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ROME: NE SLOPES OF THE PALATINE HILL. ARCHAEOLOGY OF ARCHITECTURE AND ANCIENT MASONRIES DEEP ANALYSIS

1. Introduction and archaeological framework

Since 1986 the area of the North East slopes of the Palatine hill facing the Colosseum valley has been the subject of a long archaeological research, carried out by the Dipartimento di Scienze dell'Antichità of the Sapienza, University of Rome[1]. During more than 30 years of excavations, the material remains of big buildings and monumental interventions have been discovered, testifying an environmental and topographical *continuum* where the development of different urban systems has involved a complex physical overlap of structures and architectural complexes, distributed over time (Fig. 1). Starting from the remains of Iron Age huts, found along the slope, we move on to an early urban planning attested by the presence of two sanctuaries dating to the Roman Monarchy (8th-7th century BCE) located along both sides of the ancient road leading to the Roman Forum: one of them can be identified with the *Curiae Veteres* and has been frequented until the affirmation of Christianity.

The installation of a residential district, along the road, is documented already during the archaic period: subsequently this area has been periodically rebuilt in the following centuries, until Augustus age. In this period, at the meeting point of five of the new 14 city zones planned by the emperor, the first *Meta Sudans* fountain was built, in front of the *Curiae Veteres* that were also reconstructed in monumental shape during the years of the emperor Claudius.

A real break-up here happened in conjunction with the great Nero's fire: after this disaster, Nero decided to carry out in this area a deep urban transformation ending with the realization of his majestic palace, the *Domus Aurea*. In the years between 64 and 68 CE a total reorganization of the road system was made, with a regular and orthogonal shape, according to the guidelines dictated by the palace project. In the valley the new architectural complex was characterized by columned porticoes around an artificial pond over which the Flavian dynasty will build the amphitheater; the Palatine hill slopes were regularized in terraces on arcades, while the new street climbing to the Roman Forum was flanked by arched porticoes.

The Flavian urban planning, focused on restoring a public dimension to the urban spaces occupied by the *Domus Aurea*, can be summarized in the

[1] We want to thank Prof. Clementina Panella for giving us the opportunity to participate, for long time, to her research; we also want to thank the staff of the Parco Archeologico del Colosseo (MIBACT) for the permission and support to our work, in particular Dr. Giulia Giovanetti.

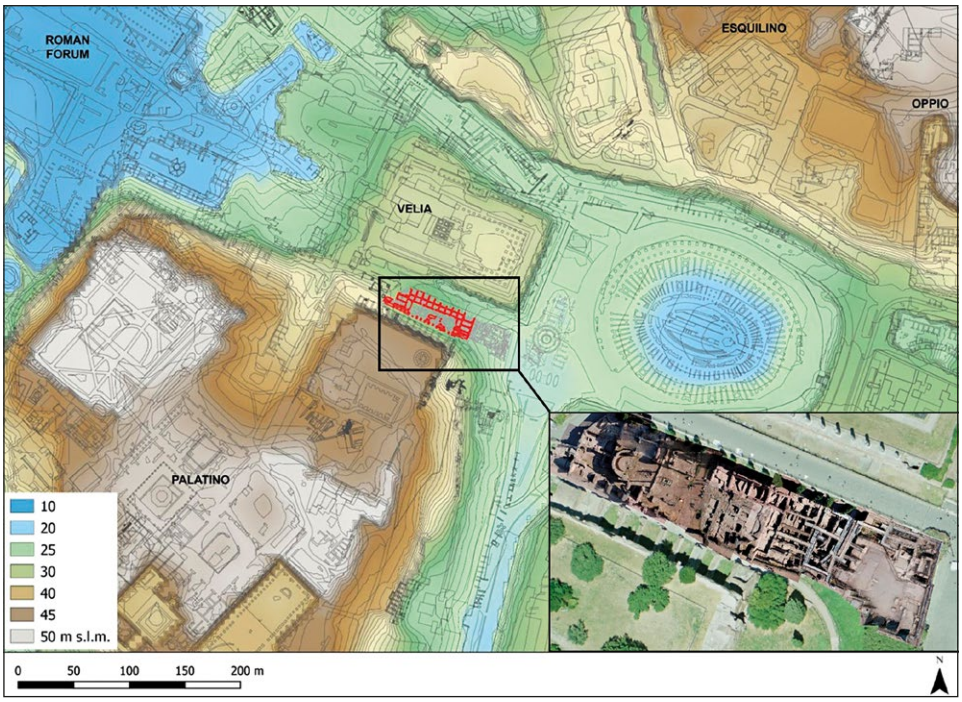

Fig. 1 – The investigated area in the centre of Rome.

reconstruction of the *Curiae* and the *Meta Sudans* fountain, both burnt in the fire, and, of course, in the construction of the Colosseum and its square. The area will be modified again by Hadrian with the construction of the Venus and Rome Temple and, on the opposite side, of a long building flanking the porticoed street going up to the Forum. After another catastrophic fire, at the end of the 2nd century CE the area was rebuilt again by the Severian dynasty: in close connection with the new sanctuary built on the *plateau* of Vigna Barberini, the whole front of North East Palatine's substructures was totally transformed while the previous constructions at its feet, destroyed by the fire, were replaced by a new building with a courtyard commonly called 'Bagni di Elagabalo'. Inside this monument, in the 4th century CE, a large banquet hall was obtained, with gardens and fountains and a small bath in the backyard.

Finally, with the construction of the Constantine's Arch and the restorations at the Venus and Rome Temple, the ancient urban history of the area was completed (for further information on the urban development of this area see Saguì, Cante 2015; Brienza 2016; Panella 2019; Panella *et al.* 2019).

The huge amount of documentation produced to record this stratigraphic sequence required the development of a data storage and management system

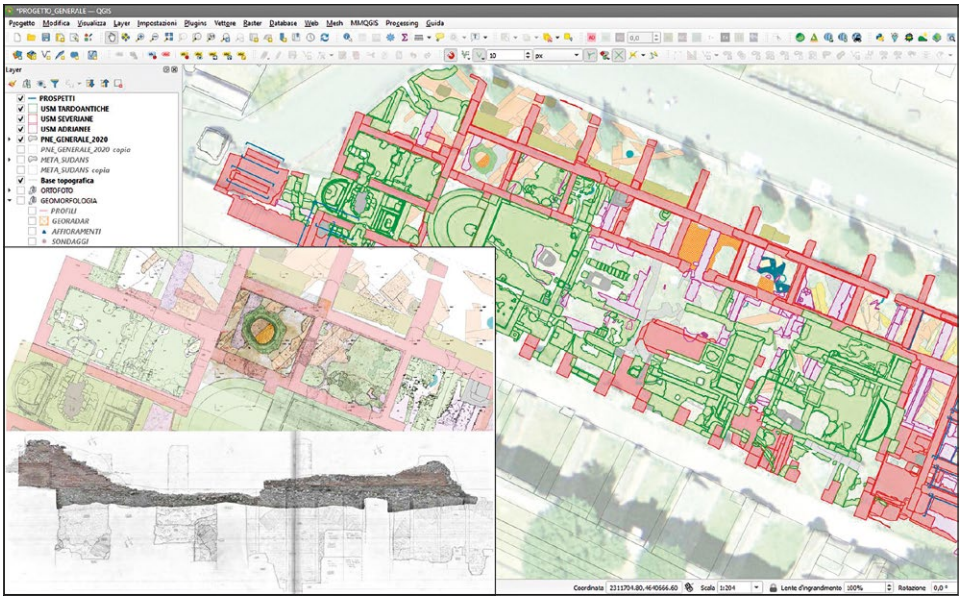

Fig. 2 – Intra-site GIS of the excavations.

dedicated to contextualize information and to propose new elements of research. The full archive is managed by an intra-site GIS for data-retrieving, spatial analysis and for the elaboration of archaeological themes and reconstructive models: this has been implemented using Microsoft Access and ESRI software, like ArcView and later ArcGIS. Over the years, this system has been updated in software, for the advent of new IT products, and in data contents: inside our spatial database, today, digital and analogical documentation (in particular handmade archaeological drawings and on-paper archaeological forms) are managed together, in order to maintain the integrity of the archive and the history of the research itself (Fig. 2) (Brienza 2006; Panella, Brienza 2009; Panella, Fano, Brienza 2015).

In order to achieve the best results in this operation, a memorandum of agreement has been approved by the Sapienza, University of Rome, the Kore University of Enna and the ISPC-CNR (Institute of Heritage Science, former Istituto per le Tecnologie Applicate ai Beni Culturali, ITABC), institution that since 2007 has collaborated with our research in particular in 3D survey and integrated geophysical prospecting (Piro 2006; Panella, Gabrielli, Giorgi 2011; Caratelli 2013; Giorgi 2013). During these years a big amount of raw data has been preserved in two different repositories, while only final elaborations were shared by the research staff: now we are working in order

to unify the separate archives in a single spatial database, for investigation purposes but also for deontological instances, in order to leave a complete and single testimony of all our activities carried out in this important archaeological site during these decades.

Our intention is focused on giving access to the scientific community, but also to interested people, not only to the data (both synthetic and in-depth format) but also to the analysis system itself: paying great attention to the issues of open-data, ArcheoFOSS[2] and public archaeology (Volpe 2020) we have tested the migration of the entire dataset and its interrogation criteria and tools to an open-source webGIS platform, using web-oriented DBMS like PostgreSQL + PostGIS and GIS software like QGIS Server + LizMap.

In this new digital environment, starting from the general site map, it is possible to decompose the single architectures into their structural contexts 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 general synthesis of file-cards and records of ancient structures (Brienza *et al.* c.s.).

E.B.

2. Methods and tools

The study of ancient architectures today can adopt survey tools able to quickly detect objects in 3D with a certain precision: through these tools we have produced ortho-photo-plans that, gradually, have joined the traditional bidimensional documentation. We have also proposed three-dimensional sequences of excavated stratigraphic sequences as well as the reproduction of some ancient artifacts, suggesting their virtual-digital restoration.

Using image-based-modelling photogrammetry techniques based on Structure from Motion (having accuracy and photographic texturing) we made a new and very detailed 3D documentation of the ancient walls (about these techniques see Remondino, Campana 2014; Zachar, Horňák, Novaković 2017; Bianconi, Filippucci 2019).

For digital photogrammetry we have used the Agisof Metashape software, supported by total station to take precise measures (at least 5 targets for each façade) directly linked to our topographical network, in order to obtain an integrated and georeferenced survey. A 24.2 megapixel Canon EOS D200 reflex camera, with image stabilizer and a focal length of 18 mm, was used for the photos; in addition, a tripod and a telescopic rod were used to ensure better quality and to reach masonry sectors at high altitude; an

[2] About ArcheoFOSS, free and open-source software for archaeology, and the numerous international workshops organized from 2006 until today see http://archivio.archeofoss.org/.

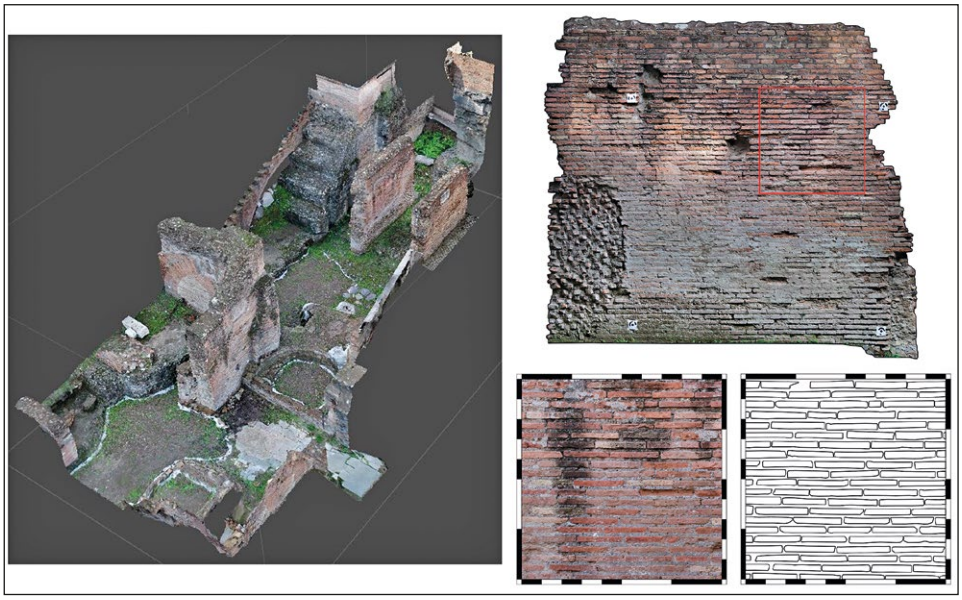

Fig. 3 – 3D survey of the ancient walls.

average of 30-40 shoots were taken for each acquisition, trying in this way not to burden the processing times.

Each wall was taken up completely, maintaining a constant distance: particular attention was paid to have a maximum accuracy survey of 1 sqm area samples, taken from facades, maintaining a maximum distance of 1 m, in order to obtain images with a high level of detail; in this way it was possible to use very-high quality orthophotos, having an average detail level between 0.2-0.4 mm pixel, for the stratigraphic reading and for samples quantifications (Fig. 3).

The new documentation included also a new Database Management System, following usual formats form ancient walls recording, but updating contents in consideration of the recent guidelines coming from the *Archaeology of Construction* and from the *Archaeology of Achitecture* (Camporeale, Dessales, Pizzo 2008, 2010, 2012; Brogiolo, Cagnana 2012; Bonetto, Camporeale, Pizzo 2014; Camporeale, De Laine, Pizzo 2016). We have planned a new file-card format to register information about the logistic of the ancient construction yards and the related dynamics on material production and ancient building organization, in addition to data relating to their measures, composition and nature.

In this way the chrono-typological analysis, which traditionally focuses on the recognition of the construction features by material aspect, has been

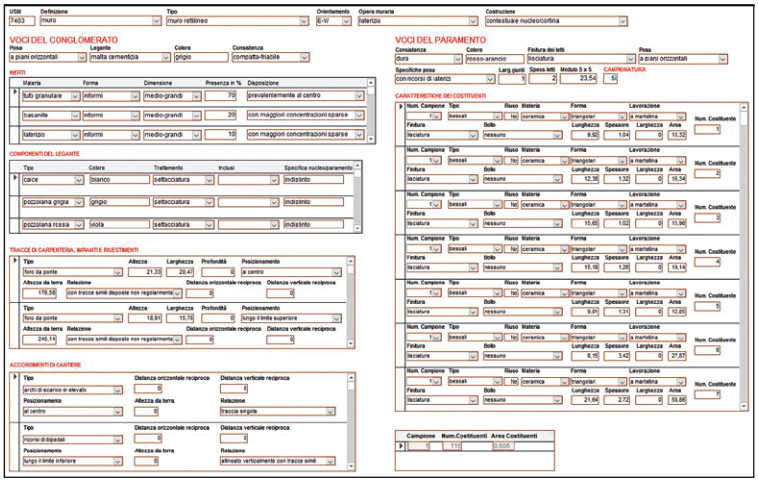

Fig. 4 – DBMS for ancient structures recording.

expanded with the collection of information related to building methods such as, for example, structural expedients for static stability, specific materials selection in relation to particular needs or quantification of the work in terms of time and number of the workers. Defining trends, measures 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 understand the formative dynamics of the ancient architectures and must be done through observation of details on the basis of a precise and clearly legible survey. Obviously, in order to normalize the data entry and editing, we have encoded standard glossaries while the detailed morphometric information, derived from autoptic analysis of samples taken from wall facades (normally their size is 1 sqm), is managed by sub-cards where each 'constituent' (i.e. brick, block, etc.) is organized by type, use/reuse, material, manufacture, finishing, and measures (Fig. 4).

Elaborations from photogrammetry have been vectorized in GIS environment; for this purpose, 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 documentary base. Here, photographs, 3D models acquired from scratch, sections and elevations, drawings and all the graphic documentation produced during the excavations, have found their place. 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.

For the quantifications of information coming from wall-facades-samples we have performed two GIS analysis procedures, comparing the DBMS data taken directly on the field, counting bricks and measures on wall facades, with those obtained automatically on spatial vector drawings made on very detailed orthophotos; in other words, the analyses were carried out on the same samples but using different ways: despite this, the results were indeed very similar, giving us a good indicator of a correct method.

Through the use of a series of expressions specifically dedicated it is also possible to calculate automatically and expeditiously the variable of the constituent/conglomerate ratio, but also the dimensions of the components of the facades with their degree of homogeneity and variability (about this type of investigation see Medri *et al.* 2016; Medri 2017; Serlorenzi, Camporeale 2017).

L.F.

3. Conclusions

Through the methodologies and tools described above, it is now possible to evaluate specific aspects of the ancient construction yards for each period, such as the extent of resources supply, the reuse index and building materials selection level and consequently refine the chronological sequence of the construction phases of the individual buildings. Furthermore, being able to have such a complex sequence of building interventions and referring them to public and private architectures, it is possible to plan a comparative analysis of the construction techniques adopted in relation to both chrono-typological aspects and to particular contingencies. Finally, we have a bigger chance to clarify the structural and contextual relationships of each construction yards with the surrounding buildings, in order to formulate wide-ranging and multi-temporal reconstructive hypotheses.

Some first outcomes of our work can be briefly exposed here. First of all, our 'very-close-range' photogrammetry approach to structural archaeological evidences, using very high definition shoots of samples and supported by total station, with automatic measurement of vectorial features, has given very encouraging results if compared to measures of samples directly taken, with a tape and one by one, on the ancient walls: the dimensions of bricks and other building components of the archaeological structure are always almost the same in both cases and mismatches are very few and very little.

In addiction, the colours and the type of materials can be clearly distinguished. This means that a mensio-chronological approach using this method can be correct; obviously a total analysis of building materials and their treatments (specially for mortars, concretes and conglomerates) still needs a direct autopsy, physical and material, of archaeological evidence.

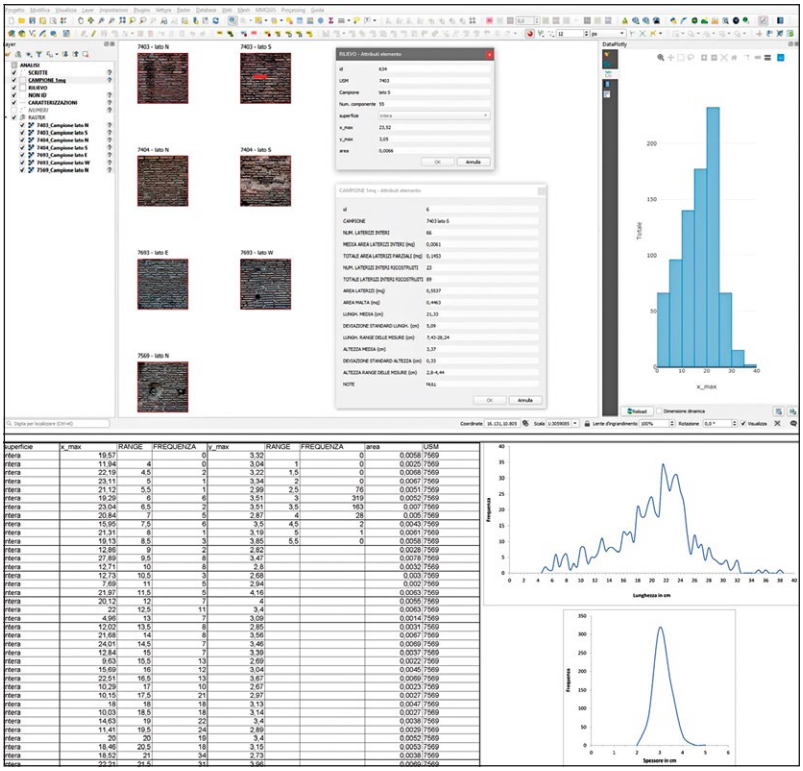

Fig. 5 – Sample analysis and statistics.

In particular cases, anyway, for emergency or during seasonal researches in foreign countries, this expeditive approach can be adopted on the field, obtaining reliable results in the subsequent study phase in the laboratory.

Another result of archaeological and architectural nature, which will be better studied during future research, concerns the accentuate reuse of building materials during the Severian age, which, compared to the topographical context (we are next emperor's palace in Rome) and the chronology (generally this building practice in the Capital is peculiar of Late Antiquity), seems to be an unusual phenomenon. However, as already detected here by a previous study of brick stamps found *in situ*, which shows the use of Hadrian's bricks in Severian masonry (Botticelli 2017), our overall analysis of the walls belonging to this period seems to confirm a very frequent use of fragmented and heterogeneous bricks that do not seem to be of new manufacture but recovered from older structures (Fig. 5). This recovery was probably facilitated by the state of the rubble after the fire of 192 CE and

by the fact that the Severian brick facades were projected to be covered by decorative layers and surfaces. Despite actual pandemic situation, we hope to be soon able to clarify and to publish next developments of our research, together with our ISPC partners.

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REFERENCES

Bianconi F., Filippucci M. 2019, *La fotomodellazione per il rilievo archeologico*, «Archeologia e Calcolatori», 30, 205-228 (https://doi.org/10.19282/ac.30.2019.13).

Bonetto J., Camporeale S., Pizzo A. (eds.) 2014, *Arqueología de la Construcción IV. Las canteras en el mundo antiguo: sistemas de explotación y procesos productivos*, Mérida, Archivo Español de Arqueología, Suppl. 69.

Botticelli D. 2017, *Epigrafia del costruito. Bolli laterizi dallo scavo delle Pendici Nord Orientali del Palatino (Area IV, anni 2007-2008)*, in C. Panella, V. Cardarelli (eds.), *Valle del Colosseo e pendici nord-orientali del Palatino. Materiali e contesti 3*, Roma, Scienze e Lettere, 49-96.

Brienza E. 2006, *Un GIS Intra Site per la valle del Colosseo: concetti, metodi, applicazione,* «Scienze dell'Antichità», 13, 123-139.

Brienza E. 2016, *Valle del Colosseo e pendici nord-orientali del Palatino. La via tra valle e foro: dal dato stratigrafico alla narrazione virtuale (64 d.C.-138 d.C.)*, Roma, Quasar.

Brienza E., Caratelli G., Giorgi C., Fornaciari L. c.s., *NE Palatine slopes: Open-source methodologies and tools for the analysis of ancient architecture*, in *Proceedings of 14st ArcheoFOSS International Conference (2020)*, in corso di stampa.

Brogiolo P., Cagnana A. 2012, *Archeologia dell'architettura. Metodi e interpretazioni*, Firenze, All'Insegna del Giglio.

Camporeale S., DeLaine J., Pizzo A. (eds.) 2016, *Arqueología de la Construcción V. Man-made Materials, Engineering and Infrastructure*, Madrid, Archivo Español de Arqueología, Suppl. 77.

Camporeale S., Dessales H., Pizzo A. (eds.) 2008, *Arqueología de la Construcción I. Los procesos constructivos en el mundo romano: Italia y provincias occidentales*, Mérida, Archivo Español de Arqueología, Suppl. 50.

Camporeale S., Dessales H., Pizzo A. (eds.) 2010, *Arqueología de la Construcción II. Los procesos constructivos en el mundo romano: Italia y provincias orientales*, Madrid-Mérida, Archivo Español de Arqueología, Suppl. 57.

Camporeale S., Dessales H., Pizzo A. (eds.) 2012, *Arqueología de la Construcción III. Los procesos constructivos en el mundo romano: la economía, de las obras*, Madrid-Mérida, Archivo Español de Arqueología, Suppl. 64.

Caratelli G. 2013, *L'aula "cruciforme" e lo* stibadium *delle "Terme di Elagabalo*, in C. Panella, L. Saguì (eds.), *Valle del Colosseo e pendici nord-orientali del Palatino. Materiali e contesti 1*, Roma, Scienze e Lettere, 87-120.

Giorgi C. 2013, *Terme di Elagabalo. Il* balneum *tardoantico: studio archeologico e rilievo 3D*, in C. Panella, L. Saguì (eds.), *Valle del Colosseo e pendici nord-orientali del Palatino. Materiali e contesti 1*, Roma, Scienze e Lettere, 55-86.

Medri M. 2017, *Studio dei paramenti laterizi delle Mura Aureliane. 1. Osservazioni generali*, in *Le Mura Aureliane nella storia di Roma. 1. Da Aureliano a Onorio*, *Atti del Primo Convegno (Roma 2015)*, Roma, RomaTre Press, 41-67.

Medri M., Di Cola V., Mongodi S., Pasquali G. 2016, *Quantitative analysis of brick-faced masonry: Examples from some large imperial buildings in Rome*, «Arqueología de la Arquitectura», 13, 1-8.

Panella C. 2019, *I contesti e le stratigrafie*, in M. Papini (ed.), *I reperti scultorei dalle "Terme di Elagabalo". Il ritrovamento, il restauro, l'edizione*, Roma, Quasar, 9-54.

Panella C., Brienza E. 2009, *Il geodatabase della valle del Colosseo e del Palatino nord-orientale ed il trattamento digitale del dato archeologico*, «Bollettino della Società Italiana di Fotogrammetria e Topografia», 3, 9-18.

Panella C., Fano M., Brienza E. 2015, *30 years of urban archaeology: Measuring, interpreting and reconstructing*, in *Proceedings of 1st IMEKO International Conference on Metrology for Archaeology (Benevento 2015)*, Benevento, 49-54 (https://www.metroarcheo.com/ma2015/files/MetroArcheo2015_Proceedings.pdf).

Panella C., Ferrandes A.F., Iacomelli G., Soranna G. 2019, Curiae Veteres. *Nuovi dati sulla frequentazione del santuario in età tardo-repubblicana*, «Scienze dell'Antichità», 25.1, 41-71.

Panella C., Gabrielli R., Giorgi C. 2011, *Le Terme di Elagabalo sul Palatino: sperimentazione di un metodo fotogrammetrico 3D applicato allo scavo archeologico*, «Archeologia e Calcolatori», 22, 243-260 (http://www.archcalc.cnr.it/indice/PDF22/AC_22_Panella_et_al.pdf).

Piro S. 2006, *Indagini georadar ad alta risoluzione nell'area delle pendici nord-orientali del Palatino*, «Scienze dell'Antichità», 13, 141-156.

Remondino F., Campana S. (eds.) 2014, *3D Surveying and Modelling in Archaeology and Cultural Heritage. Theory and Best Practices*, BAR International Series 2598, Oxford, Archaeopress.

Saguì L., Cante M. 2015, *Archeologia e architettura nell'area delle "Terme di Elagabalo", alle pendici nord-orientali del Palatino. Dagli isolati giulio-claudii alla chiesa paleocristiana*, «Thiasos», 4, 37-75.

Serlorenzi M., Camporeale S. 2017, *Anatomia di un muro romano: dati preliminari sullo smontaggio e quantificazione di alcune strutture in laterizio di epoca adrianea dallo scavo di Piazza Dante a Roma*, «Arqueología de la Arquitectura», 22, 21-33.

Volpe G. 2020, *Archeologia pubblica. Metodi, tecniche, esperienze*, Roma, Carocci.

Zachar J., Horňák M., Novaković P. (eds.) 2017, *3D Digital Recording of Archaeological, Architectural and Artistic Heritage*, Ljubljana, CONPRA Series 1, University of Ljubljana-Faculty of Arts.

ABSTRACT

The NE slopes of the Palatine hill and the Colosseum valley area have a long archaeological research history. Here the continuous urban development has produced the overlap of architectural complexes distributed over time. The huge amount of archaeological documents produced by the research is managed within a GIS environment. For the analysis of ancient walls we introduced the use of image-based-modelling photogrammetry in order to create a very detailed 3D documentation linked to a DBMS dedicated to ancient structural features. Through this methodology we can evaluate specific aspects of ancient construction yards for each period. We can also refine the chronological sequences of the architectural structures and verify the contextual relationships of the surrounding buildings in order to formulate wide-ranging reconstructive hypotheses.