



DOI: 10.5281/zenodo.292622

# GPR AND ELECTROMAGNETIC INDUCTION SURVEYS AT THE HILLTOP SITE OF UL (OLIVEIRA DE AZEMÉIS, PORTUGAL)

Adriaan De Man<sup>1</sup>, João Tiago Tavares<sup>2</sup> and Jorge Carvalho<sup>3</sup>

<sup>1</sup>*United Arab Emirates University, Department of History and Archaeology, UAE*

<sup>2</sup>*Municipality of Oliveira de Azeméis, Office of Archaeology and Museology, Portugal*

<sup>3</sup>*University of Porto, Faculty of Engineering, DEM-CERENA, Portugal*

Received: 24/01/2017

Accepted: 24/02/2017

Corresponding author: Adriaan De Man ([adriaandeman@uaeu.ac.ae](mailto:adriaandeman@uaeu.ac.ae))

---

## ABSTRACT

Ul is an archaeological site located on a hilltop near modern Oliveira de Azeméis (NW Portugal). It had several occupations over time, at least sporadically since the Bronze Age, and is nowadays a small parish with a number of scattered houses and a church, built against and around the Northern slope. Occasional fieldwork, some of it lacking publication, was carried out during the 20th century, followed by a new set of test trenches, as well as two series of geophysical surveys using GPR and electromagnetic induction methods. Some of the results from both the non-invasive and invasive approaches are presented in this paper, and integrate an ongoing discussion about Iron Age and Roman settlement in the NW of the Iberian Peninsula.

---

**KEYWORDS:** Roman hilltop site, regional settlement, castro culture, GPR, electromagnetic induction

---

## 1. INTRODUCTION

The sandy coastal area covering what is now roughly the western part of the Aveiro district, between the Douro and Vouga rivers, corresponds to a complex landscape that has been undergoing severe orographic shifts for many centuries, is now partially silted up, and acquired distinct configurations at least since the Middle Ages (Branco 1991). It forms part of an extensive geography in the Northwest of the Iberian Peninsula, in which a number of fortified settlements have been identified, loosely gathered together in what has been often called the “castro culture” (Silva 1986, Alarcão 1992, 1996), a convenient yet extremely broad designation. For at least a quarter of a century (e.g. Eiroa 1988, Fábregas Valcarce & Carballo Arceo 1991), hard data demonstrating a range from the Bronze Age to Late Antiquity has become available for many sites, and the current challenges in landscape archaeology are not to find just a sense in topography, but rather synchronies in the occupations of what used to be looked at as a much more homogeneous reality. Some modelling stems from hierarchizing principles, based on or reminiscent of central place theory, which may be challenged by new economic perspectives, and above all by the fact that only a small part of the archaeological data is currently available for comparison.



Figure 1. Location of Oliveira de Azeméis in the Iberian Peninsula

Geographic specificities do matter, of course (Arias Vilas & Villa Valdés 2005; Fernández Ochoa & Morillo Cerdán 2015), and it seems clear in any case that the local Iron Age witnessed the development of some large, dominating hillforts (Silva 1995, González Ruibal 2005, Santos Yanguas 2006-7). They articulated well with the involving territory, of course supported by a network of smaller, largely still unknown dwellings, either connected to agriculture or to distribution and trade, the latter

tending towards the great Aveiro estuary. In modern literature, Iron Age hilltop sites in this territory are usually linked either to the pre-Roman *Turduli Veteres*, mentioned by Pliny (Guerra 1995), or to Roman and medieval defensive structures, such as watchtowers or small castles (Silva & Ribeiro 2013). Elsewhere in the Northwest, several site occupations and transformations lead to the idea of continuity immediately after the Roman conquest (Alcalde López 2015). But for Aveiro there is still little information about long-term settlement patterns, an issue recent projects have tried to tackle (Silva, Pereira, Tavares & Lemos 2011). One structural, permanent element for understanding regional communication is the Roman itinerary between *Bracara Augusta* and *Olisipo* (Mantas 2012), and another one consists in the river Vouga and the key site of Cabeço do Vouga (Silva 2012), yet many secondary routes have played important parts in territorial articulation. One of these is the valley of the Ul, in modern-day Oliveira de Azeméis, where an interesting, relatively small site bears the same name. Its enduring relevance has been explained in terms of pseudo-administrative legitimacy (De Man & Tavares 2014), as a possible road station with annonarian competencies during the late Empire and the Suevic and Visigothic kingdoms.

Acknowledged for several decades as the finding place of a milestone of Tiberius (Mantas 2012) and of a *terminus Augustalis* (Almeida 1953; Silva 1993; Alarcão 2002; for discussion see Guerra 2007), Ul attracted the successive attention of both local and national historians during the 20th century (Pereira 1907; Fortes 1909; Oliveira 1943; Arêde 1951; Almeida 1953, 1956). The site corresponds to a relatively low but favourably located hilltop, episodically mentioned in medieval documentation, namely the *Chancelaria de D. Dinis* (liv. 1, fl. 103; fl. 106 v.), with a presumably condensed settlement that might have developed along the Northern slope, towards the modern village and its connection to a number of water mills. Surrounded almost entirely by two confluent rivers, the Ul, which gives the site its name, to the West, and the Antuã, flowing along the Southeast part of the elevation, the entire setting could fit a well-studied regional pattern of proto-Historic sites (Silva 2007; Grande 2008). It would have had a surrounding ditch, referred to in medieval documentation (Oliveira 1943), and three levels of contiguous ramparts, visible until the mid-20th century (Sousa 1960), which the current situation however does not allow to confirm. This particular feature has been associated to a specific type of late *castros*/hilltop sites (e.g. Pinho 2009), notwithstanding the sometimes unconvincing topographic evidence. Ul is certainly not a clear case,

especially after the very incisive quarrying activity, as well as the extensive destruction of earthworks in the successive reforestation of the hill, which has irreversibly damaged large parts of the surviving setting.

During the last few decades, applied geophysics has been used significantly during archaeological fieldwork in the Iberian Peninsula, producing a vast array of references for Spain and Portugal (e.g. synopses in Brito-Schimmel & Carreras 2005, Peña 2011, Gonçalves 2013), and some cutting-edge applications in terms of wider Mediterranean projects (of which Corsi et al 2011, Vermeulen et al. 2012, Verdonck et al. 2015 on Ammaia are perhaps the most integrated example).



*Figure 2. Terminus Augustalis of Ul, preserved in a wall of the local church, most probably separating the territories of Talabriga and Lancobriga, dated 4/5 AD*



*Figure 3. General view from the North*

## 2. ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

The first known excavations at Ul were carried out by a local priest, between 1941 and 1949, and some of his findings were described by another cleric, João Domingues Arêde (1951), who indicates a vast assemblage of pottery, glass, metals and millstones. The same objects are mentioned in some detail by Arlindo de Sousa (1960), and they seem to have been stored in the priest's residence and in the church. A handful of inscriptions were recovered as well but none have been seen in the last half a century. It is indeed unfortunate that all this material had already been dispersed in the 1980s, when a new

project identified three occupation phases following the excavation of a domestic structure and of an area adjoining one of the presumed ramparts (Marques 1985; 1989). A first, not very defined stage relates to the Chalcolithic and Bronze Age, which would account for the recovery of several pieces of silex, and a few polished stones. A second distinctive phase was associated to the Iron Age, attested by indigenous pottery and one fibula, and finally the better preserved period is linked to built structures, and visible through a large number of Roman coins, red slip and coarse ware, and glass. Stratigraphically, only these Imperial contexts were well defined, whereas the previous ones seem either scattered elements in Roman layers, or surface findings.

In recent years, Ul has been re-examined in the light of heritage management, which led to the musealization of a water mill park, the promotion of traditional bread, and the setting up of a trail with explanatory signs about the archaeological site. This ethnographic and tourism-oriented effort by the municipality was matched by a new sequence of surveys and test trenches, with the technical support of the universities of Aveiro and Porto. Two different stages of non-invasive data acquisition were set up at Ul, a first one focusing an original working hypothesis that centred research on the highest point of the hill, and another on the surrounding plateau. The reason for this had to do with some observable features, namely an apparent structure, perhaps a long, narrow wall that seems to divide this area but has not been defined yet. It roughly leads to the point where the 1980s excavation had taken place.

This first attempt to map archaeological structures used the electromagnetic method of ground-penetrating radar (GPR) and some of the detected anomalies were purportedly consistent with man-made structures. In short, both surveys came up with approximations for the position of said anomalies (Phiri & Carvalho, 2013) that were confirmed in archaeological terms. In addition, an electrical resistivity test was carried out, together with a geochemical analysis of the soils (Café 2014, Silva & Almeida, 2015), providing contradictory elements about the idea of widely scattered but anthropic alignments, whilst confirming two separate geological realities, perhaps not strictly connectable with actual settlement strategies. In order to obtain a chemical characterization of the soil, 50 samples were taken, using a manual auger to the depth of 60cm, and were later processed by Acme Analytical Laboratories (Canada). Up to 46 chemical elements were identified and their main combinations established through Principal

Component Analysis (PCA). Two of the six associations are representative of the site's geological context (Fe, Mn, Mg, Cr, Ti, Co, Sc, V, P, Ni, Y, Ca, Li, Na, Nb, La (positive), for axis 1; Sr, Th, Na, Ce, La, Ba, Ca, Rb, K, Y (negative) for axis 2, meaning the former geochemical signature is related with granite, and the latter with shale. The other four axes seem related to different types of mineralization, according to the quartz veins. One cannot exclude an anthropic origin for at least some of these signatures, however until now the archaeological results seem far more promising in the area where axis 1 is overriding. After several years of consecutive fieldwork at UL, a realistic working hypothesis is that this upper area was never heavily occupied by buildings, which in fact confirms an older perspective on its communal nature (Marques 1986).

### 3. SURVEY AND FIELDWORK

#### 3.1. 2013 Survey

Regarding the first GPR survey, an exploratory phase consisted in the acquisition of four single profiles: two 40m long parallel profiles along the main path passing through and around the site, crossed by a perpendicular 88m profile on another nearby major path, and a fourth profile was acquired passing through a previously excavated area where buried remains were discovered. Subsequently, a second phase of data acquisition took place, using the topographic mapping of the entire site, and its division into a grid of 10m<sup>2</sup> rectangular sections.

The survey covered eleven squares, as shown on the grid (Fig. 4). Their selection depended on several factors, particularly the ability to physically use the GPR equipment. However, as much as possible, interconnected squares were preferred so that anomalies identified as potentially archaeological remains could easily be recorded and linked to each other. Some of the remaining areas were left for consideration in possible future phases of the project.

Within each square, a 60cm spacing between profiles was used, equal to the distance between the wheels of the survey cart. The generic procedure involved collecting the radargrams in the South-North direction, and in some squares the data was also acquired in the East-West or West-East directions. Around 17 parallel profiles per square were obtained in most of them. In each case, possible causes of noise, such as close-by trees, roots, or outcrops, were identified automatically in the collected radargrams. GPR equipment (Fig. 5) comprised a TerraSIRch SIR System-3000 by Geophysical Survey Systems, Inc. (GSSI) mounted on a cart with encoder and 270 MHz (the most

widely used for this survey) and 900 MHz center frequency shielded antennas.

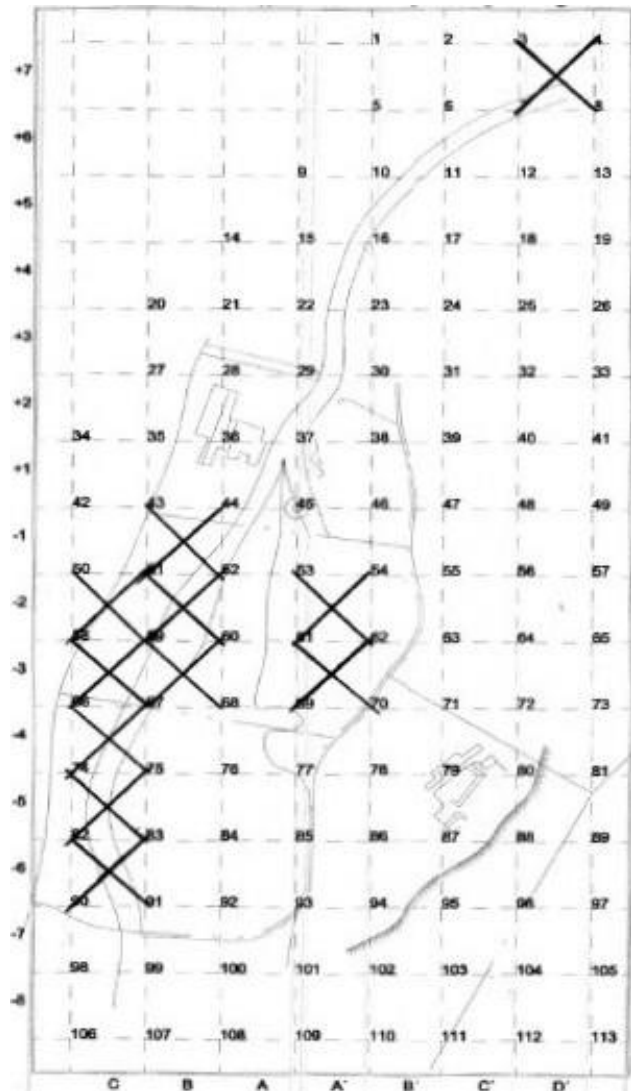


Figure 4. Grid used for the 2005 survey



Figure 5: 2013 GPR data acquisition

Acquired data was initially visualized and processed using the GSSI software RADAN, and in a later phase with ReflexW by Sandmeier G. R software. Different processing procedures were

applied to the raw radargrams, namely time zero setting, background removal, bandpass filtering and migration. Figure 6 shows two radargrams, the first one without processing and below the same with time zero setting, background removal, Kirchoff migration and colour transform added.

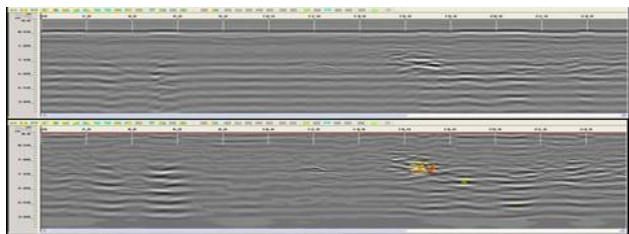


Figure 6. Two 270 MHz antenna radargrams without (top) and with processing (bottom)

Several anomalies potentially related with buried archaeological remains were detected along the single profiles as well as within the surveyed squares. Due to the presence of an irregular and often shallow bedrock, the interpretation of near-surface anomalies becomes on occasion ambiguous. The parallel profiles within squares allowed the building of 3D GPR data blocks by assembling the corresponding 2D radargram sections. Fig. 7 shows two vertical sections of the same processed 3D block, in which anomalies potentially related to archaeological targets were detected, namely on the right side of the first image and on the left side of the second one, as well as the top soil and uneven rock/bedrock interface.

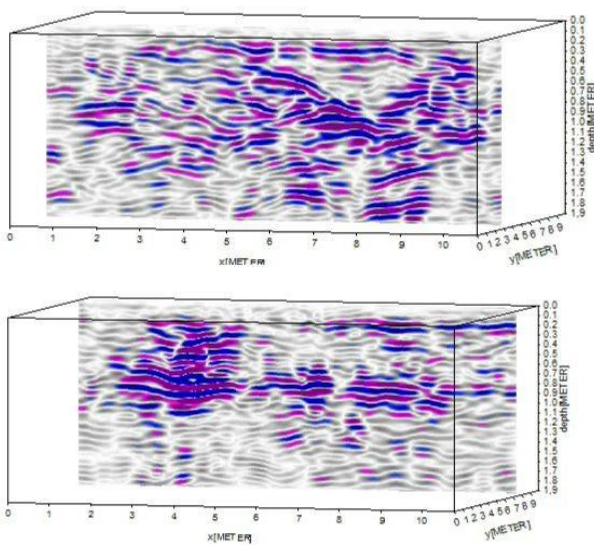


Figure 7: two vertical slices of the 3D block related to square -3A' with radargrams along S-N direction

### 3.2. 2015 Survey

In 2015, a horizontal section on the western slope was chosen for a new electromagnetic and GPR survey, in order to assess whether the area might be sig-

nificant in terms of articulation with identified structures to the South, and especially with a stone wall that may correspond to one of the presumed ramparts referred to by the earlier sources. During fieldwork, a total of about 136,780 valid measurements were taken through induced electromagnetism. The survey was carried out in an area that presented excellent quality and density of information.

One of the options was an adjustment of the distance between transects to one meter, in two perpendicular directions, at each one of the selected areas, and an adjustment to reach a depth of three meters. This fitted the purpose of targeting all upper strata covering the bedrock. Selected frequencies were 47,075Hz (more superficial between 0,25 and 1,20 cm) and 35,775Hz (medium-range penetration representing anomalies between 1,5 and 3 m) simultaneously on both records, electrical and magnetic.



Figure 8: 2015 GPR data acquisition

Analysis and data transformation was processed through GEM-2; Win GEMv3 software, and for graphic representation Surfer 9.0 and Matlab 6.5 were used. Selective decisions were made regarding the elimination of value categories, contrast enhancing, and the application of filters and colour scales. Interpretation is based essentially on the study of contrasts of magnetic data at a given location, and their relationships with those of the surrounding area. Contrasts were highlighted when they follow a pattern or a representative tendency that does not appear to be of natural or geological origin. The parameter used is that of electrical conductivity, for it provides a higher clarity of representation and, as a consequence, better information of magnetic susceptibility (López Jiménez 2016).

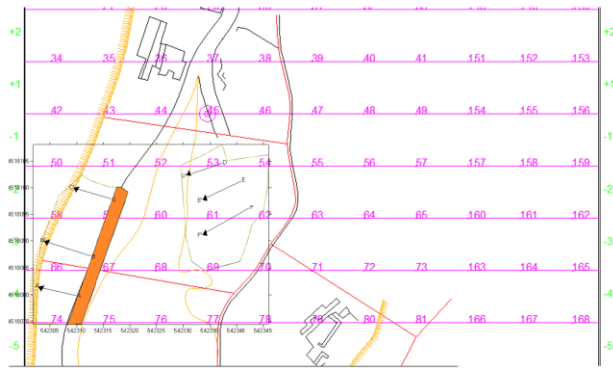


Figure 9: Survey area: electromagnetic (orange) and radar (arrows) detection

The number of generated representations and graphics is quite high, so only the most representative ones are presented below (Fig. 13). The representation of final results includes the corresponding itinerary followed during data acquisition and is identified in UTM, datum WGS84\* coordinates. The maps obtained through Surfer9.0 also represent the same UTM system. As for GPR, equipment used was composed of a Zond-12e by Radar Systems, Inc. central data acquisition device, with a double channel and a 500MHz center frequency antenna, both emitting and receiving with encoder.

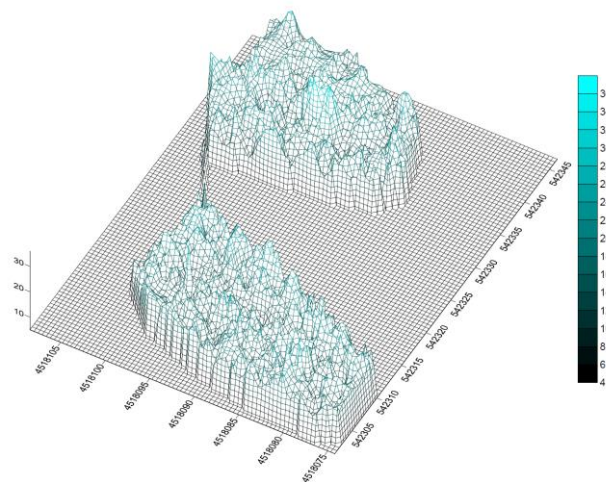


Figure 10. 3D map of the recorded conductivities in areas A and B

Results obtained in area A showed anomalies interpreted as indicators of potential archaeological evidence of different geometries, and of suggestive negative structures. Changes in the subsoil are well differentiated between area A and B; the former presented longitudinal features, along a SW-NE axis, and some perpendicular occurrences as well. In addition, some few other possible structural areas with archaeological potential were mapped, based on their low conductivity, and on the other hand also certain realities interpreted as fillings due to their higher conductivity. The representation of a less de-

finer signal within these fillings showed evidence of some regularity, at that point taken as presumably that of a collapsed building. Single signs of high conductivity could indicate further interesting areas: pits, fillings, or spaces altered by heating. Data obtained by radar confirmed the existence of areas of strong structural accumulation, which at certain points start at a depth of about 25cm, and showed consistency again between 75cm and 1m, sometimes reaching 2m.

On the other hand, area B revealed undefined structures, with only weak and near surface readings. Their discontinuity may indicate a scattered number of building materials, possibly destroyed by agriculture or the more recent planting of trees. Radar readings confirmed this situation until 30 or 40cm of depth. At a greater depth, between 1,25m and 1,5m, some isolated anomalies are probably geological in nature.

### 3.3. Confirmation

Excavation was based on the geophysical survey and the chemical results, in combination with the partial evidence from earlier occasional digs. An area on the western slope was chosen for a test trench that was ultimately enlarged, following GPR data and its tangentially horizontal topography. As mentioned above, previous results at U1 (Fig. 11) had already shown a very high degree of soil stirring, an outcome of ploughing and especially of tree plantation, together with quarrying during the last century. Therefore, archaeological stratigraphy remains occasionally intact only at some depth, and mainly in connection with structures.



Figure 11. Area excavated in 2014-2015

This reality was again registered in 2016, with the first stratigraphic units containing evidence of heavy disturbances, and scattered pottery and tiles related to the units attributed to the underlying structures. These consist in the toppled walls of a compartment, of which a corner and two alignments remain clearly visible; conductivity had shown a suggestive yet

undefined anomaly at this location and approximate depth.

As for the corresponding pottery record, one identifies an amplitude centred on an already Imperial environment, with some open, but above all closed shapes. The presence of faience, whose stratigraphic value is insignificant, indicates a merely residual modern activity on this platform that does not show coherence in its post-medieval occupations. A relevant point is the absence of clear medieval elements in the analysed set of pottery, with only one or two possible sherds. The Roman pottery associated to the excavated structures is absolutely dominant, and documents a regional production that is integrated in wider circuits, namely through imitations of red slip ware, a distinctiveness more and more recognizable in the provincial record (e.g. Morais, Fernández & Sousa 2014). Formal inspiration at UL often stems from Drag. 35-36 forms, or of later African equivalents, for instance Hayes 94. Yet the majority of red-orange productions corresponds to coarse ware, with fabrics requiring high and constant temperatures, and usual forms replicated at hundreds of Hispanic sites. One still authoritative reference for the early Imperial forms in this region is volume 5 of the Fouilles de Conimbriga (Alarcão 1975), and the Guía de la Cerámica Romana (Beltrán Lloris 1990) provides an interesting overview as well, besides the literature on specific sites in Lusitania.

In this particular case, one deals exclusively with closed shapes with flat bottom, a feature that, contrary to some common belief, is not a specifically late element (although some medieval pottery of this Atlantic region displays, in fact, a plane instead of a convex bottom; see De Man & Tente 2014). The rims in this lot are predominantly rounded, thickened or not, and the general S-shaped profiles are well observable in the more complete vessels. In short, this small selection is very fragmented, but together with plenty of Roman tiles, documents well the Imperial nature of the structure.



Figure 12. Excavation of a collapsed structure in 2016

#### 4. DISCUSSION & CONCLUSION

Two main conclusions may be drawn, based on the survey results. First, both the western and eastern slope were occupied during large – if not all – stages of the Imperial period. Initial data from the upper plateau, where no structures were found, had put such broad coherence into question, and the latest results seem to have overcome this uncertainty. On the other hand, the alleged multiple earthworks surrounding the hill are still not positively defined; survey took place on horizontal areas where Roman domestic buildings were found, partly adjacent to a long and thick stone wall that becomes visible amidst the vegetation. Its exact chronology remains however unclear.

In spite of some local pottery that would fit immediately pre-Roman productions, the lack of consistent Iron Age levels at UL is meaningful, although future excavations may alter this finding, which is based on the current state of the ongoing work. Considering the Cantabrian Wars and the administrative reforms that followed, with proven impact on settlement (Carvalho, 2008), one needs to point out the fact that a large part of the *castro* settlement might actually be Roman in origin. A large number of Imperial *castra* and *castella* do lack clear late Iron Age precedents, and even the latter are to be understood in a communal sense, not a merely topological one, as is visible, for instance, in the Bierzo Edict (Pereira-Manaut 2005). A similar process would occur in this same territory at a later stage of the Roman period (De Man 2014). Hence the need for reassessing the concept of continuity itself, which would entail a relatively strict maintenance of the same technology and interconnections, which is not the case.

This leads to the concept of social space related to *castros*, which is central to an already longstanding discussion (Parcero Oubiña 1993, Rodríguez López et al. 1993) and acculturation is certainly part of how individual sites developed, but regional studies for Gallaecia and Northern Lusitania prove or strongly suggest a multiplicity of functional and even symbolic connexions inside and between often close-by hilltop sites (Pereira Garcia & Hidalgo Cuñarro 1999, Silva 2007, Villa Valdés 2009, González Álvarez 2011, Alonso Burgos 2015). In this sense, geography becomes a determining factor in the configuration and development of *castra*, as some seem predominantly based on agriculture, whereas others are directly or indirectly connected with mining activity and security (Grande Rodríguez 2008, Pérez-Rama et al. 2015). In the end, UL is an example of a comparatively small hilltop that found significance in specific periods, its acme remaining connected to early Imperial commerce directly linked to road activity.

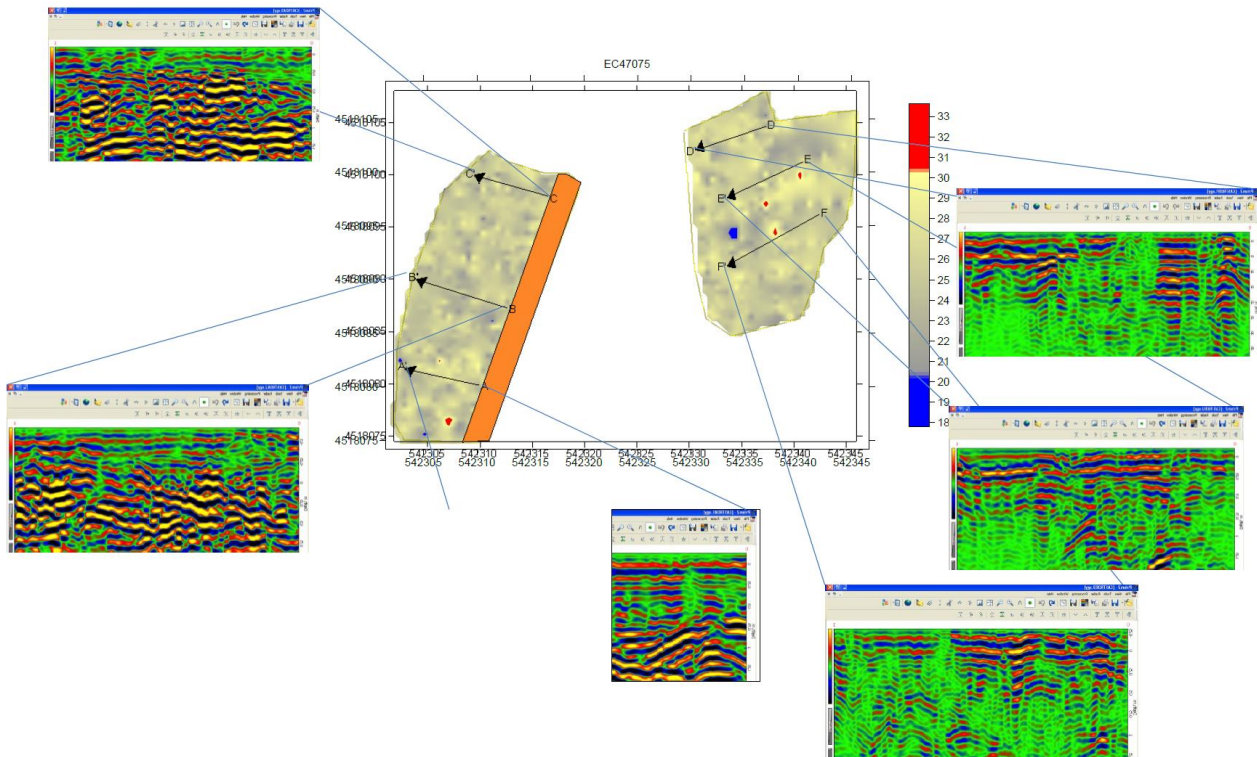


Figure 13. Distribution of the radar sections on the electromagnetic readings

## ACKNOWLEDGEMENTS

The authors would like to thank the municipality of Oliveira de Azeméis for its continuous support, and Oscar López Jiménez at GIPSIA, Spain, for his 2016 technical report on the survey results.

## REFERENCES

- Alarcão, J. (1975) Fouilles de Conimbriga V, *La céramique commune locale et régionale* Paris, De Boccard.
- Alarcão, J. (1992) A Evolução da Cultura Castreja, *Conimbriga* 31, pp. 39-71.
- Alarcão, J. (1996) O primeiro milénio a.C. In *De Ulisses a Viriato. O primeiro milénio a.C.*, Lisboa, Museu Nacional de Arqueologia, pp. 15-29.
- Alcalde López, J. (2015) Continuidad de asentamiento entre la Cultura Castreña y el mundo romano en Galicia *Arqueología y Territorio* 15, 89-104.
- Alonso Burgos, F. A. (2015) *Estructura social y paisaje simbólico: las comunidades astures y el Imperio Romano (siglos II a.C.-II d.C.)* Madrid, Universidad Complutense.
- Arias Vilas, F. and Villa Valdés, A. (2005) El poblamiento romano en el territorio de los Galaicos Lucenses, In *Unidad y diversidad en el Arco Atlántico en época romana* Oxford, BAR International Series 1371, pp. 297-308.
- Beltrán Lloris, M. (1990) *Guía de la Cerámica Romana* Zaragoza, Pórtico.
- Branco, M. J. (1991) *Aveiro Medieval* Câmara Municipal, Aveiro.
- Brito-Schimmel, P. and Carreras, C. (2005) Aplicación de Métodos Geofísicos en Arqueología: una recopilación sobre el actual estado de la cuestión en España, *Scientific Heritage* 1, pp. 1-20.
- Café, L. (2014). Desenvolvimento de um sistema de aquisição de resistividade eléctrica: análise conjunta entre geofísica-geoquímica no Castro de Ul. Aveiro: Universidade.
- Carvalho, H. (2008) *O povoamento romano na fachada ocidental do Conventus Bracaraensis* Braga, Universidade do Minho.
- Corsi, C., Klein, M and Weinlinger, G. (2012) The Roman town of Ammaia (Portugal): From total survey to 3D reconstruction, in: Börner, W., Uhlirz, S. & Dollhofer, L. (eds.), *Proceedings of the 16th International Conference on Cultural Heritage and New Technologies*, Vienna, pp. 59-73.



- De Man, A. (2014) Definindo a Lusitânia tardo-antiga: alguns aspectos regionais de defesa e controlo (s. V-VI), *Las Fortificaciones en la tardoantigüedad: Élités y articulación del territorio entre los siglos V-VIII d.C.* Madrid, Ediciones de la Ergastula, pp.13-20.
- De Man, A. and Tavares, J. T. (2014) The Roman Hilltop Site of Ul VIII *Encontro de Arqueologia do Sudoeste Peninsular*, Serpa/Aroche, pp. 5-8.
- De Man, A. and Tente, C., ed. (2014) *Estudos de Cerâmica Medieval, O Norte e o Centro de Portugal, séculos IX a XII* Lisboa, Instituto de Estudos Medievais.
- Eiroa, J. J. (1988) La Cultura Castreña del Noroeste de la Península Ibérica 15 años después, *Annales de Prehistoria y Arqueología* 4, pp. 111-123.
- Fábregas Valcarce, R. and Carballo Arceo, L. X. (1991) Dataciones de Carbono-14 para castros del Noroeste peninsular, *Archivo Español de Arqueología* 64, pp. 244-264.
- Fernández Ochoa, C.; Morillo Cerdán, A. (2015) La Romanización Atlántica: Modelo o Modelos de Impalntación Romana en el Noroeste Peninsular, *Portvgalia* 36, pp. 183-197.
- Gonçalves, L. M. B. (2013) *Estudo geoarqueológico com Georadar. Aplicação aos contextos arqueológicos da Pré-História recente à Proto-História do NW de Portugal*, Universidade do Minho: Braga.
- González Álvarez, D. (2011) De la cultura castreña al mosaico castreño: una aproximación en términos sociales a la variabilidad de las formas de poblamiento de las comunidades castreñas del Noroeste peninsular y orla cantábrica, *Estrat Crític* 5(1), pp. 213-226.
- González Ruibal, A. (2005) El castro de Saceda y la jerarquización territorial de la Segunda Edad del Hierro en el Noroeste Ibérico, *Zephyrus* 58, pp. 267-284.
- Grande Rodríguez, M. (2008) Los castros de la Gallaecia interior: arqueología, poblamiento y sociedad, *Heraikleion* 1, pp. 85-119.
- Guerra, A. (2007) Sobre o território e a sede dos Lancienses (Oppodani e Transcudani) e outras questões conexas, *Conimbriga* 46, pp. 161-206.
- López Jiménez, O. (2016) Trabalhos de deteção electromagnética e de radar GPR no sítio arqueológico do Castro de Ul, freguesia de Ul, concelho de Oliveira de Azeméis, EON, Viseu.
- Mantas, V. G. (2012) As Vias Romanas da Lusitânia, *Studia Lusitana* 7, Mérida. Museo Mancional de Arte Romano.
- Morais, R., Fernández, A. and Sousa, M. J. (2014) As produções cerâmicas de imitação na Hispania, *Monografías Ex Officina Hispana* II, Madrid, SECAH.
- Parcero Oubiña, C. (1993) Aproximación al espacio social en el mundo castreño, *XXII Congreso Nacional de Arqueología*, Vigo, 1993.
- Peña, J. A. (2011) Estudios geofísicos en yacimientos arqueológicos andaluces. Periodo 1985-2010, *I Congreso de Prehistoria de Andalucía: la tutela del patrimonio prehistórico*, Sevilla: Junta de Andalucía, Consejería de Cultura, pp. 131-138.
- Pereira Garcia, E. and Hidalgo Cuñarro, J. M. (1999) *Dos modelos de habitat castreño en el Val do Frago: Castro de Vigo e Isla de Toralla*, Guimarães, Casa de Sarmiento.
- Phiri, T. and Carvalho, J. (2013) *Application of Ground Penetrating Radar as a Geophysical Method of Site Investigation. Case of Castro de Ul Archaeological Site*, Porto: Faculdade de Engenharia da Universidade do Porto.
- Pinho, J. (2009) *O 1º milénio e o estabelecimento roral romano na vertente fluvial do Ave. Dinâmicas de estabelecimento sob o ponto de vista geo-espacial*, Lisboa, Universidade de Lisboa.
- Rodríguez López, C. M., Fernández Rodríguez, C. and Ramil Rego, P. (1993) El aprovechamiento del medio natural en la cultura castreña del Noroeste Peninsular. 1º Congreso de Arqueologia Peninsular, vol. I, *Trabalhos de Arqueologia e Etnologia* 1-2, Porto.
- Santos Yanguas, N (2006-7) Los recintos fortificados como marco de desarrollo de la cultura castreña en el norte de la Península Ibérica, Espacio, Tiempo y Forma, Serie II, *Historia Antigua*, 9-20, pp. 437-467.
- Silva, A. C. F. (1995) Portuguese Castros: The Evolution of the Habitat and the Proto-Urbanization Process, *Proceedings of the British Academy* 86, pp. 263-289.
- Silva, A. C. F. (2007) A evolução do sistema defensivo castrejo do Noroeste Peninsular, In *Paisajes Fortificados de la Edad del Hierro: Las murallas protohistóricas de la Meseta y la vertiente atlántica en su contexto europeo* Madrid, Casa de Velázquez, pp. 99-112.
- Silva, A. M. and Ribeiro, M. (2013) Castelos roqueiros da região de Arouca (Aveiro, Portugal) - contexto histórico e elementos arqueológicos, In *Fortificações e Território na Península Ibérica e no Magreb (Séculos VI a XVI)* Lisboa: Colibri, pp. 29-42.

- Silva, A. M., Pereira, G., Tavares, J. and Lemos, P (2011) *PROBA, Protohistória da Bacia do Antuã, Project de Investigação Arqueológica Arouca*, Centro de Arqueologia de Arouca.
- Silva, A.C. F. (1986) *A Cultura Castreja do Noroeste de Portugal*, Paços de Ferreira, Câmara Municipal / Museu Arqueológico da Citânia de Sanfins.
- Silva, E.; Almeida, F. (2015). Relatório Técnico conclusivo da intervenção da Universidade de Aveiro no Castro de Ul – Memorandum dos trabalhos realizados no Castro de Ul. Aveiro: Universidade.
- Silva, F. (2012) *Estação Arqueológica do Cabeço do Vouga. Sítio da Mina. Guia da estação e do visitante* Águeda, Câmara Municipal.
- Verdonck, L., Taelman, D., Vermeulen, F. and Docter, R. (2015) The impact of spatial sampling and migration on the interpretation of complex archaeological ground-penetrating radar data, *Archaeological Prospection* 22(2), pp. 91-103.
- Vermeulen, F., Corsi, C. and De Dapper, M. (2012) Surveying the Townscape of Roman Ammaia in Portugal: An Integrated Geoarchaeological Investigation of the Forum Area, *Geoarchaeology* 27(2), pp. 123-139.
- Villa Valdés, A. (2009) ¿De aldea fortificada a Caput Civitatis? Tradición y ruptura en una Comunidad Castreña del siglo I D.C.: el Poblado de Chao Samartín (Grandas de Salime, Asturias), *CuPAUAM* 35, pp. 7-26.