, with far-reaching reforms such as the variation of the front of the ramparts in the space delimited by the defensive ditches. Following the classification proposed by Álvarez Sanchís and Ruiz Zapatero (2001), this structure would fit with the central street model documented especially in the Celtiberian area (Eastern *Meseta*), with compact blocks and a limited public space. This is the pattern we have observed in the cases of Alentejo (Mesas do Castelinho), the Middle Tagus area or in Southern Extremadura. This spatial organisation differs significantly from the layout exemplified by cases such as Ulaca or El Raso, where the constructions are scattered adapted to a rugged topography (Álvarez Sanchís 2011). We do not know if this model was present in the original conception of the occupied space of Villasviejas, and it should be stressed that the image of this urban landscape that we perceive so clearly corresponds to the final stage of the settlement, which as we saw can be dated to the late Republican period.

Secondly, as already noted in section 5.4, the urban design of Enclosure B seems to respond to this late chronological context. Its logic of space does not seem to obey to previous cultural traditions, but rather to the need for infrastructures with a functionality beyond the domestic sphere. This leads us to propose that it may have been a Roman military base that was “embedded” in the indigenous community. However, we must evaluate more carefully this hypothesis elsewhere.

6. CONCLUSIONS

The combination of an extensive battery of non-invasive methods, together with the ideal conditions of Villasviejas for their use, have made possible to answer essential questions about the layout of the walled perimeter, obtaining new information about its accesses and defensive structures. We now also have a general view of its urban layout, with the identification of some of the main street links. The marked regularity observed in both enclosures, which denotes a dense and orderly pattern, is striking in this respect. This is especially evident in Enclosure B, where we have been able to individualize complete structures that clearly correspond to foreign Italic models. The validity of these conclusions can be reinforced with the available evidence of previous excavations, although obviously they raise new questions that will require a feedback with the accomplishment of new field works. In any case, thanks to the knowledge obtained, the latter can now be oriented in a much more selective way, with the consequent saving of resources. In this way we have begun to define the guidelines for future action plans on the site, which also offers new resources for presentation to the public.

In a broader sense, the results from Villasviejas complete our still limited knowledge of such a complex and debated issue as the development and evolution of Iron Age settlements, especially in their final stages. Although as far as the current territory of Extremadura is concerned it is the only case explored extensively today, it is ultimately a model of practice exportable to other large protohistoric settlements and in general to complex archaeological zones of all kinds.

With a view to the immediate future, it will be necessary to complete geophysical exploration of the whole complex and its surroundings. The combination of different methods will make it possible to deepen the quantitative relationships between them in order to produce a more consistent and reliable diagnosis. Finally, the knowledge we have gained must serve to provide answers to questions about the social and economic structure of this community in its historical context.

In this sense, the opportunity arises to revise the previously proposed demographic estimates (Hernández *et al*. 1989: 155). Similarly, such a clear record of the urban structure could serve as the basis for a quantitative approach to the social logic of space through its syntactic analysis (Benech 2007). Finally, these considerations can add elements for the discussion about the role of Villasviejas in the organization of its surrounding territory. The equivalent of the term “hillfort” in the Spanish bibliography is *castro*, that usually is opposed to *oppidum* by the connotations of this last one as a nucleus with functions of greater importance (as an administrative and/or religious nucleus, center of services, concentration of surpluses ...). The more intensive survey of the environment and a dialogue between the non-invasive exploration and the results of the excavations will help to resolve this issue.

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ANNEX: COMPLEMENTARY FILE

In the electronic version, a file is available as complementary material:

CF1. Raster layer in KMZ format with the results of geomagnetic survey of the Iron Age Hillfort of Villasviejas del Tamuja (Botija, Cáceres, Spain). It can be displayed using Google Earth or Google Maps. EPSG code: 25830.

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