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Open software, hardware, processes, data and formats in archaeological research

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edited by
Julian Bogdani, Riccardo Montalbano,
and Paolo Rosati

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and Paolo Rosati

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Foreword

This volume represents the editorial outcome of the 14th edition of ArcheoFOSS international conference, which took place on 15–17 October 2020 on the World Wide Web. The event has been held annually since 2006 and is dedicated to the theoretical framework and actual application of free and open-source software solutions and the promotion and encouragement of the Open Data paradigm for archaeology and, more generally, for Cultural Heritage.

Compared to the past editions, the 2020 conference introduced some substantial changes. First of all, the pandemic crisis due to the COVID-19 outbreak, forced us for the first time to hold a Web-based conference, a solution that introduced some important advantages. For example there was the facility to overcome geographical distances and therefore greatly broadening participation, both in terms of speakers (presentations, workshops, demos) and audience. Additionally we had the possibility to share thoughts on the specific topics of the conference with foreign colleagues from different backgrounds (universities, research centres), widening consequently the network of collaboration. We hope that the effort to open the ArcheoFOSS conference beyond Italian national borders – and beyond a small circle of individuals who in the last years have tenaciously and with great difficulty tried to keep alive the spirit of the conference – will not remain isolated, but will be further pursued in the next editions.

Another innovative aspect was the introduction of a panel dedicated to open data, open formats and open standards. While these topics have not been absent in the previous editions, the main focus has always been on the development and application of FLOS software and hardware solutions for Cultural Heritage. By specifically calling for papers dealing with the free sharing of data, we tried to go beyond software and technological development. Open and reusable data publishing platforms, available in open formats, and distributed with open licenses with no bias on the tools with which the data were created. The aim was to encourage and enhance the creation and publication of open archaeological archives, easily re-usable by the community.

This volume well represents the approach taken at the conference and the extensive participation it received. Eighteen high-level and peer-reviewed papers, well distributed in two thematic sections – application cases and development, and open data – contributed by more than forty Italian and foreign scholars, researchers and freelance archaeologists working in the field of Cultural Heritage. For an event organized at no cost, without funding or support of any kind, these are significant numbers, which reward us for the great organizational and editorial effort. The most important budget line was invested in releasing this book as open-access, using a CC BY license. We strongly believe that the conference proceedings must strictly follow the spirit of the event, and that the free distribution and sharing of the volume is a *conditio sine qua* non for its publication. This also marks a break with the past, when open-access was not always a prerequisite. It is worth noting, furthermore, that these proceedings are being published only one year after the conference. This is a decisive turnaround, which testifies to the strong will to revitalize the ArcheoFOSS community. Technology is evolving very fast, and it is not uncommon to read on fresh publications about outdated software and

workflows or scripts that have already disappeared, greatly reducing or nullifying the utility of the publication, if not (perhaps) for the academic careers of its authors.

Not strictly related to this book, but important to the ArcheoFOSS community, was the decision to accelerate the publication of the 2019 edition, which was neglected due to financial issues and the outbreak of the COVID-19 pandemic. Furthermore, it was decided to alternate 'lighter' versions of the conference, mostly focused on workshops and hands-on sessions, demos, etc. and more 'traditional' ones, based on paper presentations. This will hopefully facilitate the prompt publication of the proceedings and regain a closer relationship with younger and frequently more active researchers.

Looking to the future, we all hope for the end of the current pandemic emergency, but it is clear how much this crisis sped up many cultural processes already ongoing, by changing our lives, our way of researching, teaching, experiencing and communicating archaeology.

In the coming years, the financial resources earmarked to fund digital projects in the field of Cultural Heritage will be substantial (consider, for example, the Italian National Recovery and Resilience Plan). The challenge for our community is therefore to stand ready to proactively suggest solutions to govern and guide this change, rather than passively undergo it.

As editors, we would like to thank WikiMedia Italia and the Ministero della Cultura – Direzione Generale Educazione, ricerca e istituti culturali for financially supporting the publication of these Proceedings; the University of Pisa, which granted us the use of the infrastructure and support for the streaming of the three-day conference; the colleagues of the Organising Committee, who shared with us the organization of the conference; the scholars and researchers who supported us as reviewers in the evaluation process for the conference and for the publication. Last but not least, we thank the members of the outgoing and current Scientific Committee, whose experience and competence guarantee the scientific quality of ArcheoFOSS initiatives.

The Editors

Julian Bogdani
Riccardo Montalbano
Paolo Rosati

ArcheoFOSS 2020 Committees

Scientific committee (alphabetical order)

Luca Bezzi
luca.bezzi@arc-team.com
Independent researcher and member of ArcTeam, Cles (TN)
Founder of the ArcheoFOSS conference

Paola Buzi
paola.buzi@uniroma1.it
Full Professor of Egyptology and Coptic Civilization at Sapienza University of Rome
Honorary Professor of Egyptology at Hamburg University
Director of the Research Centre 'DigiLab' - Sapienza University of Rome

Elena Calandra
ic-archeo@beniculturali.it
MiBACT, Director of Service II - Excavations and Protection of the Archaeological Heritage, Directorate General for Archaeology, Fine Arts and Landscape
Director ad interim of the Central Institute for Archaeology

Marco Callieri
marco.callieri@isti.cnr.it
First Researcher at the Visual Computing Lab, CNR-ISTI, Pisa

Enzo Cocca
enzo.ccc@gmail.com
GIS consultant for the Honor Frost Foundation (Southampton) for which he is in charge of data management of maritime and land archaeological surveys in Lebanon.

Andrea D'Andrea
dandrea@unior.it
Director of the Interdepartmental Centre for Archaeology Services of the University of Naples L'Orientale

Benjamin Ducke
benjamin.ducke@dainst.de
Director of the Department of Information Technology – German Archaeological Institute (DAI), Berlin Headquarters

Responsible for the development and implementation of Open-Source software for archaeology and the research infrastructure of the Institute (iDAI.world).
Gabriele Gattiglia
gabriele.gattiglia@unipi.it
Researcher of Archaeological Research Methodologies at the University of Pisa

Antonella Guidazzoli
a.guidazzoli@cineca.it
CINECA and University of Bologna
Head of VISIT (Visual Information Technology) Lab CINECA

Anna Maria Marras
annamaria.marras@unito.it
University of Turin

Paola Moscati
paola.moscati@cnr.it
CNR, Research Manager at ISPC

Antonella Negri
antonella.negri@beniculturali.it
Central Institute for Catalogue and Documentation (ICCD) – Ministry for Cultural Heritage and Activities and Tourism (MiBACT)
Architect officer, responsible for the 'General Catalogue Quality Service' and contact person for the General Catalogue Information System (SIGECweb)

Silvia Orlandi
silvia.orlandi@uniroma1.it
Associate Professor of Epigraphy at Sapienza. University of Rome
Director of the Epigraphic Database of Rome (EDR)

Sofia Pescarin
sofia.pescarin@cnr.it
CNR and University of Bologna; former head of 'Virtual Heritage: integrated digital technologies for the knowledge, enhancement and communication of cultural heritage through virtual reality systems'.
Chief Editor since 2017 of 'Elsevier Digital Application in Archaeology and Cultural Heritage' (DAACH)

Alessandro Pintucci
alessandro.pintucci@gmail.com
Archaeologist

Serena Sensini
serena.sensini@gmail.com
Roma Tre University

Mirella Serlorenzi
mirella.serlorenzi@beniculturali.it
MiBACT officer
Since 2007 he has been directing and coordinating the SITAR (Sistema Informativo Territoriale Archeologico di Roma) project of the Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma, for the creation of the first archaeological cadastre of the City.

Valeria Vitale
valeria.vitale@sas.ac.uk
University of London
Pelagios Commons Education Director

Organizing committee (alphabetical order)

Julian Bogdani
Sapienza University of Rome
julian.bogdani@uniroma1.it

Emanuel Demetrescu
VHLab, CNR-ISPC Rome
emanuel.demetrescu@gmail.com

Sara Gonizzi Barsanti
Politecnico di Milano
sara.gonizzi@gmail.com

Saverio G. Malatesta
DigiLab, Sapienza University of Rome
saveriogiulio.malatesta@uniroma1.it

Luca Mandolesi
adArte Srl. Rimini
luca@adartesnc.com

Riccardo Montalbano
University of Pisa
ricca.montalbano@gmail.com

Augusto Palombini
CNR, Rome
augusto.palombini@gmail.com

Paolo Rosati
Sapienza University of Rome
paolo.rosati@uniroma1.it

Rome – NE Palatine slopes: open-source methodologies and tools for the analysis of ancient architectures

Emanuele Brienza, Giovanni Caratelli, Lorenzo Fornaciari, Cecilia Giorgi

Emanuele Brienza, University of Enna 'Kore'; emanuele.brienza@unikore.it
Giovanni Caratelli, CNR-ISPC; giovanni.caratelli@cnr.it
Lorenzo Fornaciari, University of Salerno; lorenzo.fornaciari88@gmail.com
Cecilia Giorgi, CNR-ISPC; cecilia.giorgi@cnr.it

Abstract
The excavations of the NE slopes of the Palatine Hill in Rome has been the subject of a long archaeological research. Under the direction of C. Panella, the remains of many architectures and buildings have been unearthed, part of an urban tissue made by a continuous stratigraphic overlapping. Within this framework, our research has been focused on 3D survey, building archaeology, WebGIS and data sharing, experiencing the migration of our data set, analogical and digital, into free and open-source products. This article takes into consideration not only technical aspects but also the possibility of renewing methods for collecting, managing and sharing archaeological information.

Keywords: 3D SURVEY; BUILDING ARCHAEOLOGY; WEBGIS; DATA SHARING.

Introduction

The area of the NE slopes of the Palatine, next to the Colosseum valley, has been investigated by archaeological research carried out by 'Sapienza' University of Rome for more than 30 years. This research gave light to countless material remains, ancient buildings and monuments, testifying an environmental and topographical *continuum* of different urban systems from the Iron Age to contemporary era. All kinds of new and updated methods, techniques, instruments, and devices have been involved, following, on a parallel theoretic line, the most valid and innovative research branches in archaeology. In this brief contribution we want to illustrate some new developments of our research, relating 3D survey, data-sharing and dissemination, using free and open-source tools as a philosophical and deontological matter.

E.B.

3D surveys of the 'Baths of Elagabalus'

CNR-ISPC (formerly CNR-ITABC) is involved in the survey, documentation and study activities of the archaeological structures found on the northeast slope of the Palatine and, especially, those around the so-called 'Baths of Elagabalus'. This involvement is neither fortuitous nor recent, since the authors professionally trained in this sector of the hill, which was – and still is – the best opportunity to address the archaeological heritage of the city of Rome (Caratelli 2013; Giorgi 2013).

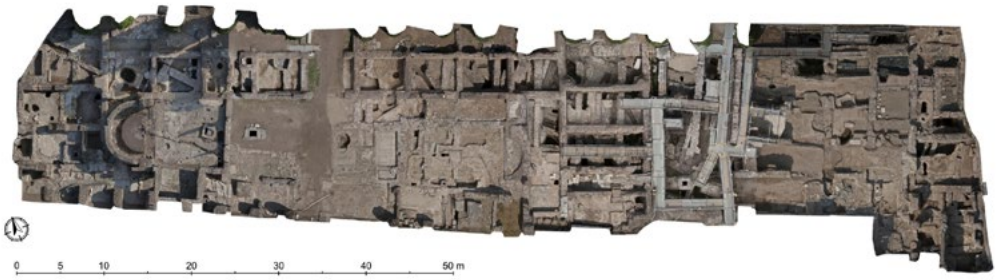

Figure 1: Rome, NE Palatine slopes. Orthophotomosaic produced by CNR at the end of the 2012 excavation campaign.

As is well known, the 'Baths of Elagabalus' – systematically investigated by 'Sapienza' University of Rome from 2007 to 2013 – are the largest portion of the excavation on the northeast slope of the Palatine (conventionally named *Area IV*). This excavation, configured as a logical extension of the fruitful archaeological investigations started in 1986 near the *Meta Sudans* (Panella 1996), is certainly one of the most complex and significant urban archaeology operations of recent years. In addition to the quality of the findings, due to the extraordinary uniqueness of the topographical context, and to the exemplary conduction of the excavation (which trained dozens of professionals), we also must acknowledge the director's openness towards colleagues from other universities and research institutes, which allowed CNR-ISPC's early involvement.

This involvement manifested itself especially in the frenetic documentation activity and analysis of the hundreds of archaeological structures that were found, by using and experimenting with modern survey technologies (laser scanner and digital 3D photogrammetry). To have an idea of the quantity of unearthed wall structures, it is sufficient to look at the orthophoto mosaic produced at the end of the 2012 excavation campaign (Figure 1). It clearly shows the complex layering of walls, resulting from the constant alternation of construction and destructive actions through time. However, it is also an excellent example of the intense and extended activity of photogrammetric survey, systematically performed by CNR-ISPC's Survey Lab at the end of each excavation campaign, from 2010 to 2012. The surveys performed with a 3D laser scanner in the context of two Master and specialization theses should also be considered as part of this activity (Panella, Gabrielli, and Giorgi 2011; Giorgi 2013).

In this context, the recent memorandum of agreement stipulated between CNR-ISPC, 'Sapienza' University of Rome and University of Enna 'Kore' is offering stimuli to launch a new season of studies and research, which should lead to the complete and systematic publication of the archaeological data in a few years. Indeed, a complete edition has not yet been produced. Therefore, in view of this fundamental and essential objective, the direction of the excavation has started a series of initiatives to recover, verify and reorganize the entire set of archaeological documentation that has been produced (it consists of a set of stratigraphical unit records, photographs, and drawings, both in digital and analogue formats, which fortunately have already been partly included in the intra-site GIS of the excavation). This documentation will form the database necessary to address the reading and analytic reconstruction of the various historical phases that, since protohistory until the Middle

Ages, have followed each other in this area, creating an extremely complex and significant stratigraphic and archaeological palimpsest.

In the new knowledge framework that should emerge from this substantial reconsideration of the gathered data, a punctual survey of the discovered archaeological structures surely could not be omitted. This should be understood mainly as a powerful knowledge tool, but also as a spatial-geometric basis to address, organize and support the vast amount of information that was produced. However, this objective, which could otherwise seem 'ordinary', in the context of the 'Baths of Elagabalus' involves several difficulties, generating a veritable challenge. Indeed, from 2013, when the archaeological surveys ended, to the present day, the area has undergone a still-ongoing, extended restoration operation (Asciutti 2015) to enable the public reopening of this sector of the Palatine slope, seriously compromised by the long exposure of the walls to climate factors. Therefore, these new interventions, were added to the heavy and often disrupting manipulations that affected this area throughout history until very recently (consider, for example, the circumstances of the discovery – following the indiscriminate digging of the large area between the Arch of Titus and the Arch of Constantine – and last century's restorations). The new actions have necessarily altered or – in the worst cases – covered the unearthed wall structures.

In these circumstances, and because the excavation is no longer directly accessible in many sectors, the photogrammetric surveys by CNR-ISPC are particularly valuable, the photographic archive being certainly an important and fundamental source of information for structures that are no longer visible or accessible.

In fact, the digital photos taken in past years have recently been recovered, in the context of the above-mentioned agreement. This data set, already used to produce general views of the excavation and in the analysis of areas investigated by the graduation theses, are being reprocessed using current Image-Based Modelling and Rendering techniques to represent the area as it was when the archaeological surveys ended, specifically in 2012.

The objective is to virtually unearth all archaeological structures at the time of discovery, to better understand stratigraphic relations, construction, and period phases, but also to provide a new way to make them usable, interpretable, and available to posterity, especially now that they are no longer visible or are undergoing integrations due to restoration.

The reprocessing of images became necessary since the photogrammetric technique used in the past was based on the principle of stereoscopic vision, using three digital images to generate point clouds with RGB values. The point cloud was then used to generate orthophotos of planimetries and façades. However, the 3D model itself – although useful for measurements and elevations – is not as readable for represented wall facings and planes, being only a point cloud and missing a representation with surfaces. The new 3D model, instead – rendered using 'structure from motion' algorithms – is a realistic high-definition representation, since it contains meshes and photo textures. It allows easy and correct reading of the represented structures and can be easily managed and used, since it can be exported to any format without the need for sophisticated computer equipment (Figure 2).

Figure 2: Rome, NE Palatine slopes. Orthographic view of the new 3D model representing the 'Baths of Elagabalus' and Vigna Barberini's substructions.

Figure 3: Rome, NE Palatine slopes. (a) Portion of the 3D model recently reprocessed with the CNR photographic archive, using multi-image photogrammetry; (b) the same portion of 3D model integrated by processing dataset acquired in the last topographic and photogrammetric survey.

CNR's photographic archive enabled indeed the rendering of this model, but there are some gaps. Therefore, in the last months a new topographic and photogrammetric survey was performed to integrate the model, especially to document some wall façades that were not studied by the graduation and Master theses (Figure 3).

Moreover, a parallel on-going activity is the 3D representation of Vigna Barberini's substructions outlining the examined excavation area to the south. During the already mentioned photogrammetric surveys performed in 2010 and 2012, many frontal shots of the enormous construction were obtained, using an elevated basket along what is now *Via Sacra* (Figure 2).

The research we are preparing to tackle is not simple or obvious at all, but it certainly represents a methodological challenge worthy to be addressed, even if only for the strong knowledge component that always stems from a dedicated and pondered survey operation.

G.C., C.G.

GIS for Building Archaeology data sharing

All the documentation produced by research (file-cards, photos, maps and drawings of many types) required the development of an IT system dedicated to managing, organizing and assembling data, in order to propose new and useful elements of research.

Our archive is managed by an intra-site GIS, used for data-retrieving, spatial analysis and for the elaboration of archaeological themes and/or reconstructive models. Here all evidence and contexts can be distinguished by their unique number and grouped by relative sequences, typologies, and absolute chronology.

Over the years this system has been implemented in software, using different products. Today, our spatial database manages together digital and analogical documentation, following the specific purpose, mainly deontological, to maintain the integrity of the research archive and its history (Brienza 2006; Panella and Brienza 2009; Panella, Fano and Brienza 2015; Brienza 2016: 32–47).

In particular, paying great attention to the issues of open-data and to the dissemination of open-source software and tools, together with the support of a wide community of developers, we have been pushed to adopt open technologies for archaeological practice.

Inside this framework, having in mind the crucial open-data issue (Arizza *et al.* 2018: 9–116), we have experienced the migration of the entire data set and its interrogation system to the open-source geodatabase PostgreSQL/PostGIS, using QGIS as an interface and analysis platform.

The new geodatabase is divided into different sets (schemas) based on the type of data (Tables, shapefiles, rasters) and reproposes the system of relations defined in the conceptual structure.

First, all available data were exported in table format, reorganised and critically summarised. After that, each table was imported into QGIS, linked to the respective vector geometries using the SQL *join* function and then re-exported as new shapefile. Finally, using the plugin DB Manager, each shapefile was easily migrated into the new geodatabase in PostgreSQL/PostGIS (Figure 4).

A special mention should be made for raster data that represent a fundamental component for archaeological analysis and require a special migration procedure. Due to the size of this type of data, it is often preferred not to transfer them into geo-databases and to consume aerial/satellite images and/or cartographic base-map as WMS services.

This process has involved not only technical aspects related to the nature of some formats but also indispensable reflections on the possibility of renewing methodologies and techniques for data collection, management, and analysis.

Focusing on the study of ancient buildings, we proceeded with the reorganization of integrated survey-filing criteria, to collect information related to construction methods such as, for example, structural expedients for static stability, specific materials selection in relation to

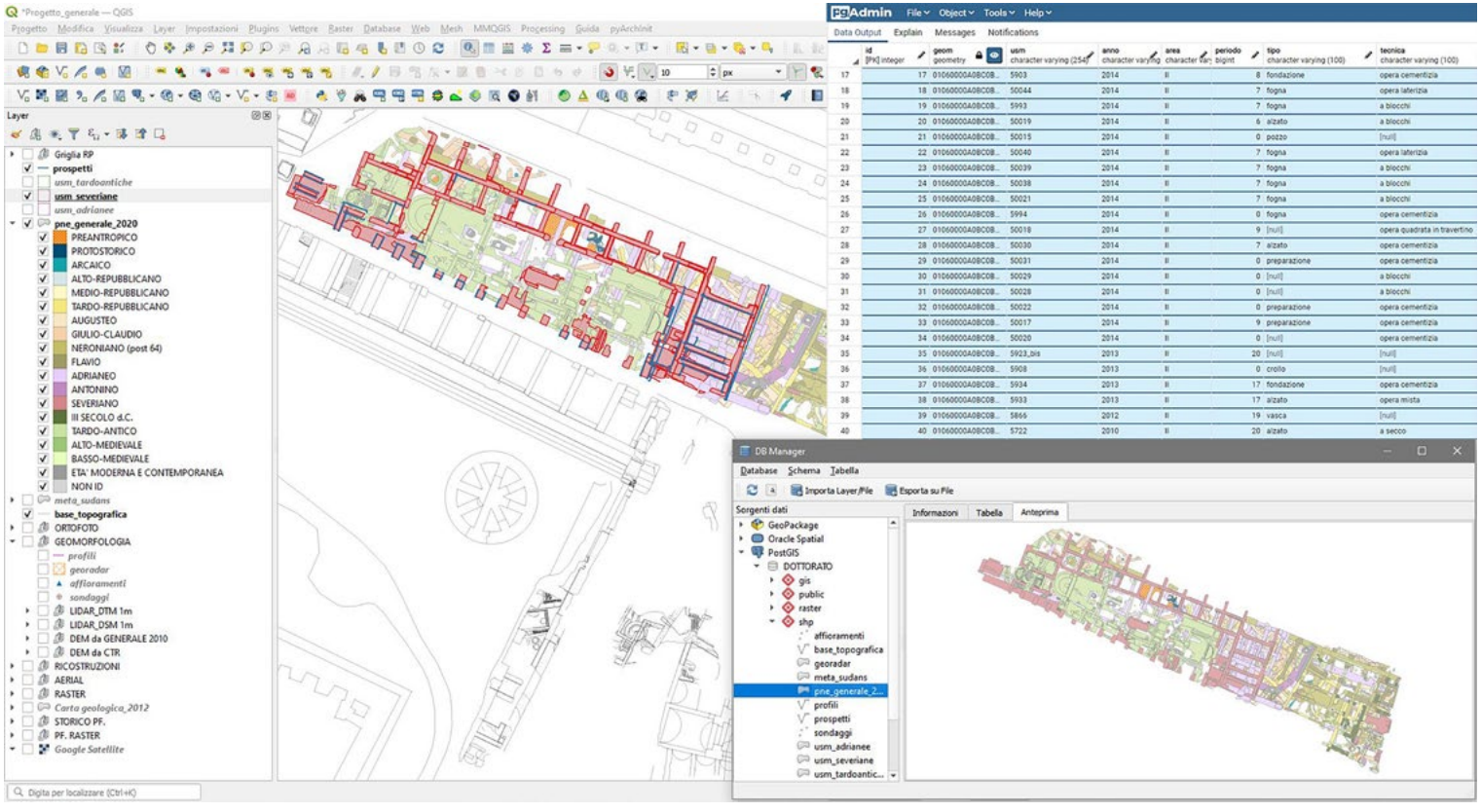

Figure 4: Rome, NE Palatine slopes. The new database on PostgreSQL/PostGIS performed on QGIS.

needs or quantification of the work in terms of time and number of the workers, following the guidelines of the archaeology of architecture and building archaeology (DeLaine 1997 for quantification, the proceedings of *Arqueología de la Construcción* published since 2008, the Italian journal *Archeologia dell'Architettura* and the Spanish journal *Arqueología de la Arquitectura;* see also Brogiolo and Cagnana 2012).

We have planned a new database for ancient structural contexts (USM) and designed file-card formats directly by the new QGIS version of our archaeological intra-site GIS, having the chance to easily perform data entry, editing, and retrieving operations in a single environment.

We have normalized the data-entry creating taxonomies and controlled vocabularies: in addiction, a particular section is dedicated to samples analysis (normally their size is 1 m^2), and detailed morphometric data collection from autoptic analysis of wall facades: here each 'constituent' (i.e. brick, block, etc.) is organized by type, size, material, manufacture, finishing. In this way it is possible to enter new information through an updated and pre-packaged entry form.

This meticulous data collection is integrated and strictly linked to orthophotos of wall façades, obtained with photogrammetric techniques with very high accuracy and definition, and then subjected to a vectorization process, validated by on-site examination.

The quantifications can be obtained from the samples following traditional procedures already widely consolidated and widespread, but also using calculation tools available in the GIS platform. Through a series of expressions, it is in fact possible to automatically calculate the dimensions of the components and quickly their degree of homogeneity and variability but also the variable of the constituent/conglomerate ratio. The computed data are then recorded in a specific sample-card giving the interpreted synthesis from which it is possible to elaborate synoptic tables and graphs (Medri *et al.* 2016; Medri 2017: 41–67). For these last ones, we use the QGIS plugin DataPlotly which allows one to build customized charts without using other applications.

Ancient wall stratigraphic data are linked to the 3D surveys at the level of detail, for the evaluation of walls samples, and at a broader level, for the diachronic and typological evaluation of the large architectural complexes of the area. An external connection with the open-source software CloudCompare[1] is a first attempt to show the graphic quality of photogrammetric acquisition and to partially overcome the 2.5-dimensional perspective of GIS.

Particular attention was paid to the question of the 'philological transparency' of information. In the new version of our intra-site GIS a new exploring process of the collected documentation has been planned for users.

Furthermore, we are developing a WebGIS for the online publication of archaeological data already structured in a GIS platform, implementing access control, customizable user interfaces, advanced tools for data querying and analysis and, finally, the functionality to export data. It will be necessary to obtain explicit permission from the *Parco Archeologico del*

[1] https://www.danielgm.net/cc/ (accessed 01/08/2021).

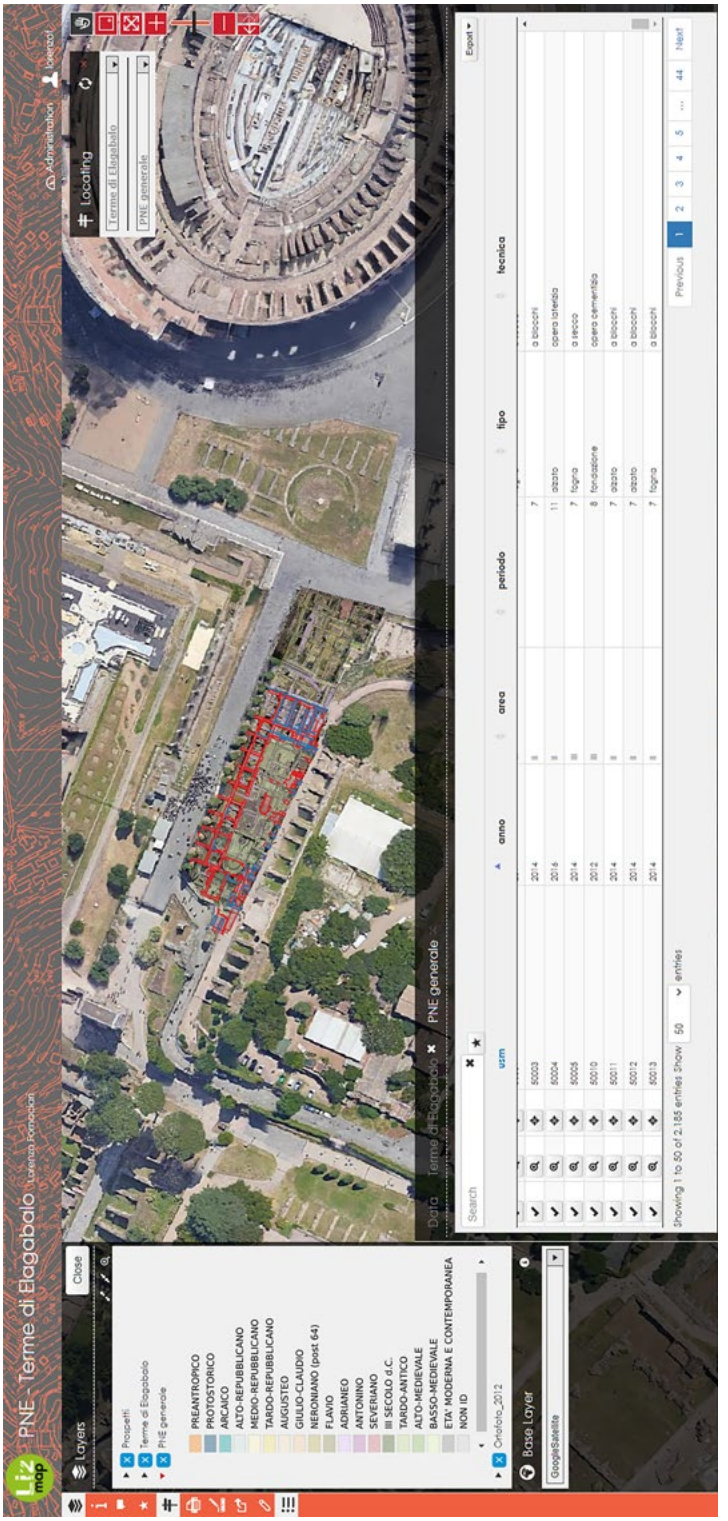

Figure 5: Rome, NE Palatine slopes. A first WebGIS development carried out thanks to the gishosting service of the Gter company (https://www.gishosting.gter.it/home/).

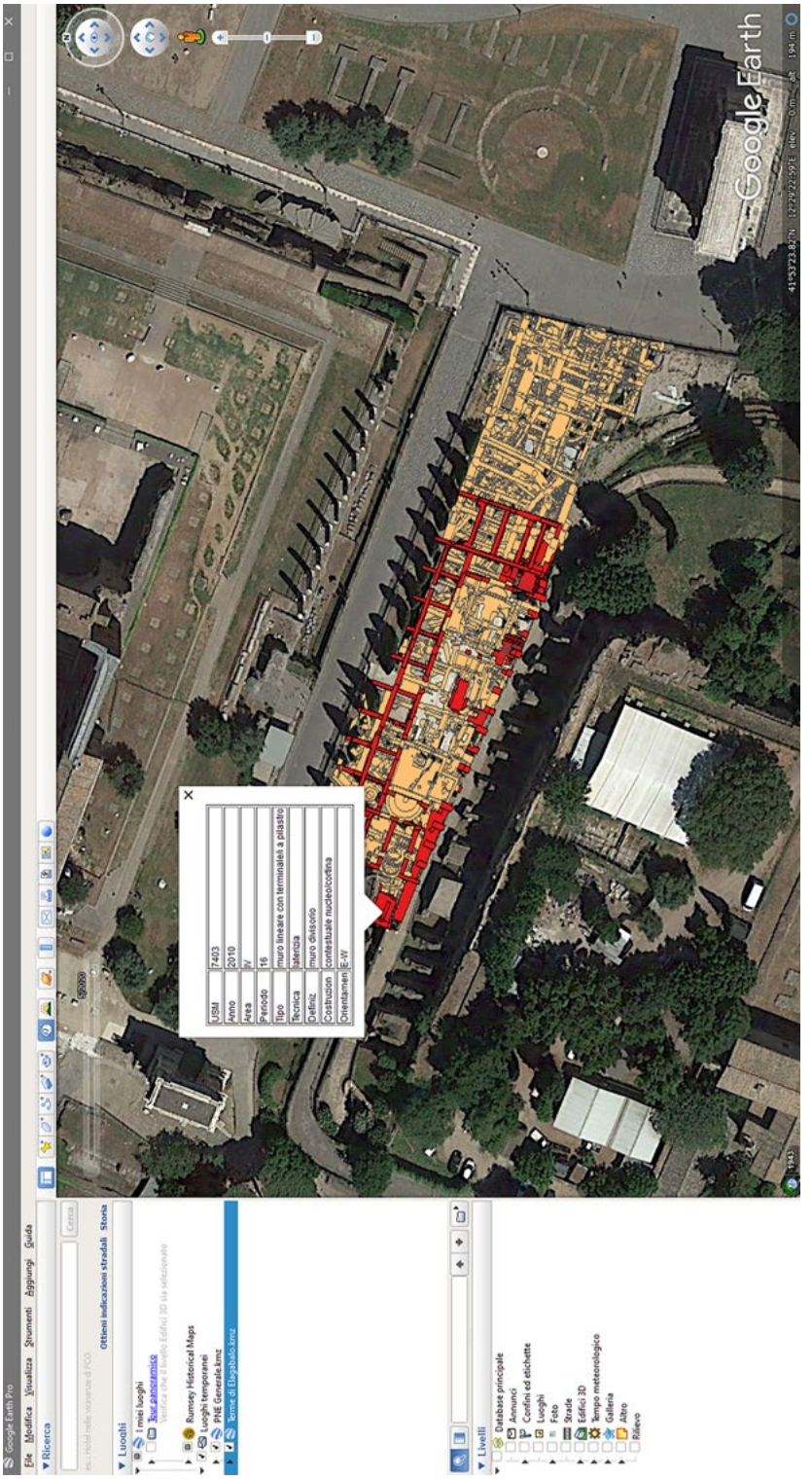

Figure 6: Rome, NE Palatine slopes. An example of exporting data in KML format and their integration in Google Earth platform.

Colosseo for the contents to be published. It is our intention, as well, to adapt our system with other already in use in Rome, such as the SITAR project.

An interesting perspective seems to be offered by the *Forma Romae* project carried out by the Capitoline Superintendency and financed with EU funds from the National Operational Programme for Metropolitan Cities.[2] The project consists in the creation of an information system for the historical, archaeological, and architectural heritage of Rome that integrates the existing geodatabases on the history, archaeology, architecture of the city. Compared to other experiences, the *Forma Romae* proposes a new way of managing the problem of fragmentary and specific information in the field of cultural heritage: the solution adopted does not involve the creation of a new database that absorbs all the others, but rather the creation of a system for accessing existing databases, leaving them unchanged. Through the combined use of data lake and AI solutions, it will be possible to access for each object, all the information contained in many distributed databases. By following this paradigm, our data set will be easily integrated in the network without losing its structure and specificity.

The new WebGIS platform that we are implementing makes use of free open-source software. In particular, QGIS Server and Lizmap Web-Client, were chosen, a combination that offers the possibility of quickly and easily publishing data as they have been defined and configured within the desktop QGIS platform

Once the data to be published have been selected (Tables, rasters, vectors), it is necessary to activate the WMS and WFS services from the project properties for each data type. Subsequently, to configure the on-line platform, we used the Lizmap plugin,[3] whose user-friendly interface allows us to set a series of variables, including interactive functions (measuring, drawing, printing, etc.), data view, query tools and front-end export functions (Figure 5). As for this last function, exporting, different file formats will be made available, including KML, SHP, GeoJSON, etc., according to OGC standards[4] (Figure 6).

We are also working on the integration of the online data set with 3D models: in this task we are testing the use of the 3DHOP software (Potenziani *et al.* 2015: 129–141).

In conclusion, we are trying to create a platform to display and share the complex set of information that fed the interpretative process. Our challenge is not only making the archaeological experience accessible in terms of final results, but also to highlight the process of knowledge and the interpretative reasons for each hypothesis.

L.F., E.B.

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[2] http://www.formaromae.it/ (accessed 01/08/2021).
[3] https://github.com/3liz/lizmap-plugin (accessed 01/08/2021).
[4] https://www.ogc.org/docs/is (accessed 01/08/2021).

Bibliography

Arizza, M., V. Boi, A. Caravale, A. Palombini and A. Piergrossi (eds) 2018, I dati archeologici. Accessibilità, proprietà, disseminazione (Roma, CNR, 23 maggio 2017). *Archeologia e Calcolatori*, 29: 9–116.

Asciutti, M. 2015. Restauro, riqualificazione e valorizzazione di aree di scavo archeologico: Valle del Colosseo/Palatino nord-orientale. *The Journal of Fasti Online: Archaeological Conservation Series 2*: 1–25

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.

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

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

DeLaine, J. 1997. *The baths of Caracalla: a study in the design, construction, and economics of large-scale building projects in imperial Rome*. Portsmouth: R.I.: Journal of Roman Archaeology.

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

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

Medri, M. 2017. Studio dei paramenti laterizi delle Mura Aureliane. 1. Osservazioni generali. In D. Esposito *et al.* (eds) *Le Mura Aureliane nella storia di Roma. 1. Da Aureliano a Onorio (Roma, 25 marzo 2015)*: 41–67. Roma: Edizioni Roma TrE-Press.

Panella, C. (ed.) 1996. *Meta Sudans I. Un'area sacra in Palatio e la Valle del Colosseo prima e dopo Nerone*. Roma: Istituto poligrafico e Zecca dello Stato.

Panella, C. and E. Brienza 2009. Il geodabase 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., M. Fano and E. Brienza 2015. 30 years of urban archaeology: measuring, interpreting and reconstructing. In *Proceedings of the 1st International Conference on Metrology for Archaeology (Benevento, 21–23 ottobre 2015)*: 49–54.

Panella, C., R. Gabrielli, and C. Giorgi 2011. Le Terme di Elagabalo sul Palatino: sperimentazione di un metodo fotogrammetrico 3D applicato allo scavo archeologico. *Archeologia e Calcolatori* 22: 243–260.

Potenziani, M., M. Callieri, M. Dellepiane, M. Corsini, F. Ponchio and R. Scopigno 2015. 3DHOP: 3D Heritage Online Presenter. *Computer & Graphics* 52: 129–141.