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Rome, Colosseum square and NE slopes of the Palatine hill: toward an integrated 3D system for stratigraphic data management and ancient urban landscape reconstruction

The investigations carried out in the valley of the Colosseum and on the NE slopes of the Palatine have disclosed a complex sequence of urban and monumental interventions whose documentation has inevitably produced a vast amount of data that is difficult to manage without the aid of an information system. With the recent development of new applications, it is possible to create a system for the integration and visualisation of archaeological data, both in two and three-dimensional format, and to experiment with new criteria and methods for the combined and effective use of documents of a different nature.

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Introduction

The urban landscape lying between the Colosseum valley, the northeast slopes of the Palatine hill and the Temple of Venus and Rome is the result of multiple urban changes occurring here during past centuries.

The current appearance, if we consider the floor in use today and the monuments present, reflects the aspect reached during the 4th century C.E. (Fig. 1). It must be said, of course, that what we see today is the result of spoliations and diggings made in this area of the city since the end of antiquity.

If it is true that the Colosseum and the Temple of Venus and Rome survived (more or less) these destructions and abuses, it is also clear that today they live in a metaphysical space because the urban connective system they belonged to does not exist anymore.

The first and substantial *coup de grâce* was given to this zone by interventions made in the first half of the 19th century (during Napoleonic administration and subse-

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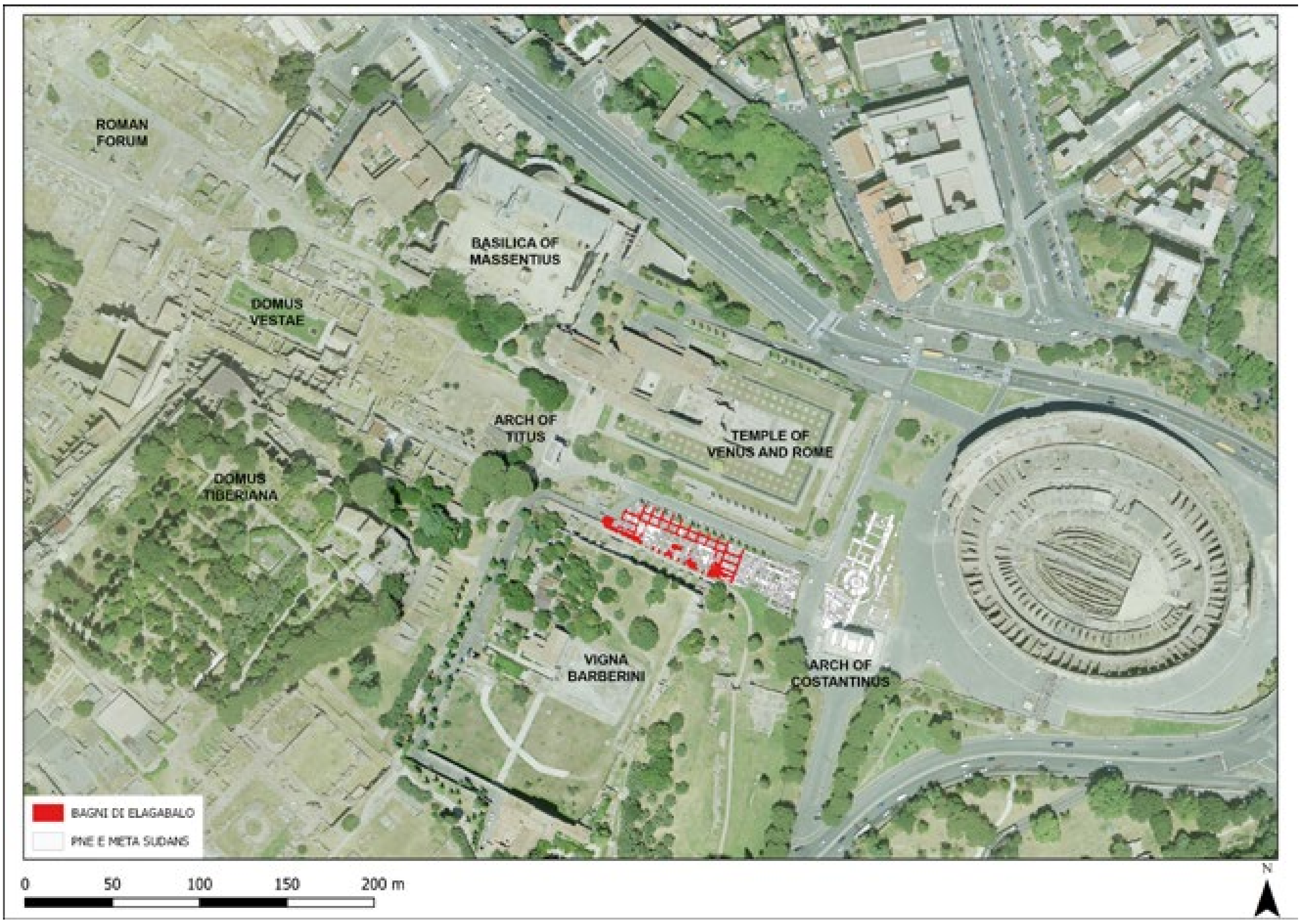


Fig. 1. The investigated urban district and the excavation areas.

quent papal restoration) and later at the end of the same century, when Rome became the capital of Italy: all of these activities were planned in order to restore the levels of the ancient city and to enlarge the valley area; sadly this included the destruction of the medieval remains.

The second act, responsible for the isolation of today's ancient architecture, happened during the fascist regime, when the *Velia* hill was almost totally demolished to build the brand new Via dell'Impero (now Via dei Fori Imperiali), linking the regime square, Piazza Venezia, with the Colosseum and after, to enlarge via di San Gregorio, renamed Via dei Trionfi, leading from the Colosseum to the Circus Maximus. On this occasion two imperial "ruins" were demolished: the base of the giant statue of Nero (the *Colossus*) and the *Meta Sudans*, a monumental fountain built in the Flavian era.

It is within this framework that the department of Antiquity Sciences of the Sapienza Rome University started in 1986 its archaeological excavations, first at the *Meta Sudans* (with an extended area going from the Arch of Constantine to the *Colossus* base) and later, from 2001, at the NE slopes of the Palatine hill, along the actual Via Sacra, reaching the Arch of Titus. The goals of these investigations were:

- to reconnect a very important monument such the *Meta Sudans* with the surrounding ancient topography
- to restore the connection between the Colosseum valley and the Palatine hill interrupted by destructive activities carried out from the end of antiquity.

During our excavations we have adopted the "big areas" strategy and the stratigraphic procedure[1]: we have investigated an area of about 4500 square meters, reaching a depth, were possible, of 8/9 meters, chasing the millenary history of this urban zone, from the first settlement at the foot of the Palatine hill (10th century BCE) to modern age spoliations and activities, including the contemporary city services and infrastructure (water pipes, electric lines and underground B line).

In order to reconstruct the original geomorphology, continuously modelled by human activities, we have conducted geophysical investigations, such as by means of augers or using tools such as ground-penetrating radar and resistivity[2].

To make an extreme synthesis of the main results[3], starting from the remains of Iron Age huts, found along the slope, we move on to an early urban planning witnessed by the presence of two sanctuaries dating to the Roman Kingdom (8th-7th century BCE) located along both sides of the ancient road leading to the Roman Forum: one of them has been identified with the *Curiae Veteres*, linked to the ancient Roman tradition and frequented until the end of antiquity. A residential zone along the road is documented from the archaic period: subsequently this area has been periodically rebuilt until Augustus age. In this period here, at the meeting point of five of the 14 city zones he first *Meta Sudans* was constructed in front of the *Curiae Veteres*, which were also renewed in monumental shape during the years of the emperor Claudius. After the big fire of year 64 Nero planned a deep transformation of the area linked with the building of his *Domus Aurea*. In the years between 64 and 68 CE it was carried out a reorganization of the roads assigning them a regular and orthogonal shape. The following urban planning of flavian emperors was focused instead on restoring a public dimension to this sector with the construction of the Colosseum and its square together and the rebuilding of the sanctuary and the *Meta Sudans*. Another big urban change will happen during Hadrian's reign with the construction of the Venus and Rome Temple and, on the other side, of a long storehouse flanking the porticoed street direct to Forum. As a result of a further fire, broke out at the end of the 2nd century, the area was rebuilt again by the severian dynasty: in connection with the reorganization of the

1 On the archaeological meaning of the terms "strategy" and "procedure" see Barker 1977, Harris 1979.

2 Arnoldus-Huyzendveld and Panella 1996; Piro 2006; Panella, Piro, Zeggio and Brienza 2008.

3 About the results of the excavations see: Panella 1996; Panella et al. 2006; Panella 2011; 2013; Panella, Zeggio and Ferrandes 2014; Saguì, Cante and Quondam 2014; Saguì and Cante 2015; Ferrandes 2016; Brienza 2016; Papini 2019; Panella et al. 2019.

imperial palace the north east Palatine's substructures were transformed and the constructions at the feet were replaced by a new building commonly called "Bagni di Elagabalo". In the 4th century CE, in fact, a banquet hall with a small bath was created inside this complex; during the same century the *Meta Sudans* and the Venus and Rome Temple were restored and finally the Constantine's Arch was built.

From the micro-history of the excavated area it has been necessary to skip to the macro-history of the whole ancient urban district, of whose landscape our investigations discovered very few parts: our research had to take into consideration the previous archaeological literature about the settlement vicissitudes of the whole Palatine, as well as of the Oppio, Celio and Velia hills; for the same reason we have acquired the data of geomorphological research focused on these zones[4].

Dealing with this purpose, we had to use computerized information tools for data collection and management, articulated into distinct chronologies and with graphic outputs able to reproduce the ancient spaces and their transformations over time, on a small and large representation scale.

C.P.

The archaeological record collection: techniques and procedures

The stratigraphic excavations have produced a large amount of material evidence related to ancient buildings and architecture of great impact, distributed over hundreds of years. In particular, the physical overlap of structures following the development of diversified urban systems is strongly linked to the environmental, topographical and stratigraphic *continuum* whose surviving traces must be connected in shape, place and time to an entire sequence of actions, in order to understand the general history of this ancient city zone.

All of this leads us to an attempt to reconstruct the historical events of an enlarged urban landscape, changing over the centuries from its first settlements to the present day.

This is why other investigations were carried out, together with the excavations, aimed at identifying and correctly positioning the archaeological and morphological evidence of the surrounding areas, reconsidering them in the light of the new results coming from updated technology.

The historical sequence reconstructed for the excavation areas was therefore contextualized in a wider urban historical framework, traced through the study of pre-

4 For the geological study of these zones see Funiciello and Rosa 1995; Funiciello et al. 1995; Funiciello, Lombardi and Marra 2002; Arnoldus-Huyzendveld 2016; Del Monte 2018.

vious bibliographies, archive data and historical cartography. The archaeological records collected during these operations were linked to a general map developed in a GIS environment, made up of several distinct plans combined into a unique reference system by overlay mapping procedures: the vector cadastre of Rome, the digital cartography of the Municipality plus several rectified aerial photos and satellite images. Over this base-map we have georeferenced several historic cartographies, in raster and vector format, such as Nolli's *Nuova Pianta di Roma* (1748), some sheets of Lanciani's *Forma Urbis Romae* and the cartographic atlas *Media Pars Urbis* made by V. Reina in 1911[5] (fig. 2).

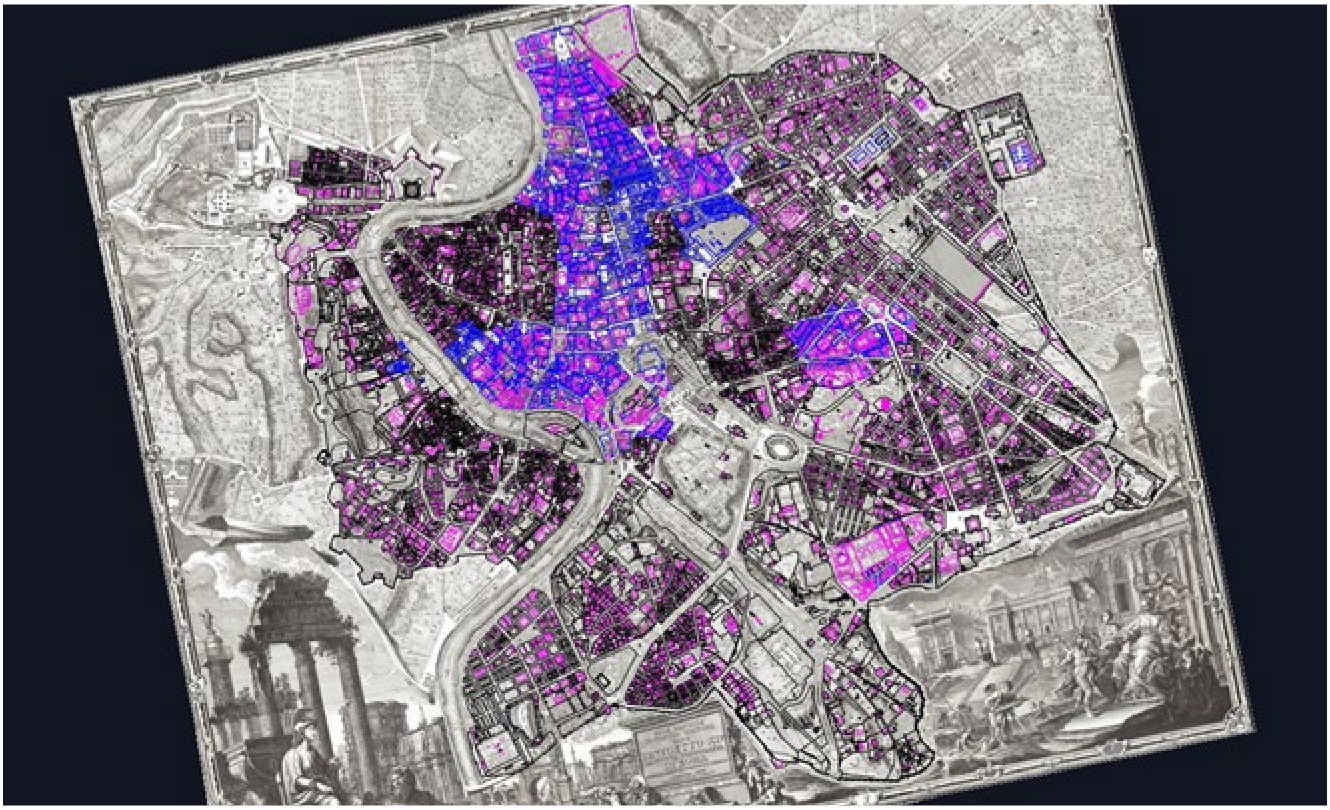


Fig. 2. Historic cartography analysis: the Nolli Map (1748) over the digital cadastre of Rome (M. Fano)

Using the data collected from stratigraphic and geoarchaeological investigations, from surveys and historical cartography, two digital terrain models have been developed: one related to the Augustan age and the other suggesting the situation after the 64 big fire and Nero's massive interventions. Those DTMs are the basis of virtual urban scenarios, modelled in a 3D environment, that can be navigated following a

5 Brienza 1998; Panella, Fano and Brienza 2013. On historical mapping of Rome see http://mappingrome.com/team/; for Nolli map see also http://nolli.uoregon.edu/ by Oregon University and the other project, by A. Ceen and J. Tice, at https://nolli.stanford.edu/maa.html.

diachronic exposition and associating each monument to its period, with the option to converse interactively with each architecture in its specific temporal version[6].

Regarding the stratigraphic excavations record, an enormous and heterogeneous amount of information was produced in the face of a really complex ancient layering process.

At the beginning we started to collect data in analogical and paper format, but later, with the increasing accessibility of electronic and IT technologies, the information gradually took a predominantly digital form. In this context the traditional survey and drawing techniques in archaeology have been continuously updated and tested in terms of accuracy, reliability and practicability[7].

Despite the use of different tools, the approach in data collection has remained unchanged: for each individual trace of anthropogenic or natural action, plans, sections and elevations were generally produced in 1:20 scale (for some particular evidence we also used 1:10, 1:5, 1: 2 or even 1:1 scales); for each stratigraphic unit (or context), moreover, photographs were taken and specific file-cards were compiled, according to the standard formats established by the *Istituto Centrale del Catalogo e della Documentazione* (Italy's Central Institute for Catalogue and Documentation).

Generally, the graphic documentation has been divided into two distinct levels; the first is composed of all the drawings made during the excavation: these have absolute priority since they are the only testimony of what has been removed and therefore, in addition to their ethical and legal value, the post-excavation interpretation process depends heavily on their accuracy and completeness.

The second level consists of graphic elaborations produced annually in order to reproduce on a single document the complete archaeological evidence brought to light during each campaign and georeferenced into the urban context (fig. 3).

These "periodic documents" testify to the situation left at the end of the excavation campaign and are fundamental proof of what has been done. The graphic documentation was completed by sections, generally and elevations, generally drawn at 1:20 scale, with a very detailed representation of masonries, layers, soils and "negative" contexts in their vertical stratigraphic development.

All of this documentation was initially produced by hand on nondeformable paper, by direct-drawing techniques supported by a total station following survey procedures increasingly integrated over the years. When the archaeological evidence could be comparable to flat surfaces (floors or wall facades), we used photo-

6 Panella, Fano, Brienza and Carlani 2008.

7 About archaeological surveying and drawing see: Giuliani 1983; Medri 2003; Bianchini 2008; Giorgi 2009; Remondino and Campana 2014; Brienza 2016b; Zachar, Horňák and Novaković 2017; Bianconi 2019.

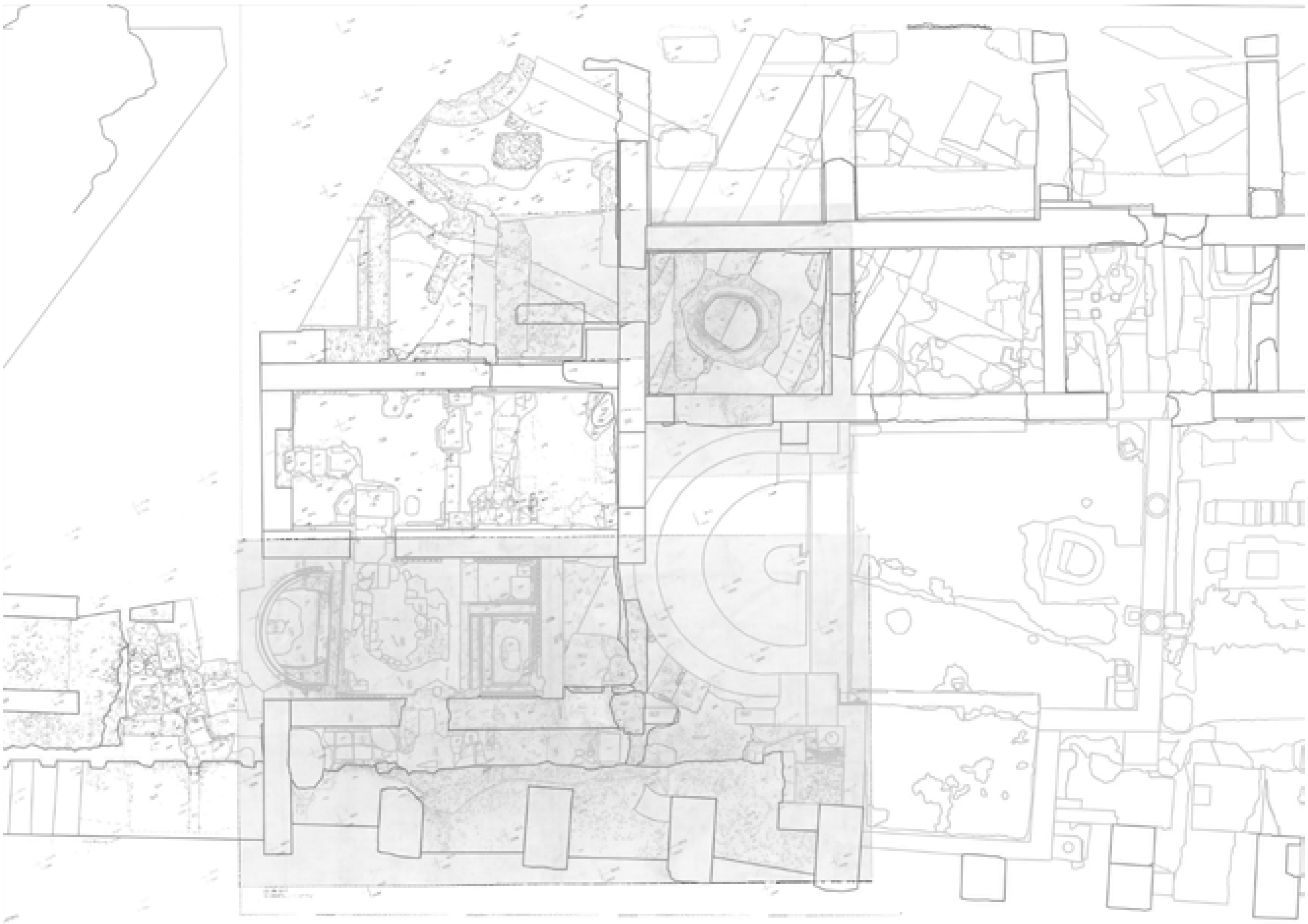


Fig. 3. Digitalization and georeferencing of end-of-excavation yearly maps (hand drawings).

rectification techniques considering, of course, the limits of application and accuracy of these tools.

During post-excavation work other graphic documentation has been produced to support the archaeological interpretation process: mainly thematic sections and a period/phase map; in the early years made on paper (and then digitized) but later, after 2000, directly produced in vector format (by CAD or GIS software) making easier the digital reconstruction process of the archaeological record.

From 2007 we started a working cooperation with the CNR-ISPC (*Institute of Sciences for Cultural Heritage of the National Research Council*, formerly ITABC) in order to test several 3D survey tools and techniques and verify their value and practicability in the archaeological field. This activity mainly concerned the architectural complex called *Terme di Elagabalo* and saw the use of different approaches: from close-range digital photogrammetry, made with image-matching tools, to laser scanning, as well as the production of general ortho-photo-maps with different techniques; semi-aerial, taking photographic series from the basket of a crane, and using UAV devices (Fig. 4). The use of these techniques was motivated by the configuration of the area itself, characterized by the overlap of big architectural complexes: our first goal was to create a general survey of the monument, including all archaeological and architectural evidence, in which to contextualize the results of imminent stratigraphic excavations and the detailed research on ancient masonries carried out in order to integrate the ancient chronologies with specific building procedures.

The huge collected data volume has required a tool dedicated to archaeological record contextualization and assemblage but also able to suggest new elements for research development.

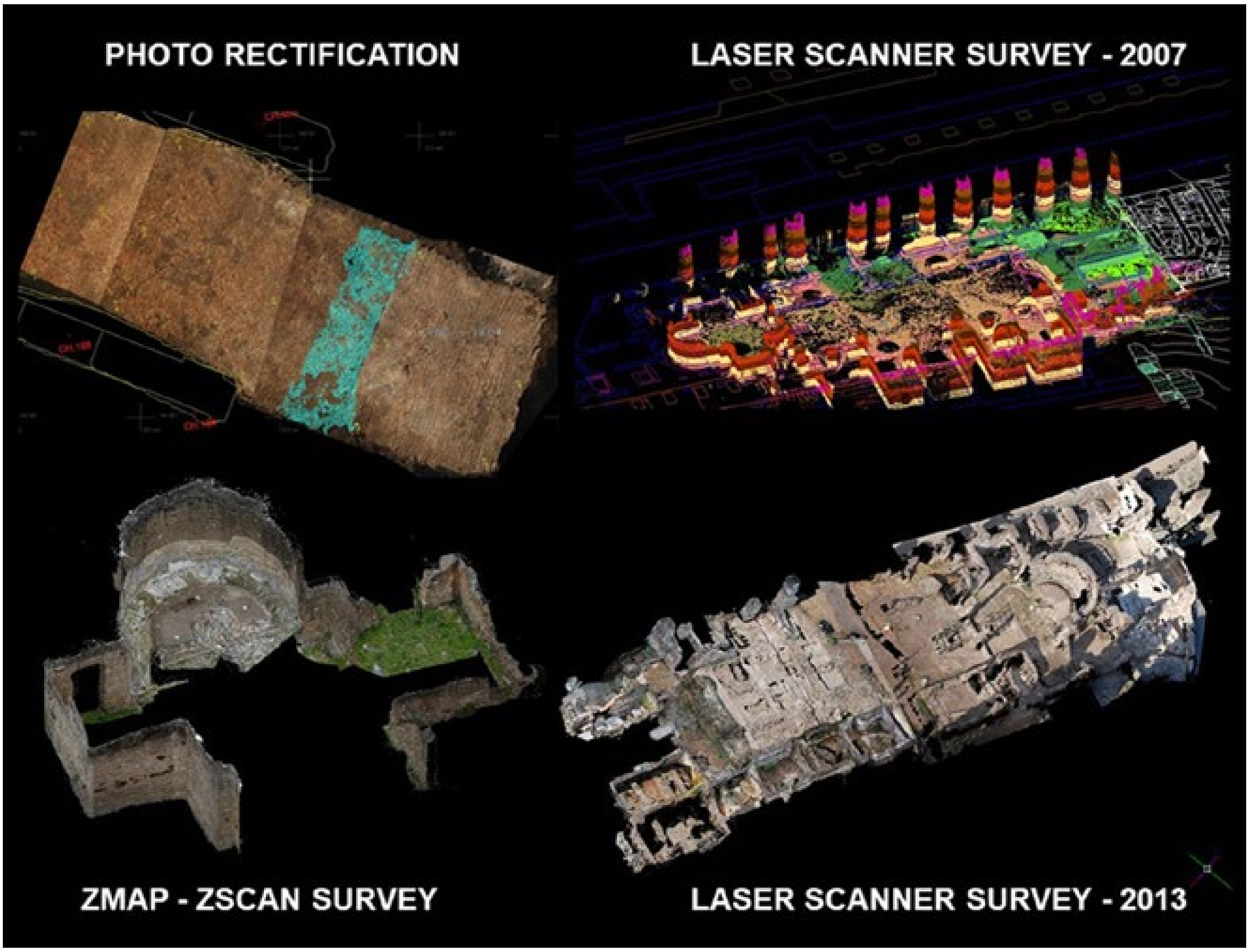


Fig. 4. Different survey tools used during archaeological excavations (years 2003-2013).

To achieve this target, all the drawings and graphic elaborations (as well as all the features represented inside) were digitized by CAD, following a regulated process of data vectorization, and georeferenced in a single general spatial archive. Here every single piece of archaeological evidence has been linked to the related written data (as well as to the photos) recorded in a dedicated DBMS. In this way, a digital version of the entire excavation archive is managed by an intra-site GIS (designed since 2001) for data-retrieving and spatial analysis but also for archaeological thematic layers and reconstructive model elaboration[8].

This intra-site GIS for excavation is integrated with the information system dedicated to ancient landscape analysis that we have already described above. They both belong to a single tool focused on multiscale reconstruction of this urban sector, where the detailed stratigraphic evidence is recomposed, compared and contextualized (for each historical period), with the results of wider surface investigations.

This system has been continuously implemented and updated over the years, adding information from new excavations and investigations but also following IT technology innovations: however, since our GIS platform, up to now, was able to manage easily, consistently and in a single environment, just two-dimensional documents, only this type of spatial data have been processed together with spe-

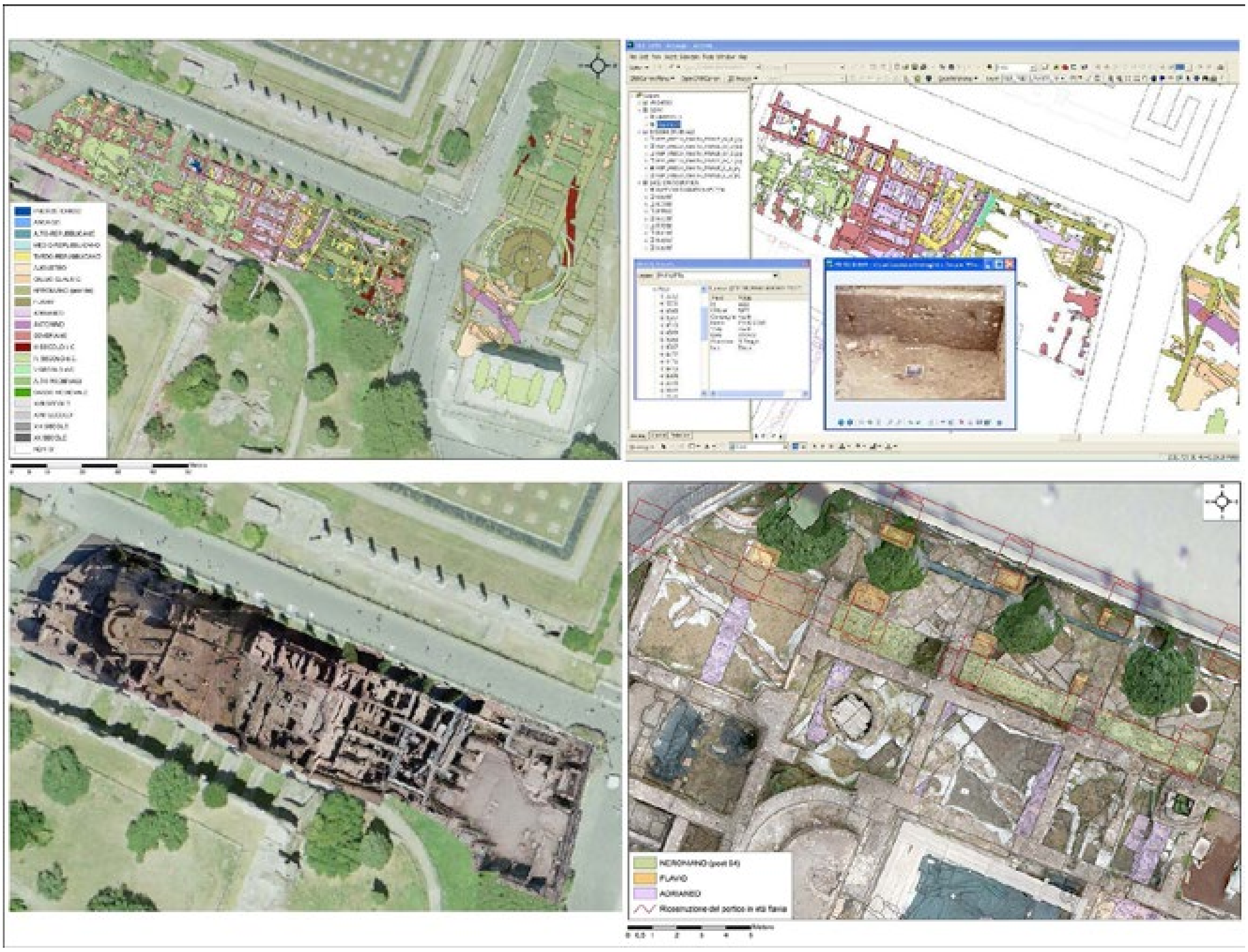


Fig. 5. The intra-site GIS: different analysis levels.

8 About this system, its integration and its updating see Brienza 2006; Panella and Brienza 2009; Brienza 2016, pp. 31-16.

cific 2D documents elaborated from 3D surveys, like vertical or horizontal ortho-photo-maps (fig. 5).

E.B.

New analysis tools

In recent years, the use of *image-based-modelling* photogrammetry techniques based on *Structure From Motion* has proven to be effective in making accurate 3D surveys and reproducing the aspects of archaeological features, seemingly almost real, using photographic textures (Fig. 6). Requiring not particularly expensive equipment, being able to detect objects in three-dimensionality with a certain precision and speed, and making simple the elaborations of ortho-photo-plans, this technique gradually joined the traditional documentation procedures (without totally replacing them) and allowed us to propose three-dimensional sequences of excavated stratigraphy and digital reproductions of ancient artifacts, suggesting their virtual reconstruction or digital restoration (Fig. 7)[9].

Fig. 6. 3D survey and sampling of ancient structural features.

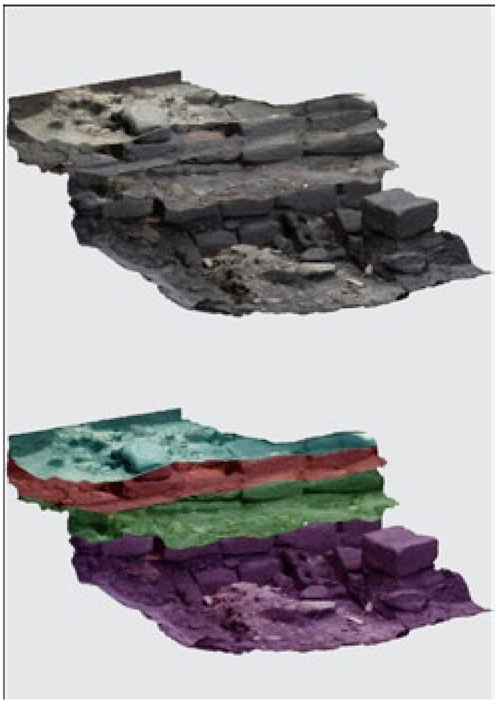


Fig. 7. 3D sequence of excavated stratigraphy.

When we started to apply this 3D survey technique in high-detailed mode for ancient structures, we decided also to update the criteria of their analysis on written records following some research guidelines suggested by specific studies on ancient architecture, in particular the "archaeology of construction"[10]. We have planned a new file-card format dedicated to recording infor-

9 Brienza 2016 pp. 97-99 and 117-138; Fano 2016, pp. 71-75. On virtual restoration see also Limoncelli 2012.

10 See the proceedings of several workshops held on this topic: Camporeale, Dessales and Pizzo 2008; Camporeale, Dessales and Pizzo 2010; Camporeale, Dessales and Pizzo 2012; Bonetto, Camporeale and Pizzo 2014.

mation about the logistics of the ancient building yards and the related dynamics of material production and construction organization, in addition to data relating to their measurements, composition and nature (Fig. 8).

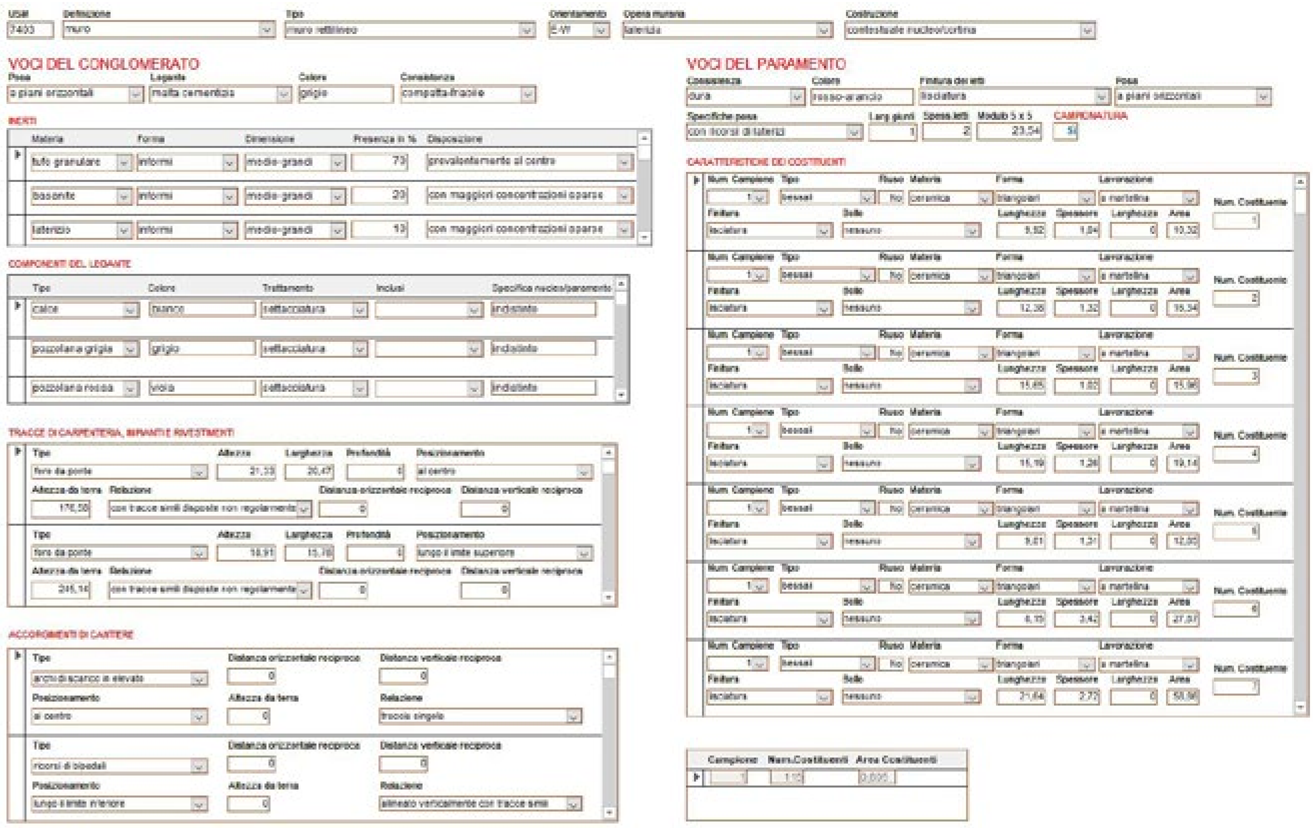


Fig. 8. File-card for structural features recording.

In this way the chrono-typological analysis, which traditionally focuses on the recognition of the single building features through aspects of their material, has been expanded upon with the collection of information related to construction methods such as, for example, structural expedients for static stability of the building, specific material selection in relation to particular needs, or quantification of the work in terms of time and number of workers. Defining trends, measurements and treatments of specific building materials can help us to identify diachronically the processes and resources of the ancient construction yards, while the stratigraphic analysis of the walls with its identification of constructive temporal sequences is crucial to understanding the formative dynamics of the ancient architectures and must be done through observation of details and on the basis of a precise and clearly legible survey[11].

11 For structural stratigraphy and archaeology of architecture see Brogiolo and Cagnana 2012. See also the Italian journal *Archeologia dell'Architettura*, published since 1996, and the Spanish journal *Arqueología de la Arquitectura*, published since 2002.

Obviously, in order to normalize the data entry and editing, we have encoded standard taxonomies for fields like *Definition/Typology/Techniques/Masonry* and controlled vocabularies for fields like *Aggregates-Materials/Shape/Dimension/Arrangement* or *Vestment-/Finishing/Laying/SpecificSetting* and so on; this descriptive apparatus for ancient masonries is appropriate for the antique architecture of Mediterranean Basin and the terms and the criteria that we have used to build it have been collected during on-field experience and the associated study of the wide bibliography about this topic[12].

In addition, the detailed morphometric information derived from autoptic analysis of samples taken from wall facades (normally their size is 1 square meter), is managed by sub-cards where every "constituent" feature (i.e. brick, block, etc.) is organized by type, use/reuse, material, manufacture, finish, and measurements. This tool automatically calculates the percentage of the constituent/conglomerate ratio, but also the dimensions of the components, with their degree of homogeneity and variability; it is also possible to evaluate chronological factors in ancient buildings, such as the extent of resource supply, the reuse index, and building materials' se-

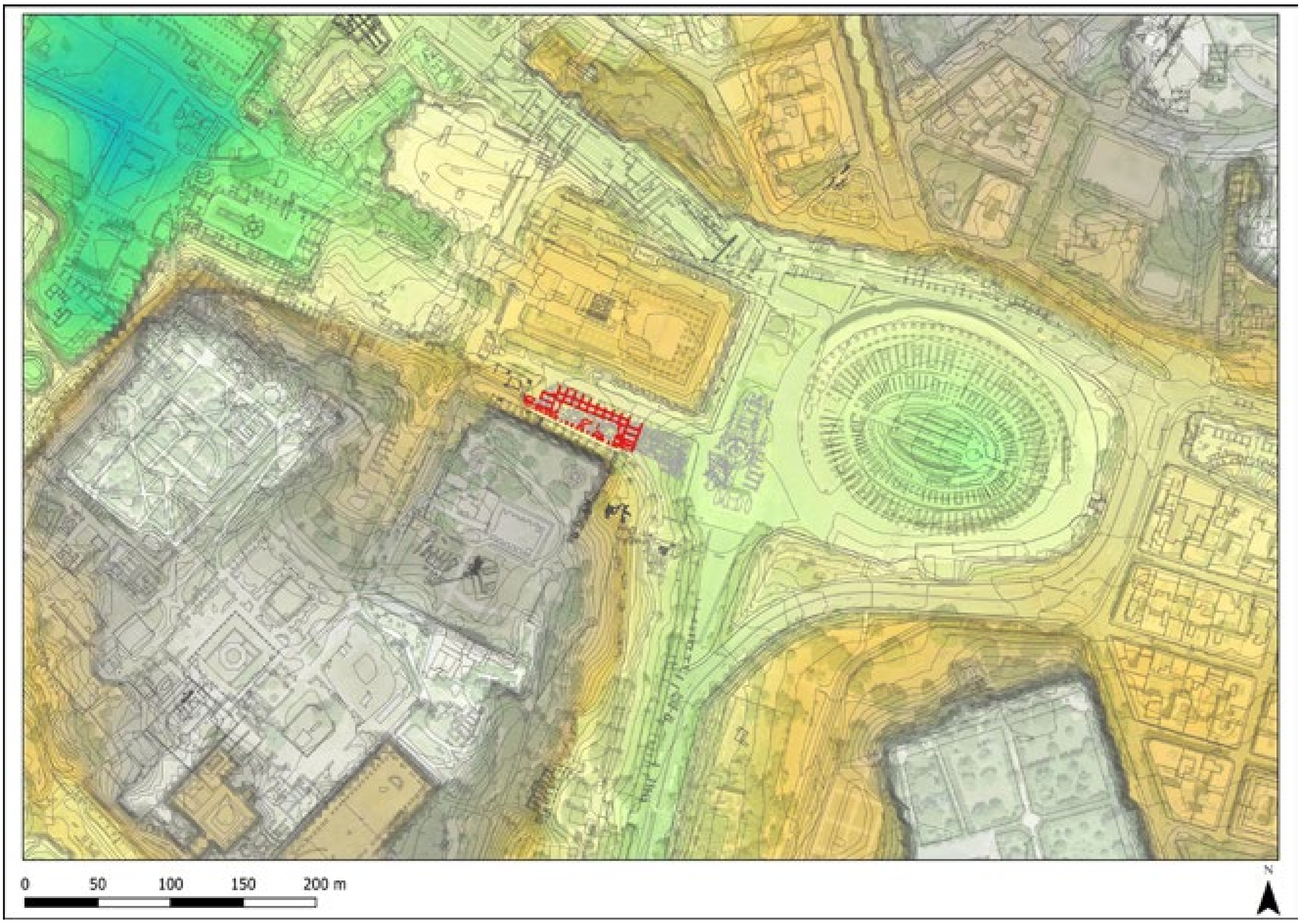


Fig. 9. Actual DEM of the investigated urban district.

12 See footnote number 10 and 11; in particular see Brogiolo and Cagnana 2012, pp. 47-59.

lection level: proceeding in this way we try to refine the chronological sequence of each single building.

Finally, we have updated the territorial study producing a digital elevation model in order to compare the current state with ancient surfaces: this DEM was produced through the interpolation of the altimetric data available at the *Geoportale della Regione Lazio*[13] and subsequently recalibrated on the basis of the altimetry detected during the annual topographic campaigns (Fig. 9). For the study of the urban landscape, it is an additional basis on which we can project the stratigraphic evidence of structures and infrastructures (ancient roads, sewers, terraces, substructures) inextricably connected to the original morphological configuration; here we can verify, using the deepest stratification data, our environmental reconstructions for the most ancient periods.

E.B., L.F.

Towards an integrated system

The stratigraphic excavations today are completed and the final state of graphic documentation is made up of two blocks: on one side the bidimensional dataset managed by GIS (surveys, drawings, photos, pictures and alphanumeric data) on the other the three-dimensional raw-data produced during years of research using different tools, excluded from integrated GIS analysis due to the technological limits described above.

The recent development of software capable of true and dynamic management of 3D spatial data (together with two-dimensional ones) is pushing us towards an attempt to unify all our information: now we want to create an integrated management system of the whole archaeological record collected on multiple dimensions, experimenting with new criteria for the combined use of documents of a different nature.

It must be added that in some documents, of both kinds, it is possible to retrieve information relating to stratigraphic masonries no longer visible today because they have been reburied.

Today, through a survey and cataloguing project of all the visible ancient structures, it is possible to unify and compare past and present documentation, with the hope that the recovery and systematization of information will give a new contribution to the stratigraphic and historical interpretation of ancient architectures, highlighting the ancient building palimpsests that can still tell about the history of

13 https://geoportale.regione.lazio.it/geoportale/

this place, even if they have been hastily reburied or covered by restoration works. (fig. 10).

We will perform a general review of all the documentation produced in the *Bagni di Elagabalo* together with a more accurate and exhaustive study of the ancient walls. Our aim is to clarify better the structural and contextual relationships between the Severian construction yard and the surrounding buildings and to formulate wide-ranging and multi-temporal reconstructive hypotheses.

The purposes of this new information system can be briefly summarized here:

- create a single historical archive of all the documentation produced during the investigations: in this way the memory of the research will be delivered to posterity and can be consulted univocally in order to verify the operations carried out, year by year, together with the progressive changes of the site;
- build an integrated management system for the collected archaeological record, both in two-dimensional and three-dimensional format: in this framework new methods can be tested for the effective use of different data;

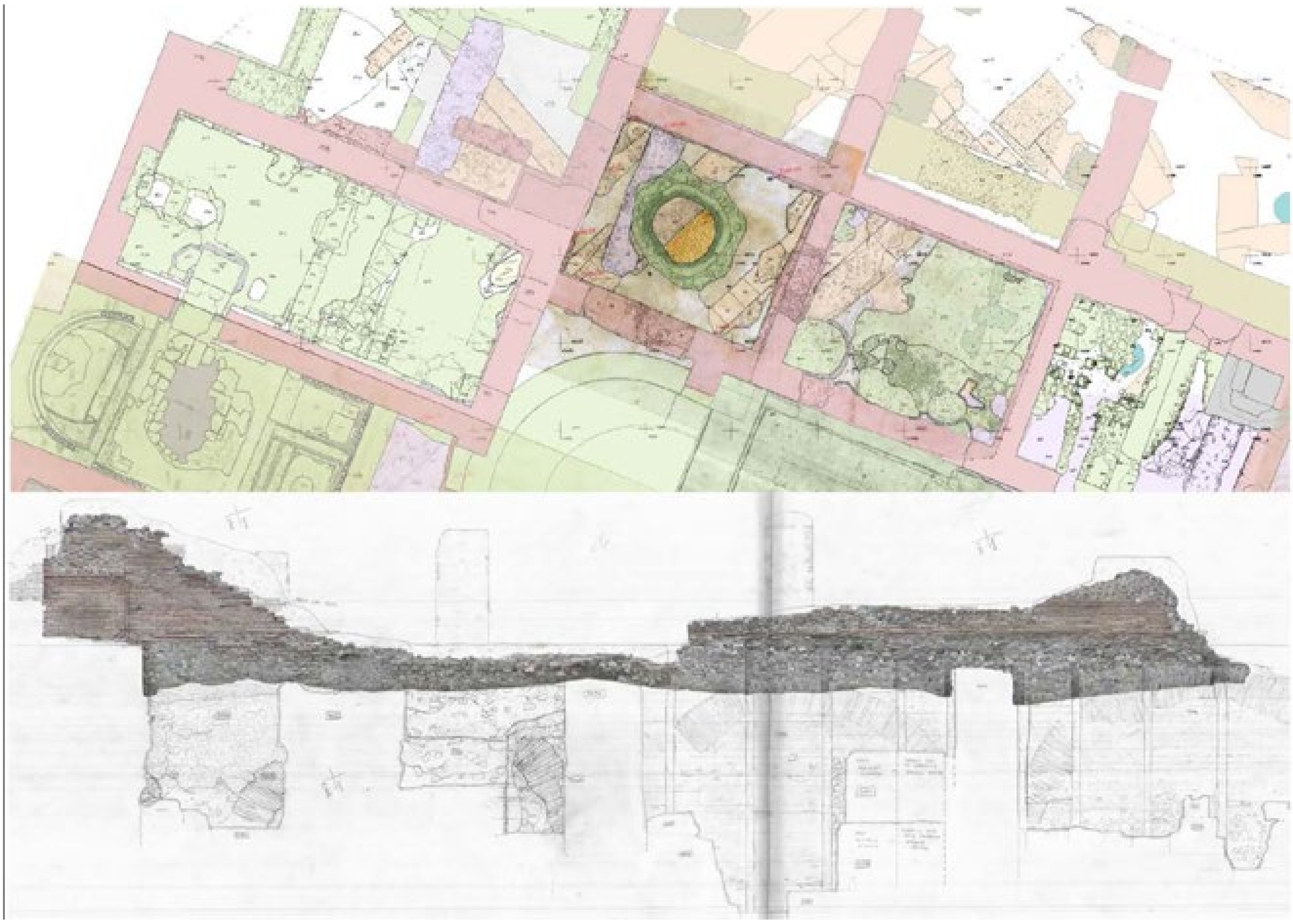


Fig. 10. Traditional survey and 3D survey data integration.

- design a new tool for archaeological analysis linked to the accuracy and precision of 3D surveys: this will be focused on the study of building techniques, production and treatment of materials, organization and logistics of ancient construction yards;
- define better the processes of use, change, destruction and abandonment of the monuments inside the wider urban historical landscape, defining crucial periods for the transformation of the city: in this way it will be possible to tell the millennial history of Rome in a clearer way, using versatile and communicative documents;
- develop web shareable formats of the digital archive to make it accessible through network archaeological resources available today[14]; the documents will be designed to be addressed not only to administrative entities, but also to the scientific community as well as to a wider audience;
- prepare a three-dimensional model as a monitoring device of the area, in order to record the conservation, consolidation and restoration interventions but also to control the deterioration phenomena in progress: this should be functional for planning conservative interventions but also for identifying the causes of pathologies.

E.B., L.F.

Data sharing

Our research was of course also focused on giving access to the scientific community and interested people not only to the data but also the analysis system that we have prepared: paying great attention to the issues of open-data and *ArcheoFoss*, we have tested the migration of the entire dataset with its interrogation and management criteria on the *Qgis*[15] open source platform: doing this, obviously, we had to expand our geodatabase with a section strictly dedicated to metadata, sharing formats and a detailed description of the "origins of information"[16].

Next to the module dedicated to the analytical database of the ancient walls, a new apparatus has been created for the collection of all the data relevant to the docu-

14 See Bogdani 2019.

15 While it is not a problem to share a *shapefiles* format between different GIS products, it is not the same for user interfaces, GUIs, or symbology, which we had to reproduce following the options the *Qgis* software offers.

16 With "*origins of information"* we mean the documentary base referred to each archaeological context: here, in comparison with the meaning of same terminology used by the SITAR (the ministerial archaeological information system of Rome: see Ruggeri and Cecchetti 2011; Serlorenzi et al. 2012), no reference is made to administrative nature contents.

mentary base. Here, photos, 3D models acquired from scratch, sections and elevations, as well as extracts of historical cartography, drawings and all the graphic documentation produced during the excavations, have found their place in the form of attachments.

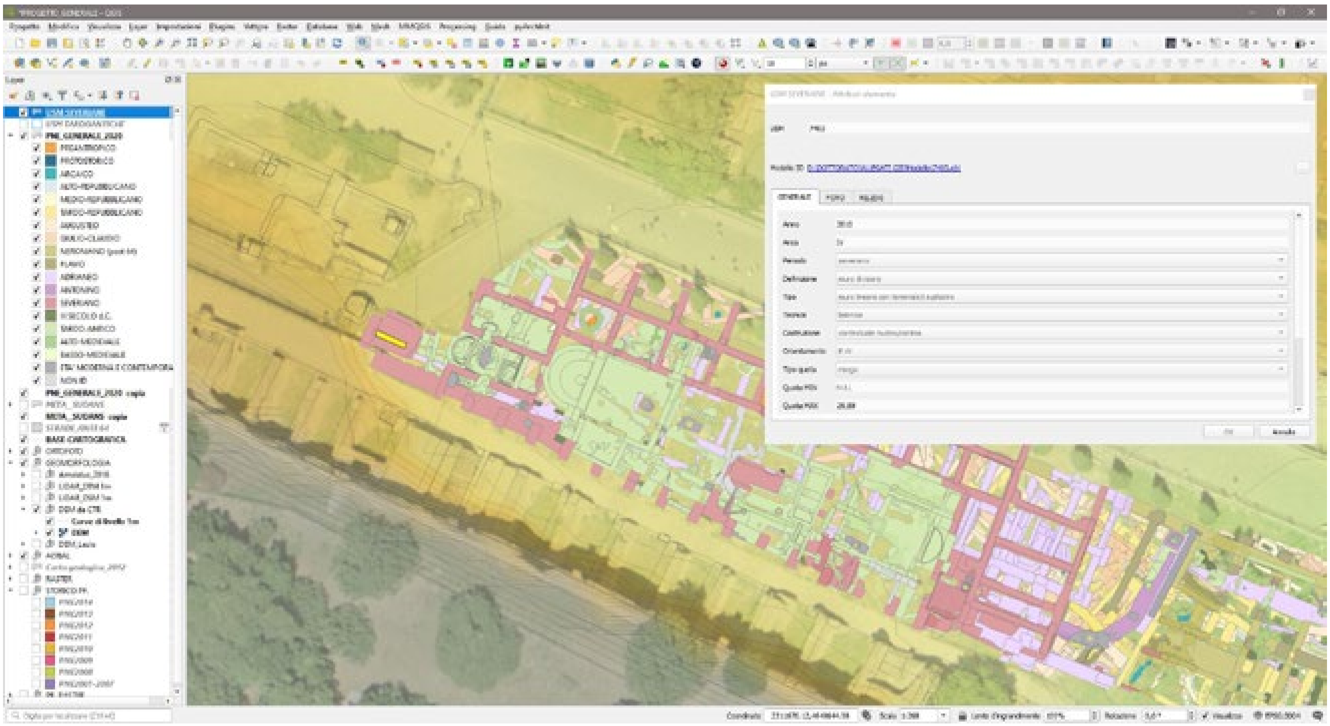
In this way, through a simple query, it is possible to trace the whole corollary of raw and elaborated data that constitute the starting point for the analysis of each context.

Furthermore, the external connection with 3D visualization software[17] allows the graphic quality of the photogrammetric acquisition to be appreciated and for, at least partially, the traditional two-dimensional perspective of GIS to be overcome (Fig. 11, 12).

Although these early developments are still far from the realization the integrated system we want to reach, we believe that the use of an opensource software, giving the option to consult the documentary base of each feature, represents a fundamental step in the perspective of transparency and dissemination of data.

In this way, in fact, starting from the general site map, it is possible to decompose each architecture into its structural context and features and verify the cognitive process for each one of them: passing from photos to 3D models, then to elevations, wall-samples, up to the textual file-cards of synthesis on ancient structures.

Fig. 11. Open-source GIS version: main data inquiry (QGIS)



17 We use *the opensource CloudCompare* (https://www.danielgm.net/cc/) compatible with main systems and able to read the most common 3D formats.

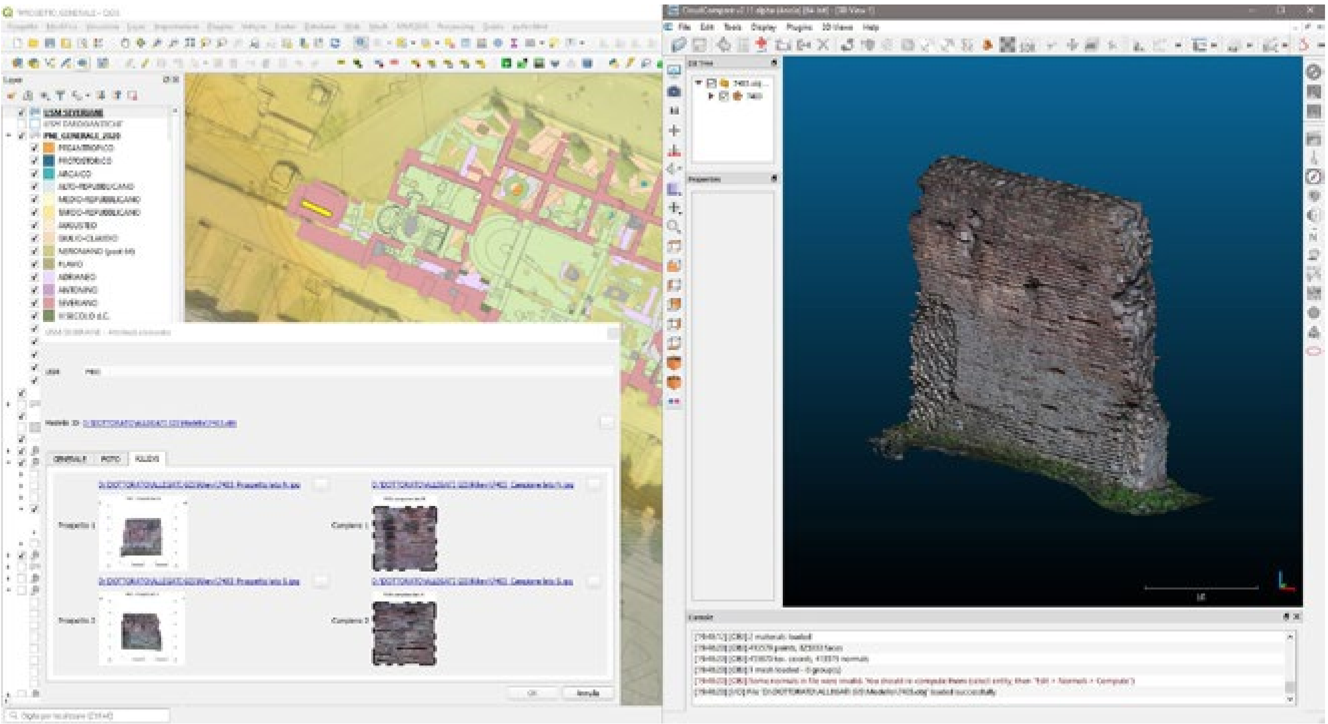


Fig. 12. Open-source GIS version: 3D data visualization (QGIS and CloudCompare)

This further management of raw data requires time and effort: however, this seems sustainable and necessary to offer not only an aseptic sum of data but a digital environment for data sharing and comparison of ideas.

In order to share our data inside the web community and to act in the best way for this purpose, we are testing the export of our spatial documents (mainly shape files) in a *PostGIS* archive, meanwhile we are evaluating and testing the construction of a web-system based on *QGis Server* and *Lizmap*.

To provide us with a communication tool of easier to access, suitable also for not particularly experienced users, we are also thinking to create a Social Network account where we can give updated news about our research and share data in KML and KMZ formats, according to permissions granted by the *Parco Archeologico del Colosseo* that manages the site of our research.

L.F.

Considerations on 3D GIS and BIM for the study of ancient architecture

Having to deal with the above issues we had to take into consideration digital tools and approaches related to ancient architecture, recently performed on 3D structural analysis: from our first survey of actual scientific literature we detected some elements we will have to deal with in the future development of our research.

First of all, in the general framework, we think that it would be more appropriate to make a distinction between software and systems.

In the first case we refer to IT applications or modular software able to manage data, from the acquisition phase up to, through processing steps, correct outputs.

By systems we mean instead a set of procedures connected to a work flow in which the knowledge of individual expertise contribute in the data management and processing phases to the achievement of the desired goal. One of the basic principles of these systems is interoperability, the chance for various professionals to act simultaneously during the process and to exchange data through shareable output formats.

In this perspective it seems to me that the substantial difference between 3D GIS and BIM (*Building Information Modelling*) does not concern the application areas but essentially the different contributions that these tools can give in data-processing, making the two technologies complementary rather than opposite.

In the archaeological field, the recent development of 3D GIS has led to a transition from an exclusively two-dimensional to a three-dimensional perspective, opening new horizons in archaeological data management and making these systems even more useful not only in survey work integration but also in spatial analysis and data contextualization and characterization.

Referring to BIM, we mean a management system for planning, construction and maintenance of brand new buildings. The starting point of the entire system consists in the digital drawing of the features that make up the new constructions together with the related structural and material information. This set of elements can be used in simulation and validation procedures of the entire model, in order to verify the feasibility and the static capacity of the architecture under construction.

The acronym HBIM (*Historic/Heritage Building Information Modelling*) identifies the declination of BIM systems in the management, maintenance and enhancement of historical-architectural heritage[18]. This methodology, however, has to clash very often with the deficit of the designing process of the historical buildings: those, moreover, are present and concrete instead of being in digital format.

While standardized architectural elements are created in the construction of a new building, the same levels of data discretization cannot be adopted for historical building analysis since the final result would inevitably be a simplified replica of reality.

18 About HBIM see Scianna et al. 2015; Adami, Scala and Spezzoni 2017; Canevese and De Gottardo 2017; Nicastro 2017; Brusaporci et al. 2018; Carpentiero 2018; Pratali Maffei, Canevese and De Gottardo 2019.

The BIM approach to historical-architectural heritage cannot be compared to that used by contemporary architecture studios and necessarily requires a general revision of procedures, where the modelling phase cannot be separated from an accurate and detailed three-dimensional survey of the building itself.

In this sense, the *range-based* (laser scanner) and *image-based* (photogrammetry) digital survey techniques offer excellent possibilities for the acquisition of spatial data and for the creation of three-dimensional cloud models of points (almost) adherent to reality. These documents will represent the information base on which, through complex segmentation operations, it will be possible to categorize the single architectural features and components: the aim is the creation of a library of objects retaining the original morphometric elements in order to avoid simplifications and schematizations[19].

Expanding the field of application of HBIM to archaeology, in particular in the elaboration of reconstructive models for ancient buildings, further problems are added to the perplexities just expressed, primarily related to the conservation status of architectural artefacts[20].

In the archaeological field we almost always find buildings often brought down to fragments of walls or just remains of foundations or also, in the most unfortunate cases, hollow spaces that are the indirect evidence of entirely removed structures. In addition to fragmented data, it is also necessary to consider local varieties of construction techniques and material selection: in fact, any reconstructive hypothesis must necessarily take into account information concerning geographical area, chronology and function. In this framework it is clear how fundamental the contribution of tools recording the singularity of the artefacts is, highlighting their contextual peculiarity.

In conclusion, it is evident that for the *Bagni di Elagabalo* the combined use of 3D GIS and BIM systems can represent an effective practice in order to understand the construction methods of the architecture and propose multi-temporal reconstructive models.

Using GIS potentials it will be possible to manage the complete archaeological record in a wider context in order to correlate information not directly linked to each architecture but compatible by stratigraphic position, chronology, typological comparisons, materials and function.

Starting from this base we will proceed then with BIM modelling, verification and visualization of reconstructive hypotheses: our results will represent a point of

19 D'Andrea 2016.

20 About ARCHEOBIM studies see: Garagnani, Gaucci and Govi 2016; Garagnani 2017; Gaucci 2017; Bosco et al. 2018; Bosco et al. 2019.

arrival but also a research trigger since "*le ipotesi ricostruttive costituiscono un modo fondamentale per comprendere, tramite ciò che è scomparso parzialmente o integralmente, ciò che invece ancora esiste*"[21].

The issue of "transparency" as a declaration of the philological relationship with the information at the basis of the reconstructive model represents one of the fundamental principles of our research: this is why we are studying also new methods for visualization and dissemination of the results[22].

Using Computer Graphic solutions and Information and Communication Technology (ICT) we will attempt to create a platform where we can share the complex information system that has fuelled the interpretative process. In other words, it will be a matter of creating a system that makes the archaeological experience accessible by sharing not only the results but also the process of knowledge and interpretation that led to each hypothesis.

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21 "Reconstructive hypotheses constitute a fundamental way of understanding, through what has partially or wholly disappeared, what instead still exists." Carandini 1991, p. 146.

22 See Limoncelli 2012, on the definition of correspondence models.

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