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THE LAST TEN YEARS OF RESEARCH AT TARQUINIA

The Centro di Ricerca Coordinata "Progetto Tarquinia" of the Università degli Studi di Milano is a League of European Research Universities (LERU) exemplary interdisciplinary research project that involves groups from the Università Statale di Milano (Archaeology, Information and Communication Technologies, Geoarchaeology, Palaeoanthropology), the Politecnico di Milano (Architecture and Topography) and bridges the gap between soft and hard sciences. This project stems from the "Progetto Tarquinia" conceived by Maria Bonghi Jovino in 1982 (Bonghi Jovino 2010).

In the past ten years our integrated system of tools and services, supported by ICTs (ArchMatrix), through which multidisciplinary domain experts can examine all the typologies of data of a given culture (Barricelli *et al.* 2015), has made it possible to concentrate on the links between data-sources focusing on the recurrence of association rates within different aspects of material evidence and of phenomena (Bagnasco Gianni *et al.* 2013).

The fields of application of our methodology in the domain of archaeology and epigraphy are multifaceted as regards the inside and outside connections of the Tarquinian heritage, whose necropolis with the famous painted tombs is a UNESCO World Heritage Site. Research includes areas of the Civita plateau: the "monumental complex", the Ara della Regina sanctuary, fortifications, and archaeological sites previously explored. In the past ten years, research in the necropolis (roughly 6,000 tombs, of which 400 are painted) and in the territory has also been implemented and has produced the complete corpus of the painted tombs of Tarquinia (Marzullo 2016, 2017).

Our holistic approach encompasses archaeological analysis of small (mobile finds), medium (archaeological contexts) and large scale (territory and landscape) architectural analysis and applications for integrated solutions for the cultural heritage. We implemented the first bilingual Virtual Museum dedicated to an Etruscan city (Bagnasco Gianni *et al.* 2007), now available on-line (www.tarchna.it), which offers a dynamic overview of the cultural heritage of Etruscan Tarquinia and the first application dedicated to the results of international groups working in the area of Etruscology (http://www.etruscologia.unimi.it/index.php/progetti/80-progetti/127-etruscanexpo-project).

1. Dealing with images of ruins, shards, epigraphic texts and markings (*sigla*)

Such multifaceted evidence involves different degrees of reliability. A first application of our procedure focuses on the recurrence of the same association

of details in pottery by means of the study of the features of every single fragment in order to reconstruct the formal and stylistic choices of the community influencing the basic models of the local pottery production conceived for the inhabited site. Such hypothetical reconstructions might be supported by archaeometry, since we can take advantage of a reliable identity card of the local Tarquinian productions in their articulations and compare the ceramic body of the shards we presume belong to the same production in order to verify our hypotheses of reconstruction (Bruni 2007).

For example, the study of Tarquinian depurated wares has demonstrated that objects from inhabited and funerary areas can be similar but not perfectly match one another, and even minor differences in details might have relevant symbolic meanings that illuminate articulated Etruscan approaches to foreign ones (Bagnasco Gianni 1999, 2007).

A second application concerns the identification of a similar recurrence of associations of objects in different stratigraphic units or in different funerary contexts, even if plundered. Recurrence of phenomena guarantees the existence of minimal sets that can be compared and contrasted to others in order to attain the next step, which is the reconstruction of the entire equipment, as happens with funerary equipment (Bagnasco Gianni 2002).

A third application concerns the assessment of the purpose of single objects or sets of objects within their original contexts in order to understand their proper role and, as a consequence, the related behaviours and actions. The results of such an application are also crucial for interpreting epigraphic evidence, often fragmentary and formed by text and markings. These markings, called *sigla*, are studied within the framework of the "International Etruscan *Sigla* Project" (IESP), a joint undertaking of the Università degli Studi di Milano and Florida State University, with the aim of investigating their potential for communication (Bagnasco Gianni, de Grummond in press). By means of a semantic network that enables the integration of different data, we expect to verify the existence of recurrent associations among similar *sigla*, between *sigla* and their location on the artifact and between *sigla* and their archaeological contexts, and foster their interpretation (http://159.149.130.120/IESP/).

A fourth application monitors recurring archaeological features among different areas of the Tarquinian sanctuaries. Given the exceptional framework of the "monumental complex", the Ara della Regina sanctuary and the emporic sanctuary of Gravisca (Bagnasco Gianni, Fiorini in press), it is possible that a number of selected structures were used as visual references. Such visible arrangements were employed to mark space over time and reflect the concepts of memory, authoritativeness and identity that are crucial for the survival of traditions for the majority of the ancient communities. Their presence also rules space and deserves attention because of potential effects

on the circulation of persons all around the different premises (Bagnasco Gianni 2005, 2012).

In other words, such an approach is based on the dialectic comparison between the purpose or function suggested by direct observation, for example of the shape of an object or monument, and of its effective pragmatic use, which can be assessed from time to time according to different series of contexts – taken separately or together, when all present – such as the archaeological, epigraphic and iconographic (Bagnasco Gianni 2008).

Therefore, concentrating on the syntax linking the separate units of the evidence we deal with, we finally identify what might help to locate actions and behaviours in the general setting of iconographic, archaeological, and topographic "sites" and their related "landscapes".

G.B.G.

2. The archaeological analysis of the ancient city and its landscapes

Research started in 1997 when Maria Bonghi Jovino approached the situation of the Civita plateau with an overview of the aerial photos and recognition of the fortifications (Bonghi Jovino 1997; Harari 1997). It subsequently involved a systematic study of the circuit of the fortifications, carried out in collaboration with the Politecnico di Milano in the framework of a national project (*Mura tarquiniesi*, PRIN 2008), aiming at the reconstruction of the city extension enclosed within the walls, by reconsidering the infrastructures, the palimpsest of the signs from a historical point of view and the relations with the settlement phases (Bagnasco Gianni 2014). All the available cartographies and aerial photos were collected and analyzed. The research continued with an extended interpretation of the signs that characterize the area of the Civita, and took into account the geomorphological and structural aspects (Bortolotto, Favino, Simonelli 2014). On that occasion it was decided to perform a laser scanner survey Light Detection And Ranging (LiDAR) of the entire territory: this technology, used here for the first time at a national level for purely archaeological purposes, made it possible to identify each geomorphological discontinuity of the plateau, bringing back the digital elevation model as a point cloud, for an area of about 90 ha (Garzulino, Perego, Zerboni 2014).

The encouraging results obtained through investigation of the fortifications (Marzullo 2014) launched a new stage of the research in cooperation with the Soprintendenza Archeologia, Belle Arti e Paesaggio per l'area metropolitana di Roma, la provincia di Viterbo e l'Etruria meridionale (Russo, Trucco 2015), which produced a new and updated archaeological heritage map of the entire settlement (Fig. 1).

The comparative study of signs related to each cartographic threshold, carried out by inserting data into a Geographic Information System, has

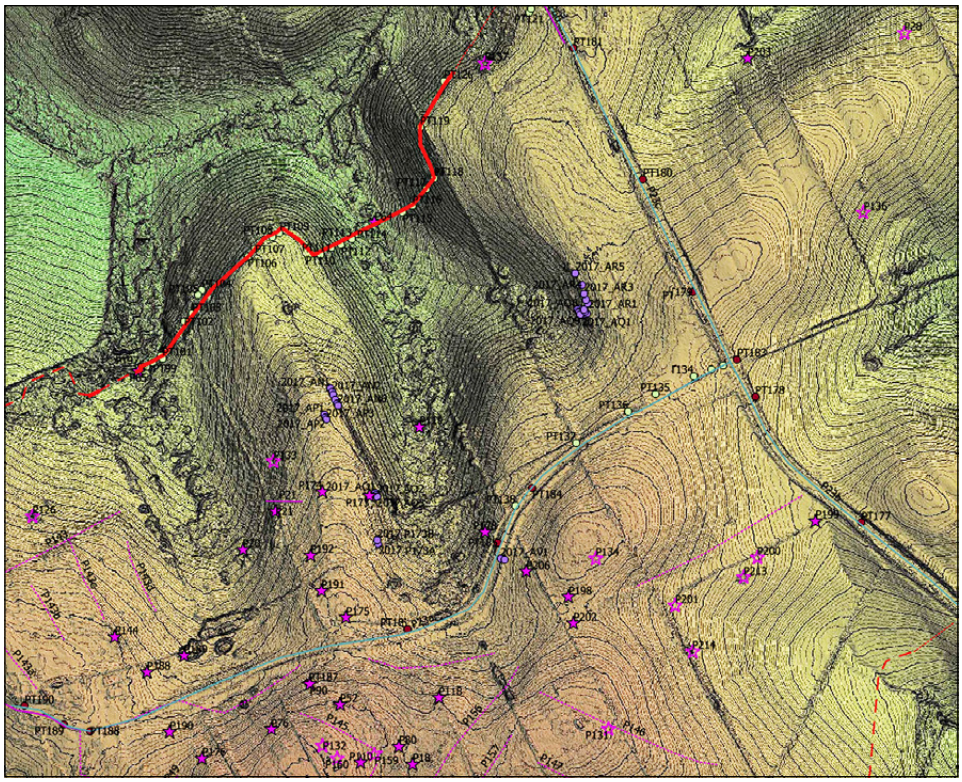

Fig. 1 – LiDAR Digital Terrain Model with the location of the elevation curves every meter and of the sites composing the archaeological heritage map of the Civita plateau.

highlighted the elements that form the palimpsest of the Civita, which can be both ancient and modern. In this regard, the systematic analysis of the historical documentation and of the thematic representations from the Renaissance to the present made it possible to understand which of these elements were ancient, while at the same time extending the basis of available information. The LiDAR data processing produced the most updated, accurate and comprehensive cartographic base of the plateau. Thanks to its versatility – to the capability to isolate the different materials that compose the surfaces, to exclude the vegetation, to measure the height and extension of the geomorphological evidence, and to observe all cartographic representation, consistently shaped according to the conformation of the territory – it was possible to georeference very precisely all the information collected.

One of the most significant results is the assessment of about 220 sites including a number of unknown or poorly known sites. Each one has been

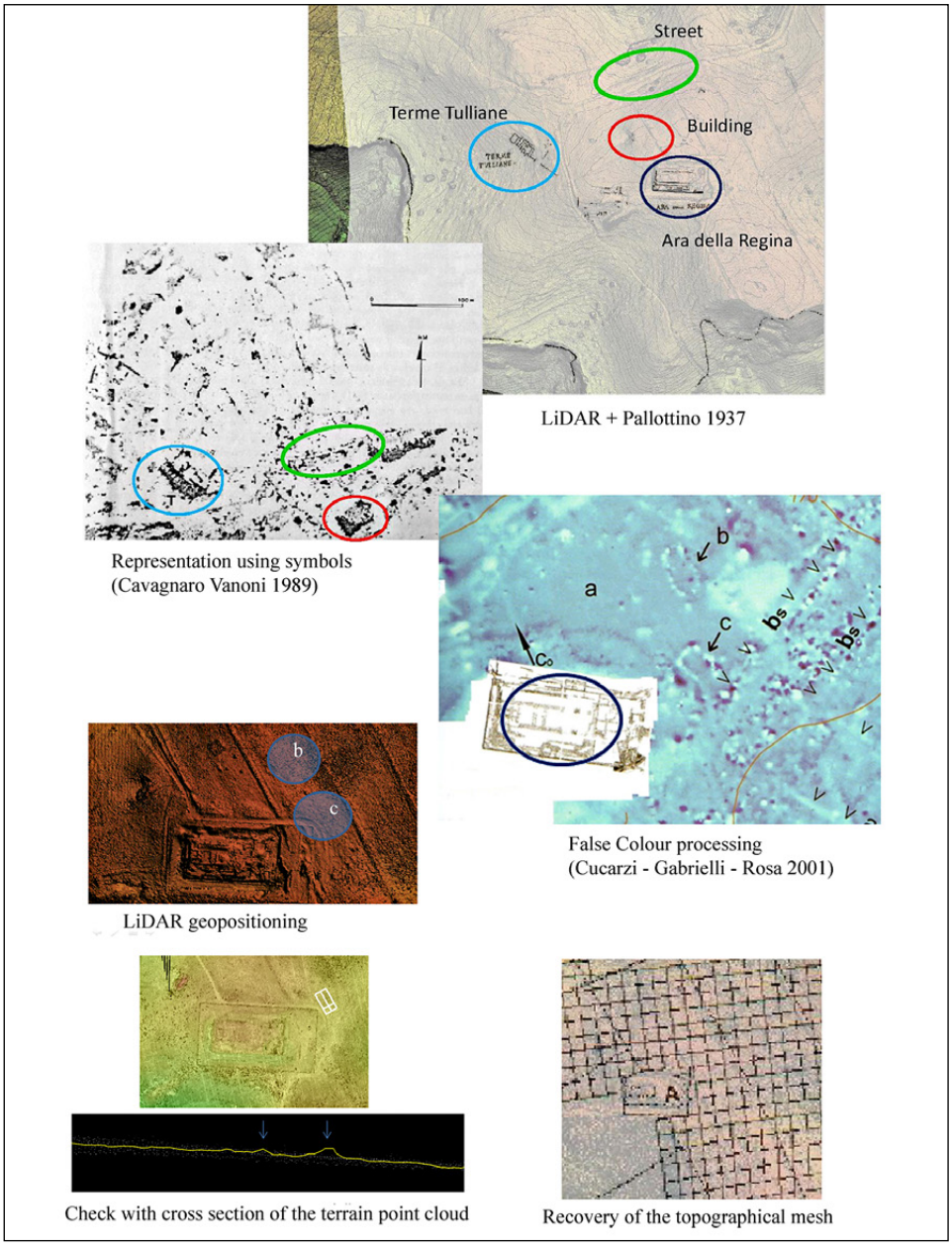

Fig. 2 – GIS comparison between signs concerning buried archaeological remains and the results of magnetometry; check of every single sign by querying the LiDAR point cloud; positioning of the mesh with the topographic cornerstones.

examined in a systematic way, and the GIS has been provided of specific links to data sheets that contain information about the location, chronology, description, graphic documentation and bibliography of each element identified.

If, on the one hand, this is a remarkable achievement itself because it had been impossible to observe so much information together in a single topographic view before, on the other hand, this is just the starting point for further researches. One of these concerns an implementation of this open system, which now makes it possible to recover a set of fundamental spatial information, resulting from the geophysical prospections carried out by the Fondazione Lerici between the 1960s and 1980s. While the Monterozzi prospections detected approximately 6,000 tombs, in the Civita the data analysis was not brought to the same level of detail: the output of the prospections were not processed in a synthesis embracing the entire data. The global analysis was focused exclusively on the subject of road networks, highlighting the anomalies hypothetically related to road alignments (Cavagnaro Vanoni 1989).

It is clear that the particular value of such achievements lies in the scope and breadth of the work, which is difficult to replicate in modern times, but also in the uniqueness of the conditions of the plateau at that time, not yet polluted by waste and metal objects. Although the reliability of such acquisitions has never been argued, the main issues that have prevented experts from the use of prospections concern the amount of data, the difficulty of interpretation, and the topographic positioning. The first two topics will be discussed in a specific contribution, whereas in the present contribution we will focus on the third. The Lerici system is set according to the magnetic N, which does not correspond to the geographic N. In addition, each square of the basic grid on the map corresponds to a predetermined linear length, and does not take into account the geomorphology of the terrain. This means that the Lerici's cornerstone mesh does not match the corresponding physical limits of the same area on any maps. We must also consider that to produce some of the larger-scale diagrams, the results of the acquisitions have been reduced and merged like a mosaic, producing distortions, which are considerable in some cases. This means that to retrieve the data, we have to properly position the topographical mesh on the ground, molding it according to the existing rugged terrain. This is hampered by the disappearance of the geographical references to the topographical marks used at those times to place the grid. Without such data, the only elements on which we can now rely are the immutable signs still readable in the territory and discernible in the Lerici output.

The GIS containing all the maps and the reliable archaeological evidence described above, combined with the precision and versatility of the output of LiDAR processing, were crucial to solving such problems. It was possible to compare signs clearly associated with buried archaeological

remains to the results of magnetometry, verify this data set by querying the LiDAR point cloud and obtain their appropriate positioning. This allowed to overcome the issue created by the disappearance of the topographic mesh cornerstones (Fig. 2).

The result we achieved is to re-anchor the geophysical prospecting outcomes to the territory and numerous terms of reliable comparison for data analysis – essential tools to tackle the reconstruction of the urban dimensions of Tarquinia.

In this context, the above mentioned integrated system of tools developed at the interdisciplinary level (ArchMatrix) provide a set of services for federating different existing data-sources (GIS, including 3D tools), through the definition of a semantic network of relationships among landscapes, stratigraphic layers, structures and artefacts. Therefore it allows to switch from territorial scale to the scale of the structures within the archaeological sites and from this to the dimensions of the findings, successfully managing related searches among all the topics identified in the GIS Archaeological Map and thereby facilitating the comparison between different series of evidence within the same town. Our project, of course, aims to reach an overview as exhaustive as possible and a specific chronological definition of archaeological evidence identified so far, in order to offer an updated diachronic interpretation of the city, the territory and its occupation.

M.M.

3. Architecture: research documentation, analysis, restitution

The research documentation activities are framed within the cognitive actions to define and understand the history of historical artifacts and their distinctive features. The analysis of several data, gradually refined and discretized, leads, in fact, to the representation of all the information considered useful for the transmission of the acquired knowledge (Bertocci, Bini 2012). Therefore, the consideration of survey and representation activity as a mechanical application of specific operations, instrumentations or software is very reductive, particularly in the case in which we have to deal with discontinuous and complex situations such as in the archaeological field.

From the point of view of architectural and virtual reconstruction concerning the Tarquinian structures (both in cities and tombs), it was decided to implement the solutions developed on an interdisciplinary basis during the last ten years (Bagnasco Gianni *et al.* 2013; Marzullo 2016).

Although the operations are shared and the instruments are clearly known by now (Bonghi Jovino, Bagnasco Gianni 2012), the large variability and wealth of the Tarquinian scenario offers a unique testing ground to fine-tune and verify new methods and strategies.

For example, the "monumental complex" shows very particular and heterogeneous geometric, morphological, material and constructive characteristics, which are very difficult to document, survey and represent simply using predefined tools and techniques.

One of the greatest strengths consists in the joint choice of the data collection methodology by architects and archaeologists, focusing on what is considered necessary to represent.

We make use of both direct survey techniques and the great variety of indirect methods (Campanella 2017) for more complex and articulate contexts, by defining the operations to be used each time and with mutual consent. In fact, the combination of topographic surveys through total station, two-dimensional photogrammetry, laser scanning and three-dimensional photogrammetry, which takes advantage of image-based modeling and structure from motion systems makes it possible to obtain all the necessary information from both the archaeological and the architectural point of view.

The case of the "monumental complex" is also particularly emblematic from the point of view of architectural analysis and reconstruction of the structures. Here, the built remains, often isolated and, at first glance, without reciprocal connections, seem similar to one another with regard to their materials and construction techniques, elements that remain substantially unchanged over the centuries. The archaeological research on the contexts has highlighted how these structures sometimes do not constitute parts of buildings, but are symbols deliberately left in memory of actions that occurred in the same place even many decades or centuries before. For this reason, it is very important that each built structure must be evaluated from a structural and architectural point of view both as a whole and in its individual elements. It was therefore decided to devise more specific investigations capable of better defining their characteristics. The purpose is the creation of a constructive set collector containing the mineralogical and petrographic analysis results, the study of the microstructure and the physical-chemical characterization of materials, the geometrical and morphological investigations, as well as the mechanical characteristics of the structures and of the single elements that compose them. The combination of this information, managed through the above mentioned ArchMatrix system, can integrate the excavation data, simplifying the phase of study, dating and archaeological interpretation. At the same time, this data-set is crucial in the assessment of the conservation state of the structures and in the selection of the most suitable materials and intervention techniques for their conservation.

In conclusion, the overall evaluation of the archaeological, architectural, compositional and structural elements, performed from a historical viewpoint with direct and indirect comparisons, aims to recreate the real consistency of

the structures during their lifetime. This, of course, fosters their representation, which is founded on certain and reliable data from which reconstructing the perception of lost evidence.

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