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Counting the finds, measuring the properties of soil: Archaeological diagnostics in the *suburbium* of a Roman town.

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***Abstract* – Ammaia is a deserted Roman town located in the region of Alto Alentejo, in Portugal, included in ancient province of Lusitania.**

In recent years, a series of geophysical surveys have been carried out in the framework of the European Community (EC) funded project Radio-Past, in the supposed intra-mural surface and suburbia. A 'total coverage' magnetometer survey was achieved by several teams, using different instruments in an around the ancient town. The selected sectors have been investigated with high-resolution Ground Penetrating Radar (GPR) and earth resistance methods, revealing a highly detailed layout of the town with its most important monuments and infrastructures and disclosing crucial aspects of the surrounding humanized landscape of Roman times.

These data have been integrated with different other non-destructive geo-archaeological methodologies.

Here the interpretation of geomagnetic survey, aerial photography and surface artefact collection are discussed with respect to the main results and to certain data-integration strategies.

I. INTRODUCTION

In the framework of the European Community (EC) funded project Radio-Past, a series of geophysical surveys have been recently carried out on the supposed intra-mural surface and suburbia of the deserted Roman town of Ammaia (Alto Alentejo, Portugal). The site of Ammaia, a mid-size inland town of Lusitania, probably founded in Augustan times, can be described as a 'green-field' site, as the urban centre was definitely abandoned in Early Middle Ages and almost no modern buildings occupy the terrain today. The former town area is now almost completely inserted in the extensively cultivated Archaeological Park of the Cidade Romana de Ammaia, and its proposed site is only disturbed by an Eighteenth c. farmhouse (now museum) and by a provincial road cutting it in two (Fig. 1).

A 'total coverage' magnetometer survey was achieved by several teams, using different instruments in an around the ancient town. The selected sectors have been investigated with high-resolution Ground Penetrating Radar (GPR) and earth resistance methods, revealing a highly detailed layout of the town with its most important monuments and infrastructures and disclosing crucial aspects of the surrounding humanised landscape of Roman times. In particular, earth resistance and magnetometry were deployed to capture and describe urban elements on a large scale, and magnetic susceptibility methods to model the physical characteristics of certain features.

Ground-penetrating radar was used to explore the volumetric aspects of buried features and to detect structures under the modern road deck. A set of quantitative methodologies for comparing and collating various kinds of geophysical survey data illuminate the nature of anomalies for the purpose of archaeological interpretation.

Furthermore, a series of other survey activities and ground truthing, such as augering, fine topographic measurements with DGPS, artefact surveys, shovel pits and small scale excavation, combined with a total revision of former research and old excavations, concurred to the correct interpretation of the geophysical results. The GIS-based data integration, together with comparative research, allowed a 3D reconstruction of the extensive townscape, incorporating also the information acquired during earlier excavation activities and on-going material studies.

II. MEASURING THE PROPERTIES OF SOIL

A. Strategies and methodologies

Starting in 2001, the geo-archaeological research carried out in Ammaia by an international multi-disciplinary team [1], brought to the definition of the hypothetical wall-circuit, that would have delimited a total surface of almost 20 ha, only 16 of which would have been settled, the hillslope included in the fortified perimeter only for strategic reasons.

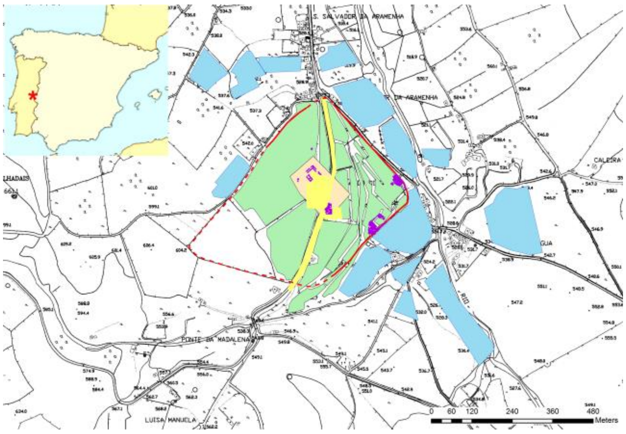

Fig. 1. Ammaia: Area investigated with georadar (yellow, 2008-2010: L. Verdonck), with magneotmetry survey (grey, 2009: University of Southampton and J. Verhaegge) and with magnetometry (green, 2010-2011: P. Johnson; blue: Eastern Atlas) on the base of the estimated intramural surface (elaboration: C. Corsi).

Contrary to the intramural survey, the geo-magnetic survey carried out by the team of the German company Eastern Atlas aimed at a general definition of the suburban landscape of the Roman town, of the density of the occupation, of the identification of the roads exiting the gates (Fig. 2).

Taking into account the uneven geological asset, a specific setting of the parameters to measure the magnetic properties of both the archaeological features and the natural underground has been necessary, since different amplitude levels were expected as manifestations of archaeological structures. Moreover, the choice of the array of the probes and their setting was based on the peculiar topographical conditions, on the soil characteristics and on the need of investigating large areas in a reasonable time [2].

Six Foerster fluxgate gradiometers have been mounted on a three-wheeled and hand-driven cart. The good accuracy of 0.1 nT was guaranteed by the application of the high-resolving digitizer LEA D2, specially designed for archaeological prospection. The gradiometer cart was additionally equipped with a GPS receiver novAtel SMART-V1G. Combining both with the distance data recorded by a survey wheel on all measured profiles and the coordinates of fixed points at the edges of the area, a positioning accuracy of 0.2m was attained.

The technical details concerning the investigation are specified in Table 1. The greyscale images in GeoTiff file formate are presented in dynamic scales of ±10 nT, ±20 nT, ±30 nT, ±50 nT and ±100 nT. These images are available in UTM29 WGS84 and ETRS89 / Portugal TM06 projections. Magnetic data were processed using the open source GIS system QuantumGIS (www.qgis.org); magnetic anomalies were delineated with polygons and classified in positive, negative and dipole-like (bipolar) ones.

In a second step, these anomalies were further divided on the basis of their amplitudes (more or less 20 nT). After screening out all the anomalies of geological origin and other disturbances of different nature, the anomalies attributed to archaeological origin were classified by their dimension, magnetic value and shape, resulting in six categories (walls, roads, ditches, pits, pavements and fireplaces).

B. Results

Of the total of 12 areas (divided in 18 sub-areas A to V) in which the survey was carried out (see Fig. 2), we will discuss here only the sub-area G, located NE of the Ammaia museum (Fig. 3). It covers an area of approximately 1 ha, that at the time of the survey was ploughed and harrowed. Nearly the entire site is dominated by linear negative anomalies that indicate the sub-surface presence of building and road structures. The orientation of the anomalies is approximately parallel in relation to the supposed north-eastern city wall and the structures uncovered in the surroundings of the museum. In the northern part an 8 to 9 m wide road or path runs from the city towards the river Sever. In the central part of the extensive building complex, which links the intramural area and the river Sever it has been possible to delineate the plan of several compartments, in some cases identifying paved floors. Indeed, the magnetic anomalies attributed to the presence of buried walls and the associated structures like pavements, pathways and pits indicate a comparatively favourable conservation status.

As we will see soon, GIS processing of different datasets brought to formulate the hypothesis that at least in two sectors of this Area G artisanal activities, implying the use of furnaces and the production of magnetised ores, took place. This assumption seems very reasonable, considering the proximity of the road exiting the town and the presence of the river. The latter could lead to interpret the more 'basic' pseudo- rectangular structures as fences for vegetable and fruit gardens.

The peculiar condition of the terrain, that is among the very few areas where agricultural activities are permitted, and the availability of detailed information coming from excavations in the area of the newly built

Fig. 2. Ammaia. Location of the extramural geophysical survey areas. © Eastern Atlas GmbH.

parking of the museum [3] allowed the integrated processing with data captured by means of other methodologies of investigation like coring and artefact collection surveys, enhancing our understanding of the functioning of the city, particularly regarding the interrelation of city and river.

III. COUNTING THE FINDS

A. *Strategies and methodologies*

Since the surface record results of long term daily practices, such as cleaning, dumping and abandonment, a long history of occupation, that implies re-building and re-functioning, changes of function and processes of abandonment and post-depositional disturbance, it is impossible to argue for a direct relationship between the finds collected on the surface, eventually in gridded plots, and sub-surface archaeological structures.

For this reason, contrary to conventional archaeological practice, quantitative methods have not been applied simply to count quantities but rather to assess the composition of the surface record. The aim of these methods is to measure relative frequencies of material categories and patterns of their absence and presence within the samples. To reach this goal, the samples have been compared between themselves using multivariate statistical methods, such as clustering and factorial analysis. In this way, artefact survey has not been targeted at raw counts of material but rather at detecting complex patterns in the surface distribution.

After designing a grid of 10x10 m, orientated like the one used for geophysical survey in the intramural area, several surface material collections were performed under the coordination of the researchers of the project, Dimitrj Mlekuz and David Taelman, whereas all collected material was washed, classified and quantified under the supervision of pottery specialist José Carlos Quaresma.

Table 1. Technical specifications of the extramural magnetic survey. © Eastern Atlas GmbH.

Method	Geomagnetic prospection
System	LEA MAX
Sensors	*6x Förster Fluxgate Gradiometer FEREX CON400*
Vertical sensor separation	0.4 m
Sensor height over ground	0.4 m
Horizontal probe separation	0.5 m
Measuring point distance	ca. 0.05 m
Data logger	Digitiser LEA D2 (10 channels), (manufactured by eastern atlas)
Measured variable	Vertical gradient in nT
Configuration	6 sensors, mounted on cart (manufactured by eastern atlas)
Investigated area	ca. 12 ha
Processing tool	Decoding program including offset and drift correction
Distance measurement	Odometer (survey wheel), GPS NovAtel SMART-V1G
Data format	ASCII, GeoTiff UTM29/WGS84, GeoTiff ETRS89/Portugal TM06
Image resolution	0.25 m x 0.25 m

All collected finds (a total of 4111 pieces, for most part related to building material) have been studied from the quantitative point of view, measuring first the number of finds per unit of collection, assessing the spatial distribution.

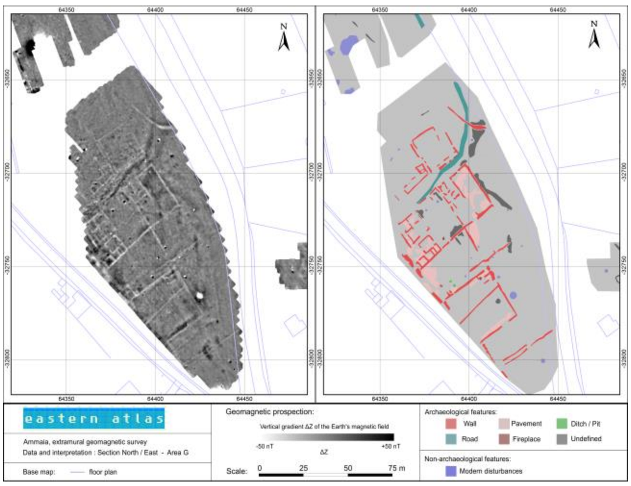

Fig. 3. Ammaia, section east, Area G. Geomagnetic survey data and archaeological interpretation. © Eastern Atlas GmbH.

In a second attempt, samples have been compared on the basis of their diversity. 'Diversity, as used here, is a measure of variability in the composition of an assemblage. It is composed of two factors: richness and evenness. Richness refers to the number of categories of material within the assemblage; evenness describes the relative proportion of each material category in an assemblage' [4].

In order to have a measure of the species diversity, a statistical approach was used, applying the Shannon-Wiener index. The measure of the evenness was made dividing the Shannon-Wiener index by the maximum value of the observed richness, and obtaining normalized values between 0 and 1. In this way, a fully even assemblage is characterized by a value equal to 1, while to uneven assemblages corresponds values close to zero. Both richness and evenness are commonly used in landscape ecology, and are related to information content or entropy of the sample. Thus very even samples may indicate high entropy, smoothed assemblages, heavily transformed by post-depositional processes.

B. *Results*

The analysis of spatial distribution shows three discrete zones of larger samples. The first is located near the hypothesised town walls, a second large zone lies between the subsurface structures and the river and a third area extends north of the Roman road detected on magnetometer survey. This pattern is explained thanks to the integration with the data resulted from the augering, showing that the cultural layers, i.e. the layer whose soil composition or the presence of artefacts prove to belong to anthropised horizons, are less and less thick as far as we are away of the urban centre, while the depth of topsoil remains constant (Fig. 4). Thus, the large carpet of larger samples between the subsurface structures and the river could reflect the thickness of the cultural layer.

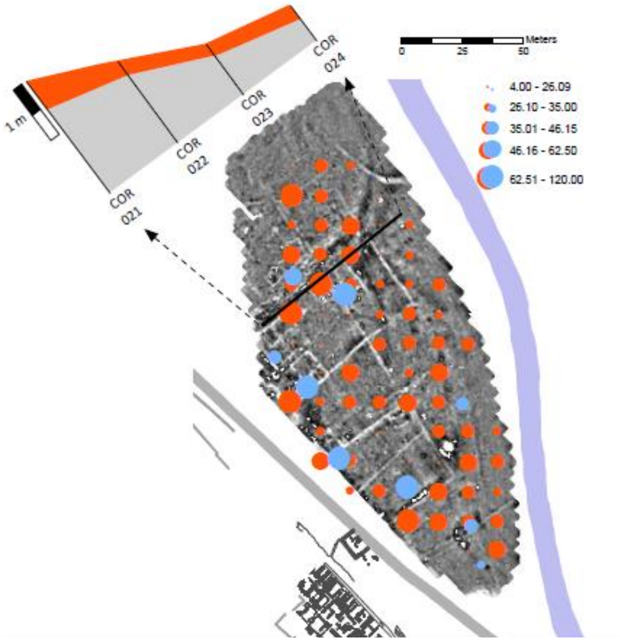

Fig. 4. Ammaia. The assemblage size with the depth of the layer with cultural material, derived from the coring survey© D. Mlekuz.

IV. CONCLUSIONS

In general, we can observe how in the area G the spatial organisation of the detected structures of assumed Roman origin corresponds well with the topographic conditions. The two production areas were located along roads leading to the NW and SW where either a convenient water supply was guaranteed or primary materials might have arrived from their sources. It is important, then, to underline the tight relationship between and the town and the river Sever.

As anticipated, these data can be interpreted also in the light of the information coming from the excavations in the Parking of the museum, carried out in the early 2000s. Unfortunately the strategy and methodology of the excavation adopted at that time did not allow establishing an accurate chronology for the structures and their frequentation, neither for the absolute nor for the relative perspective.

On the basis of the available information, however, the funerary monument excavated in front of the museum can be dated to the 1st or at the latest the 2nd century A.D., and probably this chronology can be extended to the other similar monuments detected with the geophysical survey, in other areas.

However, in the area G the main vocation seems to be productive. Thus, examining the available data for understanding the 'function' of the suburbium (Fig. 5), in Ammaia we can point at many elements of the 'economic', 'residential' and 'funerary' functions, with manufacturing, agricultural and pastoral activities documented at the same time, infrastructures and houses characterising the landscape together with the funerary monuments.

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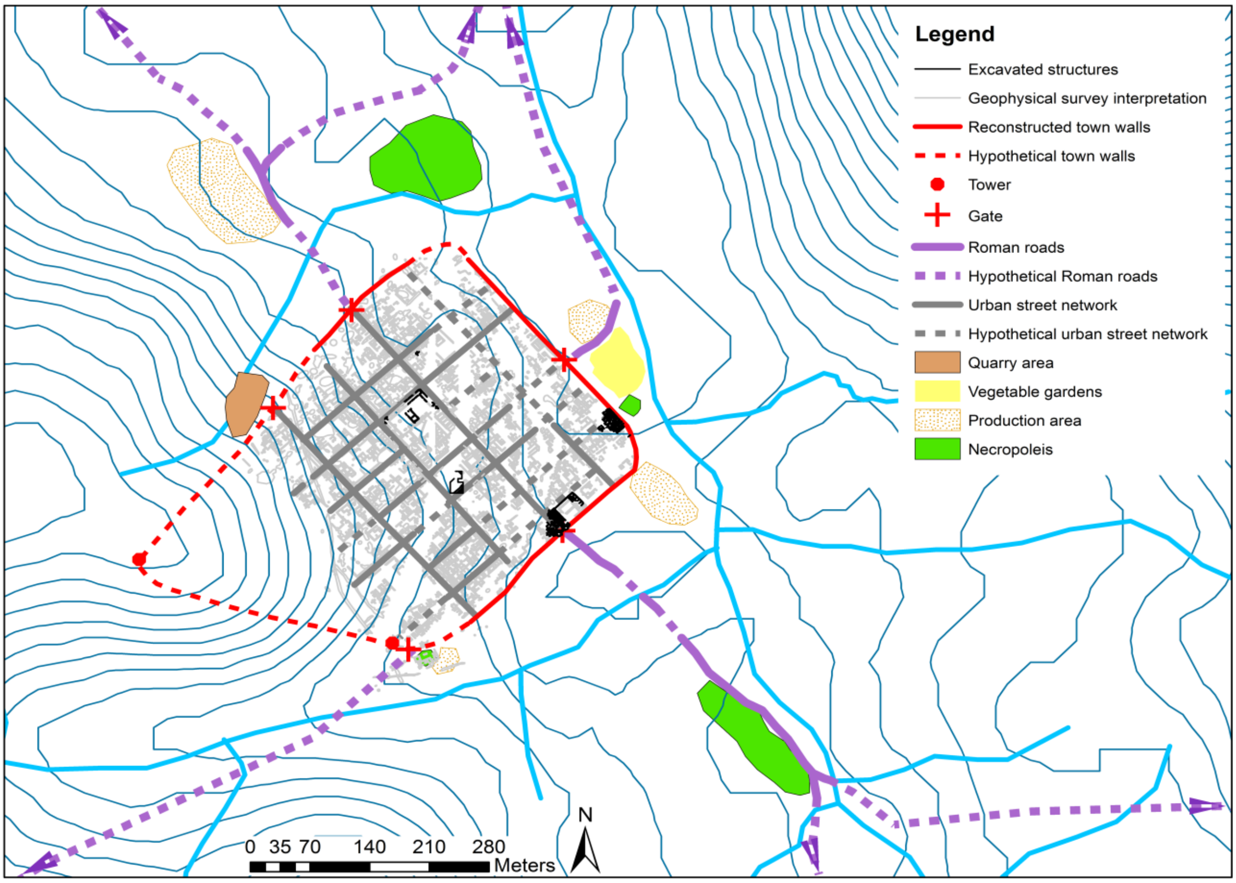

Fig. 5. São Salvador de Aramenha, Marvão (Portugal). The suburbium of Roman Ammaia as it can be reconstructed on the basis of aerial photography and geophysical survey interpretation (elaboration C. Corsi).

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