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Non destructive 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 the ancient province of Lusitania. In recent years, a series of non-destructive archaeological diagnostics have been carried out in the framework of the European Union (EU) funded project Radio-Past, in the supposed intra-mural area of the ancient town and its immediate surroundings. As part of a validation procedure of innovative integrated archaeological survey methods, 'total coverage' geophysical prospections have been performed inside the Roman town, testing integration between several non-destructive archeological methods. Each methodology is constrained by specific limits, mainly related to geomorphological and geological assets, soil matrix, environmental conditions and pollutions, producing inaccuracies in the results of the archaeological interpretation. For these reasons, the scientific community is increasingly seeking technological solutions that make use of the integration of data acquired with multiple non-destructive techniques. In this paper, we will present the results achieved thanks to the integration of some of these approaches for the investigation of a selected suburban area of *Ammaia*. The novelty of the followed approach lies in the diversification and integration of the applied methodologies, and in the complexity of the scientific questionnaire, not focused only on mapping, but rather on the understanding of the spatial phenomena. The interpretation of the magnetic surveys and surface artefact collection are discussed with respect to the main results and to data-integration strategies. The historical interpretation of these data will reveal a highly detailed plan of the layout, most important monuments and infrastructures of the town, and will disclose crucial aspects of a humanized landscape of Roman times.

1. Introduction

By the term 'archaeological diagnostics', we mean a whole array of methodologies and approaches to the survey of archaeological sites, mainly referring to those that do not imply excavations. Given that archaeological excavation entails the removal of the stratigraphic matrix in which archaeological evidence is embedded, and that this destruction is irreversible, the newest trends in archaeological research are centered around so-called 'non-destructive' or 'non-invasive' approaches.

The definition of 'archaeological diagnostics' is manifestly borrowed from the medical sciences: as in medicine, we can make a diagnosis assessing the state of the art (medical history), analyzing the phenomena and evidence visible from outside (symptomatology), applying instrumental diagnostics and finally resolving to excavation (surgery) only when and where really needed, with the least "invasive" approach possible [1].

Since the first methodological definitions of Landscape Archaeology were drafted, most of these approaches, instruments and tools of research for the investigation of ancient landscapes (e.g. geo-archaeological survey, remote-sensing, geomatics, surface artifacts collection, geophysical survey) have been available to archaeologists [2–5]. In the last twenty years, technological developments, enhancement in the different methodologies, and improvements in the accuracy of the measurements have skyrocketed the application of such approaches in archaeological research.

Whereas archaeological data collection and processing have evolved in a quite spectacular way in recent years, data interpretation has not,

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and a limited effort has been done to increase the quality of the information. For instance, geophysical prospection is generally applied for (better) locating and evaluating sites or buried structures rather than fully investigating them [6].

Each methodology proved to be constrained by specific limits, mainly related to the geomorphological and geological assets of the techniques, soil matrix, environmental conditions and pollutions. For instance, in aerial photography the elements that act as "mediator" for the presence of an archaeological feature (such as vegetation growth in respect to the depth of agricultural soil) are influenced by seasonal and climatological factors.

Archaeological geophysical survey has to deal with the quality of materials used for archaeological buildings against the geological substratum, the presence of fragmented stone such as shale at the surface, modern pipelines, power lines, field terracing and dense vegetation can produce a sort of background noise.

Taking into accounts all these constraints and limits, if applied individually, these technologies can generate inaccuracies in the archaeological interpretation. For these reasons, the scientific community is increasingly seeking technological solutions that make use of the integration of data acquired with multiple non-destructive techniques.

The possibilities offered by the integration of the different approaches for the study of complex (mainly deserted) archaeological sites and the potential of digital technologies for visualization and valorization of these sites have been explored in the framework of a European-funded project, short-named Radio-Past [7].

In the framework of this project, several fieldwork activities have been performed on the supposed intra-mural area and surroundings 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 center was definitely abandoned in the 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 hypothetical surface is only disturbed by an eighteenth-century farmhouse (now museum) and by a provincial road cutting it in two (Fig. 1).

These characteristics made of *Ammaia* the perfect ground to test a series of integrated methodologies of archaeological fieldwork.

In this paper, we will focus on the fieldwork activities carried out in the suburban area of *Ammaia*, aimed at a general definition of the suburban landscape of the Roman town at its density of the occupation, and at the identification of the roads exiting the gates of the town walls (Fig. 2) [8]. In particular, the paper is focused on the sub-area G in Fig. 2, one of the 12 areas (divided in 18 sub-areas from A to V) of the suburbium of *Ammaia* [9]. This area was chosen because its current use of the land allowed the application of a wider range of research methods, including magnetic survey, surface artifact collection, and augerings.

The specific strategy for this project has been designed to answer two manifold scientific questions. The first was methodological. Even if successful surveys have been carried out in other towns of the Roman West [10,11], there is a limited casuistry of studies aimed at investigating the town-country relationship by means of non-destructive technologies (e.g. the excellent example of Wroxeter and its hinterland in Britain [12]).

The second question was more historical: given the scarcity of total surveys of deserted Roman towns and their hinterland in the *Hispaniae* (see, e.g., the early works at Italica in Andalusia [13], and more recent and extensive research at Contributa Iulia in Extremadura [14]), we wished to collect as many data as possible on the material and functional aspects of the *Ammaia*'s suburbium, attempting the reconstruction of its landscape, at least in its heydays.

The novelty of the approach lies in the diversification and integration of the applied methodologies, and in the complexity of the scientific questionnaire, not focused only on mapping, but rather on the understanding of the spatial phenomena.

The resulting datasets are discussed with respect to the general interpretation and to data-integration strategies.

This information will be enhanced thanks to the integration with a revision of former research and old excavations.

2. Measuring the magnetic properties of soil

2.1. Principles of magnetic prospection

The whole range of geophysical survey techniques relies upon the measurements of a set of physical properties of materials, for the main part electrical and magnetic parameters. A geophysical survey of an archaeological site is performed by recording changes in these properties at thousands or millions of points, the frequency of space/time intervals among the measurements determining the space resolution of the survey.

In magnetic survey, the effectiveness of the measurement of the magnetic properties of soil for detection of anthropic activity is due to the fact that human interference with the environment has caused either a 'magnetization' of some materials or the accumulation of materials with significantly different magnetic properties [15,16]. The presence of ferromagnetic minerals and human-made magnetic substances in the sub-soil affects field intensity and direction of the Earth's magnetic field measured above the surface. The magnetometers that are carried around the site register the field intensity or amplitude of the Earth's magnetic field. These field values are visualized showing variations due to any sort of interference, natural or human-made. Many cultural processes, indeed, imply magnetization of materials by means of fire, as it happens e.g. in the process of setting a hearth or fireplace, baking bricks and pottery, working metals. Moreover, when material with a higher magnetization is moved into contexts characterized by lower magnetic field values, this can result in a concentration or depletion of magnetic materials. This is observed at fillings of formerly excavated structures like pits, wells, and ditches, i.e. what archaeologists call 'negative structures'. When a ditch is dug into subsoil with specific magnetic properties and is later filled with topsoil or other material (e.g. ashes, organic waste, debris, and so on) with different magnetization, a specific and recognizable pattern of magnetic field values is observed. Thus, the graphical depiction of the magnetic field values may reveal the location and outline of buried archaeological structures.

In particular, two types of magnetization can be observed during magnetic measurements: the induced and the remanent magnetization.

The induced magnetization is ascribed to the effect that the elementary magnets of a matter are enhanced by external magnetic fields (e.g. the Earth's magnetic field) and, consequently, partly align with it. The propensity for this alignment and the enhancement's strength is determined and described by the magnetic susceptibility. In soils, the highest magnetic susceptibility values are observed at ferromagnetic or ferromagnetic minerals like the iron oxides magnetite and maghemite. These minerals occur ubiquitously in the soil, forming microscopically small grains. There are several possibilities to explain their origin and concentration in soils:

1. Heating: In soils with rich organic content and in reducing conditions, iron oxides of low magnetization can be transformed into magnetite and maghemite under the influence of fire [17].
2. Microbial mediation: Microbes populating rich organic deposits can change the soil conditions sufficiently to favour the conversion of weakly magnetized iron oxides into more magnetic forms [18].
3. Magnetotactic bacteria: These bacteria are able to produce intracellular crystalline magnetite which allows them to navigate using the Earth's magnetic field. These magnetite crystals remain in the soil after the death of the bacteria [19].
4. Pedogenetic origin: The magnetic susceptibility can increase during