CAA2015

KEEP THE REVOLUTION GOING >>>

Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods In Archaeology

edited by

Stefano Campana, Roberto Scopigno,
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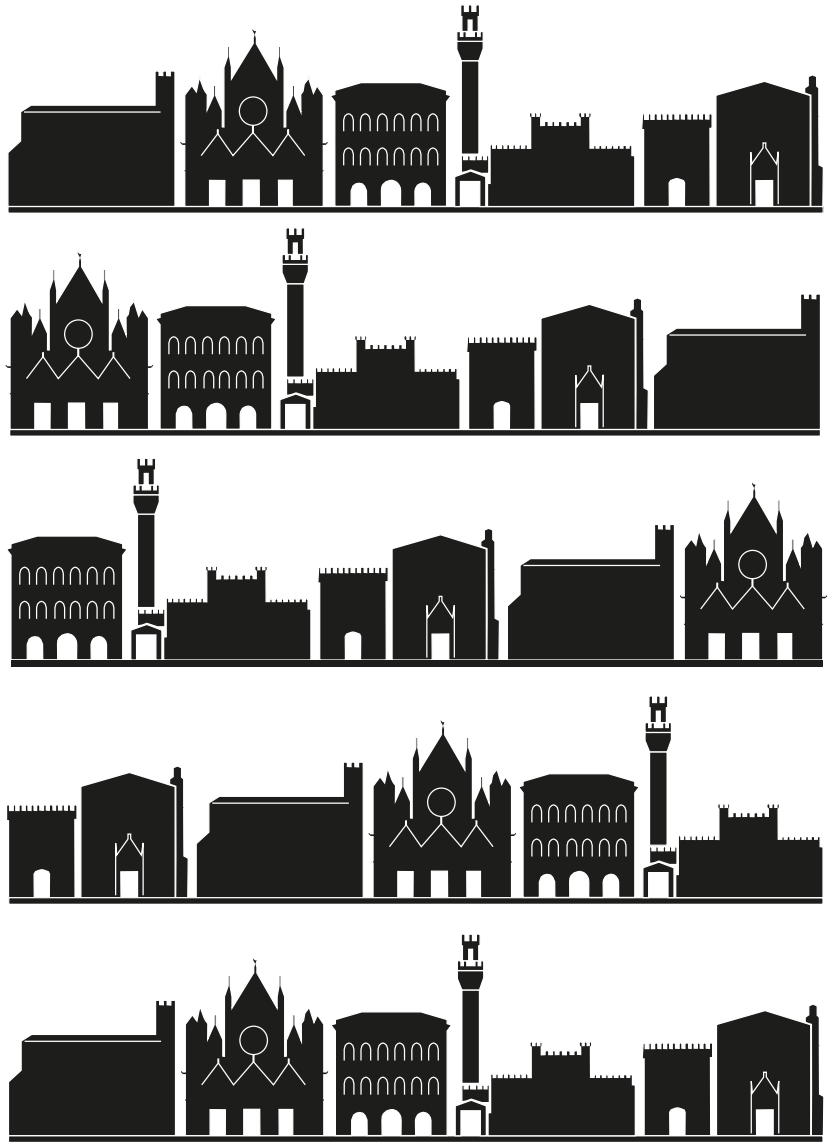

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CAA Computer Applications & Quantitative Methods in Archaeology

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A Dig in the Archive. The Mertens Archive of Herdonia Excavations: from Digitisation to Communication

Giuliano De Felice
giuliano.defelice@unifg.it

Andrea Fratta
andrea.fratta@unifg.it

Departiment of Humanities, University of Foggia, Italy

Abstract: Since 2004 the Department of Humanities at the University of Foggia has held the historical archive of Herdonia, containing the documentation of archaeological research carried out in the Roman town of Northern Apulia from 1963 to 2000.

The story hidden in the archive is long and complex, written in the documentation produced during 40 years of excavation and survey that led to the discovery of one of the largest Daunian, Roman and medieval sites in southern Italy. The archive is a unique memory covering a long time-span, containing documents that are parts of the history of archaeological research, linked with various methodologies (from long trenches and Wheeler methodology to big areas) and realized using different techniques and technologies (from paper drawings to CAD models, to 3D scans).

The purpose of activities carried out at the Digital Archaeology Lab is to share all the documents of the Herdonia archive starting from spatial data, carrying out specific workflows for building a common environment in which the digitized legacy data and digital born data can stay together.

The first phase of the project has been thus the recovering all the hand-drawn maps, their digitizing and georeferencing in an open source GIS. For the first time all of the sectors and trenches dug up on the site of Herdonia stay together, georeferenced, under the same roof.

Keywords: Archaeological archives, GIS, Communication

1 *Herdonia*: a Roman city in southern Italy (G.D.F., A.F.)

Herdonia is more of a unique case than a rare one in the archaeology of southern Italy. Abandoned in the Late Middle Ages, in comparison to other equally important sites, it has conserved exceptional monumental traces of a multi-millennial history that dates from the pre-Roman era to the 12th century AD. In the conspicuous mounds, which are over 7m high in some places, the histories of an uninterrupted *continuum* are stratified: from the indigenous populations to the Roman settlements, through the centuries of the Republic to the Roman Empire; from being the exceptional witness to centuries of decadence and to the transformation of a wealthy Roman city into a village, to its abandonment and the reconstruction of a small rural borough which still exists near the site (Fig. 1.1).

The main goal of Mertens' first excavations in *Herdonia* was to understand the general topography of the ancient city, starting from the detection of the city walls (Mertens 1965) (Fig. 2.1). This was one of the most important discoveries made by the Belgian team. In the 3rd century BCE, a first dirt wall was built, surrounded by a moat; it was soon replaced by a new wall of unfired bricks. Only at the beginning of the 1st century BCE did a new solid wall in *opus cementicium* replace the ancient fortifications and delimit an urban space of 20 hectares (Fig. 3-1).

During the Second Punic War (218-201 BCE) *Herdonia* was destroyed by Hannibal's army and its population was deported to Metapontum and Thurii. In the 1st century BCE *Herdonia* became a *municipium* and it was assigned to the *gens Papiria.* Many monuments and public structures were built. *Herdonia* experienced a flourishing period after the *Via Traiana* was created. It became an important commercial city, especially for agricultural products.

Between the 2nd and 3rd centuries the city centre of *Herdonia* was pleasant and elegant thanks to the monumental forum surrounded by temples, public buildings and markets; there were also affluent homes and thermal baths. Though earthquakes in the 4th and 5th centuries destroyed many buildings, such as the Basilica, *Herdonia* still kept its importance, as the presence of the bishop *Saturninus*, at the end of the 5th century, proves (Fig. 4-1).

The large quantity of graves and cultivated areas seems to confirm the reduction of the urban space during the Dark Ages, until a new phase began in the 11th century, after a new church was built on the northern hill of *Herdonia* and a village of wooden houses arose around it. In the 12th century the church was converted into a *castellum* surrounded by a defensive moat and it became a royal residence owned by Frederick II. The medieval village of *Herdonia* was ultimately abandoned between the 14th and 15th centuries.

FIG. 1.

FIG. 2.

FIG. 4.

FIG. 3.

Excavations had to stop in 2000 because of disputes over the ownership of plots of land, with the result that the archaeological area is currently abandoned. It seems that such is the fate of this extraordinary site, as predicted by Silius Italicus in the 1st century CE, when he called the city '*obscura Herdonea*' (Volpe *et al*. 2007).

Yet it is not only the material dimension that makes *Herdonia* an 'object of memory'. The history itself of the discovery and the long experience of field investigations, which have brought to light a large part of the site, help make it a unique case and enhance its value even more. Explorations in the area began in 1962 and continued uninterrupted for 40 years. Under the direction of J. Mertens of the Catholic University of Leuven (Belgium) and Giuliano Volpe of the University of

Bari (Italy), *Herdonia* was the longest archaeological research project in southern Italy, a melting pot in which archaeologists from different nations and cultures met and exchanged their experiences, field investigation methodologies and techniques over nearly half a century (Mertens 1995). There was not one methodology that was not applied to the sites of *Herdonia* nor one technique of documentation that was not tested out. From the small sites managed by a few archaeologists with many workmen to the international sites with over a hundred archaeology students; from the long trenches and squares using Wheeler's method to the large areas and surveys; from the excavation notebooks, plans and sections of every millimetre to the first experiments in CAD surveys and digital management of the data, from the negatives on glass and the 35mm films to digital photos and laser scans.

From this exceptional experience of research and training an important and unique trace remains: the historical archives of the digs. A veritable palimpsest of memories and techniques, materials and testimonials, which records in analytical form 40 years of archaeology. An extremely important documentary base, yet very complex too, given the nature of its history and the great variety of its contents, from the first historical nucleus of the digs by the Belgian team, donated by Prof Mertens to the University of Foggia in 2003, to the documentation of the Italian digs (1993-2000) (Volpe, Leone 2008). Hence it was decided to undertake an ambitious project to integrate, transfer to digital format and make available the data to researchers and, more in general to the community (Fig. 5-1).

2 A dig in the archive. The project

The main aim of the project is the definition and experimentation of a workflow for referencing and blending sources belonging to different phases of the research, starting from graphic documentation and written sources. These kinds of documents represent the majority of our - and we can imagine most - archaeological archives and it is mandatory to extract from this kind of documentation as much information as it is possible.

From the time of the acquisition of the archival core, the digital archaeology lab of the University of Foggia has taken on the task of preserving and using the archival data. After field work was halted, several projects of digital archaeology were commenced that were dedicated to the reconstruction of the different phases of the city, starting from the research data and obviously using the data in the historical archives. As of today, reconstructed models of the principal monuments of the Roman forum and baths have been realised.

As we believe that it is mandatory to make these data available for all kind of users, we are currently implementing a WebGIS platform that can be handy for several purposes, from research planning to visitor support. This platform is currently undergoing test phase on a smaller context of the roman Forum, where a very complex stratigraphy describes life phases from pre-roman times to early Middle Ages; the aim is to build an interactive 3D environment with a reconstruction of the whole chronological sequence and share it on a website.

'A dig in the archives' forms part of a doctoral project in 'History and Global Landscape Archaeology', a postgraduate course in the Department of Humanities at the University of Foggia. The idea is part of the research being carried out by our Digital

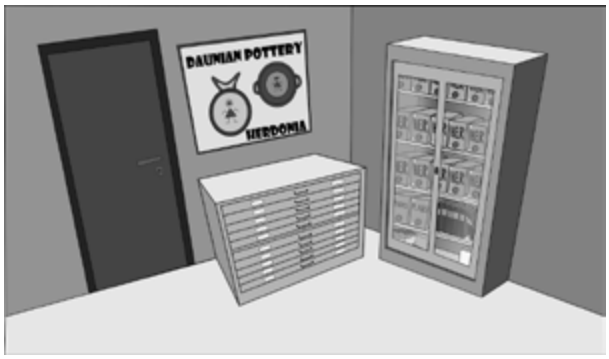

fig. 5.

Archaeology Lab: archaeological survey and documentation, data processing and communication to the general public. We are seeking to examine the real potential of a complete data processing workflow, focused on sharing information and, in this way, spreading archaeological knowledge (Bonacchi 2012). The project was started at the beginning of 2013 with the aim of digitising the whole of the archives and testing some possible ways of sharing the informative potential of visual archaeological documentation using web applications.

The methodological planning adopted for this task was divided into three main phases:

1. Data acquiring and processing
2. Management
3. Sharing

The *Herdonia* archive is a very interesting case study because it allows us to deal with issues concerning both topographic data management – such as integration between different kinds of data, collected in different periods with different techniques – and social repercussions.

Moreover, the recovery and digitising of the archives fit in well with the general debate over sharing and open access in archaeology: in 2008 the Europae Archaeologiae Consilium created a specific working group to examine the processes of archiving archaeological documentation in the ARCHES project. The main goal of ARCHES is 'to make archaeological archival practice throughout Europe consistent, in order to facilitate access to and preservation of archaeological records. This is achieved by producing standards and best practices for the creation, compilation, transfer and custody of archaeological archives that are sustainable and open to further development' (ARCHES Project 2012).

Therefore archives represent the place where archaeological information is deposited and encoded in many kinds of documents. For us, the *Herdonia* archives represent the ideal case–study to test all the methodologies of documentation which we carry out, to integrate different spatial and topographical data and to give them a wider social role in order to make people aware of *Herdonia*, even though it looks abandoned because of ownership disputes.

3 First steps (2013–2015). Acquiring, processing and managing documentation

Though *Herdonia* is well known to archaeologists,[1] it still lacks any real knowledge among the communities that live in the region and, more in general, among a larger public. This is the reason why we believe that sharing data from Mertens' archives is absolutely necessary. We are convinced that archaeology must have a positive social role, and to fulfil this aim we need to make research available to the general public. If we dig in these archives we can get and share information not only about the history of *Herdonia* but also about the history of excavations, methodologies and practices adopted in archaeology.

3.1 Acquiring data

The archives contain many kinds of documents. All the written records are stored in binders divided into chronological order; here we can find daily journals, reports, many articles from both Belgian and Italian newspapers about Belgian archaeological projects in Italy and letters that J. Mertens received from his collaborators. There are also sketches and drafts of particular finds, such as ceramics, coins and architectural elements. Archaeological finds have been listed in many inventories grouped by year. Most of them are collected in the Museum of Foggia and in the soon to be opened Museum of Ordona, but we still have their descriptions, slides and drawings in the archives.

Visual documentation consists of geographic aero–photogrammetric maps with a rough positioning of excavations and many ground plans and archaeological sections of the dig areas; stratigraphic units are often filled with different colours: each colour corresponds to a chronological phase. Studying the archives helps us better understand not only how archaeological information had been organised, but also the methodologies adopted by the Belgian team in the practice of digging and spatial data recording.

As already mentioned, the archives contain many kinds of data and several investigations could be carried out. However, for at least for two reasons, we considered overriding the creation of a global digital cartography where spatial data can be kept together in a geo–referenced system:

- After 40 years of excavations we still don't have a complete map of the Roman city.
- If we convert maps into digital format we can integrate both analogical and digital data such as total station and photogrammetric data.

3.2 Processing

Considering that we chose to work on the topography of *Herdonia*, the first step focused on the collection and examination of all the charts drawn by Belgian archaeologists. The investigations in the archives had different purposes, first of all the arrangement of the visual documentation. We organised all the charts following the order used by the Belgian archaeologists. Each chart was labelled with a number to indicate a precise topographical context of the archaeological area. Each chart has been scanned and converted from a raster format to a vector one in order to give each geometrical entity three dimensional spatial coordinates.

Visual documentation is strongly conditioned by the methodology of excavation. As we can easily imagine, a map drawn in the 1960s might look very different from the normal visual outputs we use today. This is the case with the Mertens archives. There are many differences compared with the features of current visual documentation. For example, single stratigraphic unit overlays do not exist. Belgian archaeologists drew plans with logical groups called *niveaux* (levels), where stratigraphic units were represented in different chronological phases but were connected for functional reasons.

Another considerable difference is the lack of elevation quotas. This is an issue we have had to deal with, because it makes 3D modelling of archaeological layers more difficult and less accurate. However it is very important to notice changes in the methodology of excavations by analysing visual documentation. After the long trenches of the early 1960s, Mertens decided to investigate larger areas, digging with Wheeler's method in the 1970s, until definitively pass to even larger areas at the end of the 1980s (Fig. 6-1).

After maps were entirely vectorised with CAD software, we created a GIS by positioning them on a digital CTR, the Regional Technical Map of Apulia. An initial positioning has been carried out thanks to the measurements of angles and distances from a modern building that Belgian archaeologists used as a reference point. Of course we had to deal with many errors in the global positioning of these maps in current digital cartography. We managed to check the errors of positioning by working on fields with electronic instruments; however, with the exceptions of the areas where there are still remains of ancient buildings, it is quite impossible to carry out, since many trenches have been covered over due to the use of the land for agriculture. Nevertheless, global positioning of archaeological entities made by Mertens on an aero–photogrammetric map is almost correct, even if we take into account the approximation occurring with elevated scale factors.

In this phase we also studied all the diaries of the excavations in order to understand better the criteria that conditioned the field work and, of course, the visual documentation, and to collect precise information about stratigraphic layers.

3.3 Management

Herdonia GIS represents not only a system to visualise geo–referenced maps, but also a basis of archaeological information linked to spatial data (Teodor 2014). The software we used for this is Quantum GIS; free and open source software is often used in many subjects, including archaeology (Fig. 7-1).

We used QGIS to categorise the geometric entities of all the vector layers of the trenches in order to allow users to search for information by asking certain questions. After a preliminary subdivision, we created three main categories: year of excavation, topographic context and chronology. In this way it is possible to visualise different thematic maps of

[1] Eleven volumes of the series 'Ordona' have been published. There are also a short book about the history of the Roman city, many scholarly articles and many MA and PhD theses.

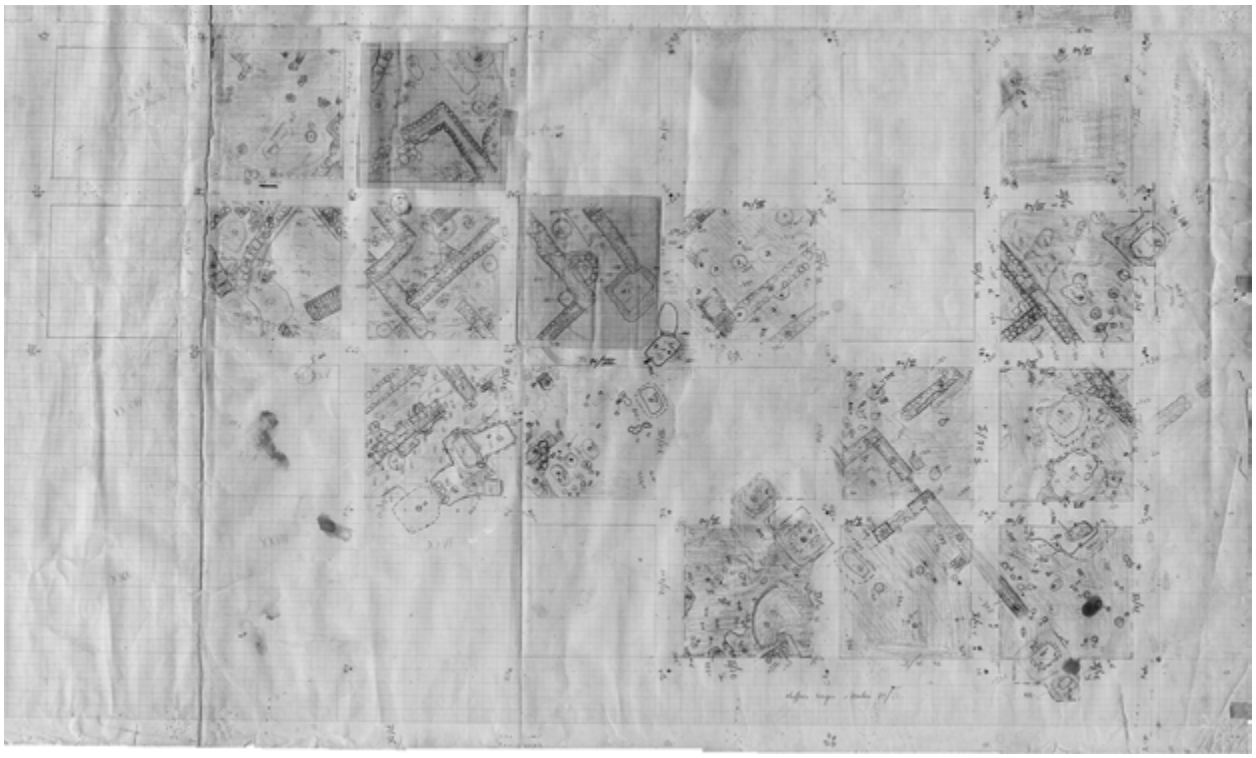

Fig. 6.

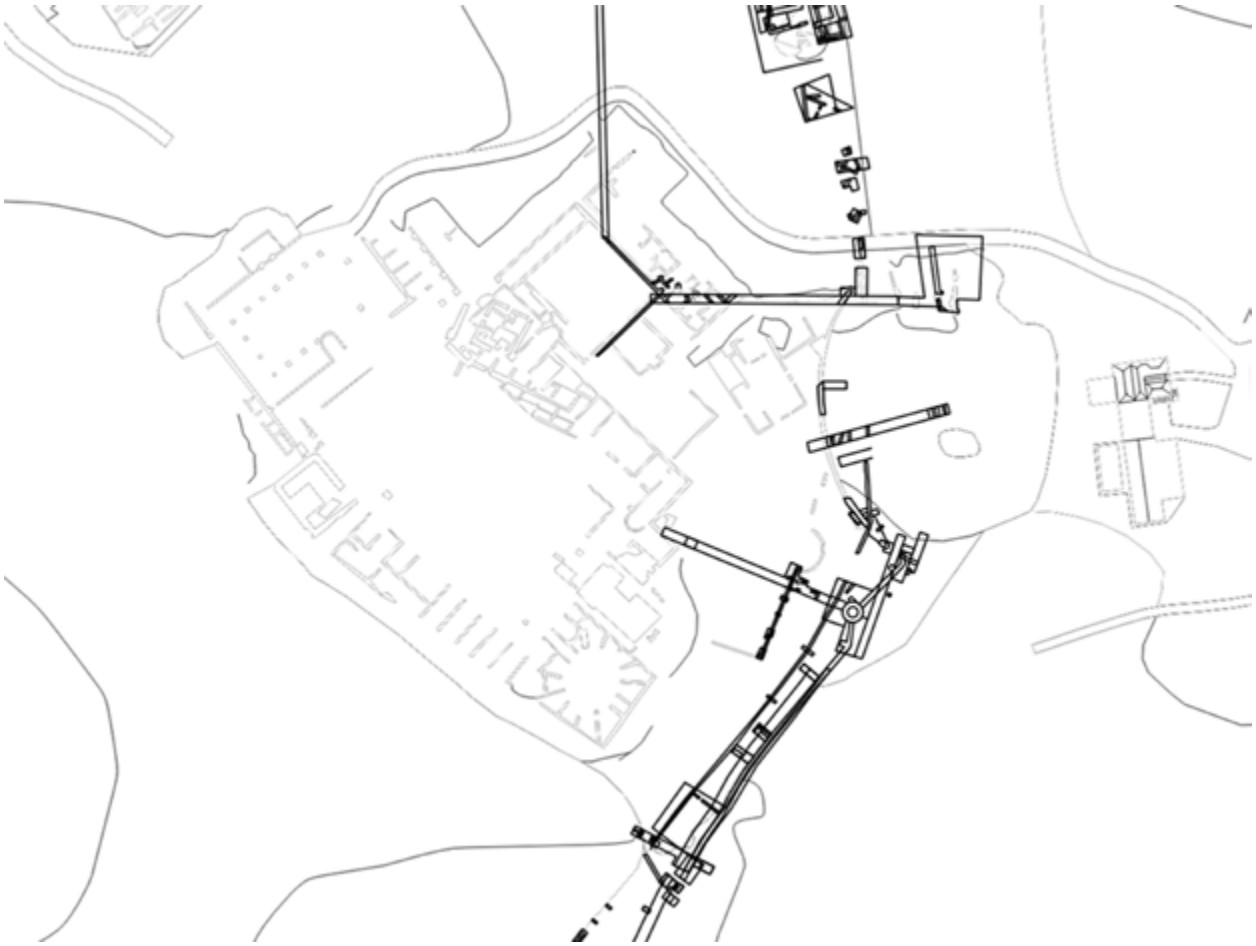

Fig. 7.

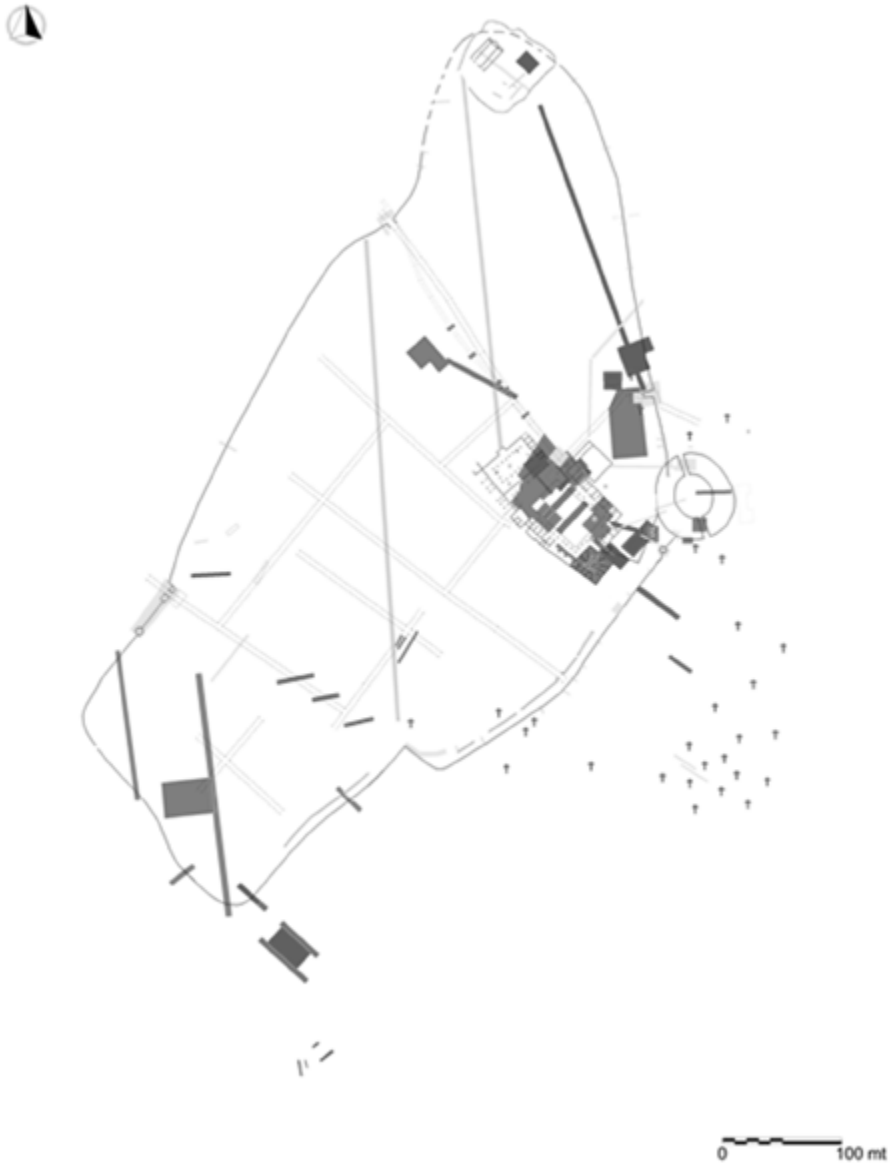

FIG. 8.

Herdonia, where layers can be labelled depending on the year of excavation or the chronological phase (Fig. 8-1).

Of course, it is possible to create a more detailed information system, and to do so, a more in-depth study of the individual trenches is required. In any case, we consider as a first, important goal the realisation of a global digital cartography of *Herdonia*, which still does not exist. More than 200 maps have been acquired, vectorised and imported to the *Herdonia* GIS. Moreover, a future step we're working on is the integration of other documents in the geographical system. In particular we aim to add the enormous quantity of pictures taken during the excavations and link them to vector data thanks to very useful plugins such as eVis (QGis 2009). Apart from GIS, we also used a MySQL database to organise all the raster data. Users can easily browse maps and sections and easily find them in the real archive.

4 Next steps – Merging new and old data and sharing

Sharing data and interactive visualisation. If the main idea of this project is the disclosure of data from Mertens' archives via a WebGIS where users can quickly find legacy data related to geometric entities in a digital geo-referenced cartography, there is also a second goal that we would like to achieve: the creation of a 3D environment in order to understand better the chronological sequence of a part of the ancient forum, the area of the Basilica (Fig. 9-1).

Belgian excavations reported a very complex stratigraphic sequence on the northern side of the forum, and in this area we can notice the profound changes that modified the urban layout throughout the centuries: from the Daunian defensive moat surrounded by chamber tombs to the different phases of the Roman forum with underground rooms and the construction

fig. 9.

of important public buildings, such as the Basilica; from the reuse of part of the Roman walls in the Early Christian era to the Medieval village and then ultimate abandonment (Mertens 1971; Mertens 1997).

We also carried out a photogrammetric survey in order to obtain a high quality 3D model of the area through a low cost processing system, like Autodesk 123DCatch (Autodesk 123D 2015). Our idea is to model all the geometric entities from paper to screen and put them in a common system with 3D models of the area of the Basilica in its present state. So users can scroll through the archaeological layers and learn about the history of the ancient city and the archaeological methodology of the excavations. In other words, we'd like to let users 'dig in a virtual scene. In this application we'd like to show not only the documents, maps and photos we used to reconstruct the stratigraphic sequence, but also the archaeological way of thinking. In other words, we're writing a short story to illustrate the urban evolution of *Herdonia*.

3D surveying has been one of the main activities of the Digital Archaeology Lab since its foundation. We use TOF laser scanning to acquire point clouds of buildings or archaeological sites; a low cost laser scanner for small objects, such as particular finds (De Felice *et al*. 2012), and also 3D photogrammetry. We believe that 3D data can be very useful not only for spatial and morphological analyses, but such data can also be implemented as 3D objects in different 'viewers' for communication (Fig. 10-1, Fig. 11-1).

fig. 10.

In the first phase of our project we had to test whether 3D data acquired by laser scanning or photogrammetry could fit in a virtual interactive environment or in a common web browser. Scanned data processing is not easy and a lengthy procedure is imperative for many reasons: data are too heavy and generally real–time engines impose a maximum value of vertices. Moreover, meshes generated from point clouds might

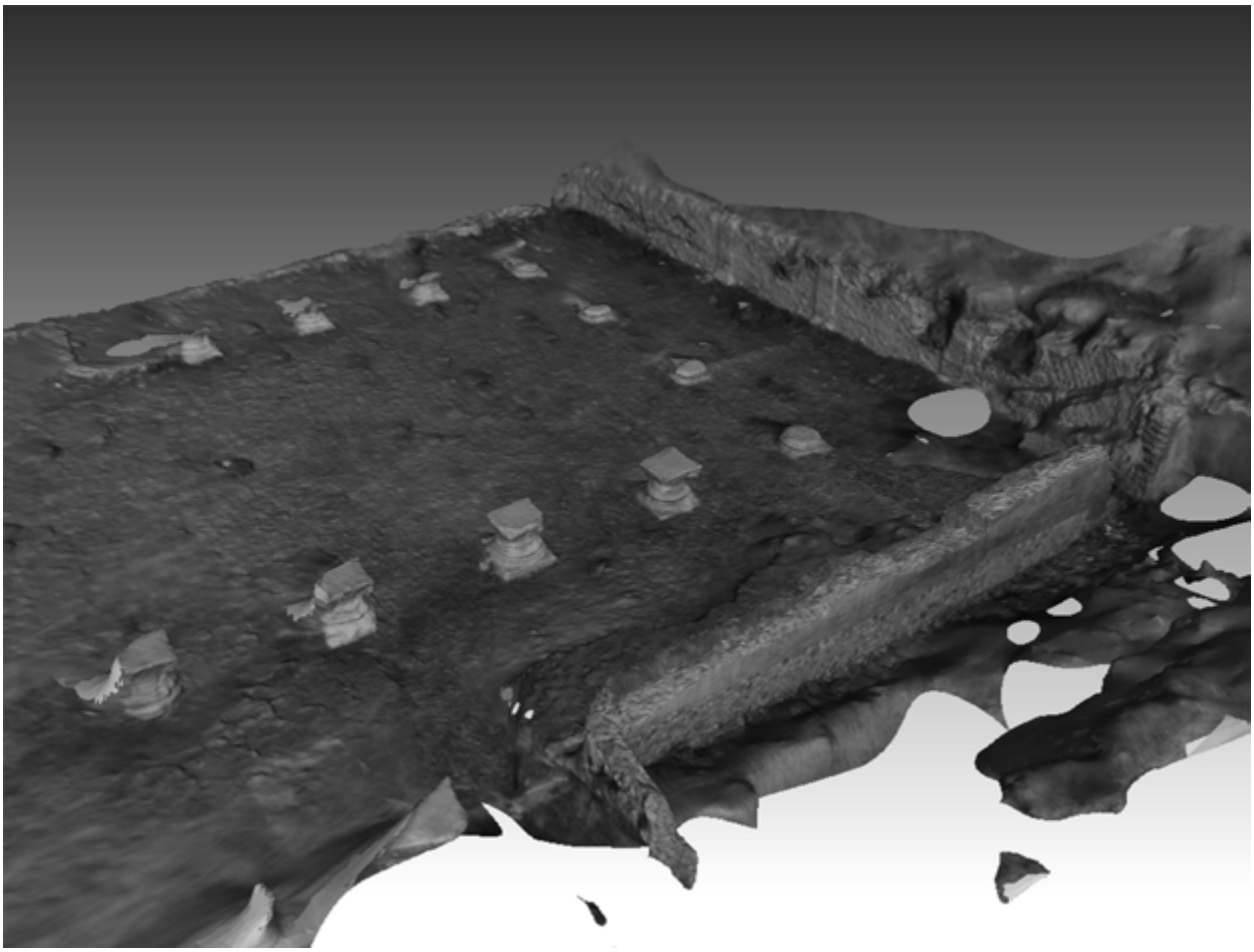

FIG. 11.

have several non–manifold components and so they could not be imported into these scenes. Meshes generated from 3D surveying techniques can be conveniently processed in order to reduce the number of geometric primitives, delete eventual errors in the 3D surface and transfer attributes such as colour.

Before starting the project, we carried out a process to elaborate raw 3D data until they were ready to be embedded in frameworks for interactive visualisation (Guidi *et al*. 2010). It doesn't matter that we are working with real–time engines or 3D viewers for browsers: complex 3D meshes need to be reduced and optimised (Scopigno 2006). But how can we do this? Will we lose the high level of detail of the original mesh?

The general workflow we employed for data processing consists of two main phases: the first one concerns the geometry of the model, and the second one the layout. In MeshLab (Meshlab 2015) we made copies of the original mesh using its powerful remesh algorithms that allow us to generate a new mesh usually with no non–manifold components. After that, it is possible to state the number of the triangular faces thanks to decimation tools. In this way we can control the number of vertices and respect the limits imposed by real-time engines.

For the second phase we preferred working with Blender (Blender Foundation 2015). This software offers the possibility to transfer attributes from one 3D object to another, if they are imported in the same scene. Thanks to 'baking' tools it is possible to generate raster maps of attributes from a hi-poly to a low-poly mesh, and transfer chromatic information or normal face in order to make textures and normal or displacement maps. In this way, even if the 'destination' model has a very simplified geometry, it still looks very detailed. Thanks to this procedure we successfully imported meshes to online 3D viewers (LAD 2012) such as Sketchfab or p3D.in and even to virtual interactive games (Comune di Deliceto 2014).

Tests on 3D data confirmed the effectiveness of these processes in order to import complex 3D meshes to interactive scenes. We consider 3D data as an essential part of archaeological documentation, along with legacy data and 2D outputs, such as ground plans, overlays and stratigraphic sections. Now our question is: can we use this documentation to spread archaeological knowledge? (Fig. 12-1).

5 Conclusions

In the first two years of activity about 300 maps had been acquired in raster format, georeferenced and vectorised and 90 trenches had been added to the global cartography of *Herdonia*. For the first time we have a digital and complete map that can be easily used by all kind of users. Furthermore other typologies of data, such as pictures, journals and inventories of archaeological finds can be linked to *Herdonia* GIS.

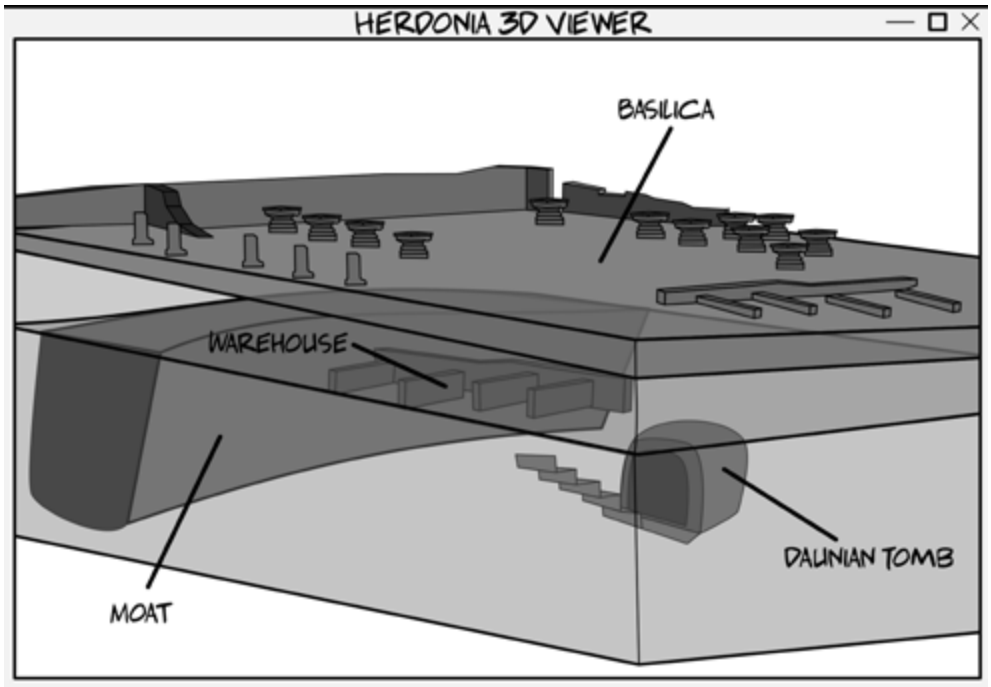

fig. 12.

The 'dig in the archive' project is just at the beginning. Many other 'digs' could be done and many other paths could be trodden, but we are sure the direction we have taken is the right one.

A strong relationship between archaeology and communication occurs, and Mertens' archives are the proof: 40 years of excavations and only the central area of *Herdonia* is visible today. Most of the archaeological ruins are still buried, but information about them is stored in the archive. Our purpose is to continue investigations in *Herdonia*, making interlocutors – both specialists and the general public – more interested.

Opening an archive means spreading knowledge. This is our attempt to make access to the archives easier. We began to work on topography since, thanks to GIS, we are able to link different information to geographic data and we can share a complete digital cartography of *Herdonia* with the community of archaeologists for the first time.

But we can do something more. Many people do not want to read all the documentation related to a site. They just prefer to understand its history. This may not be the right place to talk about effective communication in museums or archaeological sites, but we strongly believe that 'translating' archaeological data into something that people can better understand is the archaeologist's task. That explains why we would like to propose a 3D interactive application to make users aware of the archaeological stratifications of *Herdonia*: layers are the facts with which archaeologists write the story of a site. And 3D is just *one* way, not *the* way. We need to find the solutions that best fit our communication purposes. Technologies do not work without contents: a good tale is what people are looking for.

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