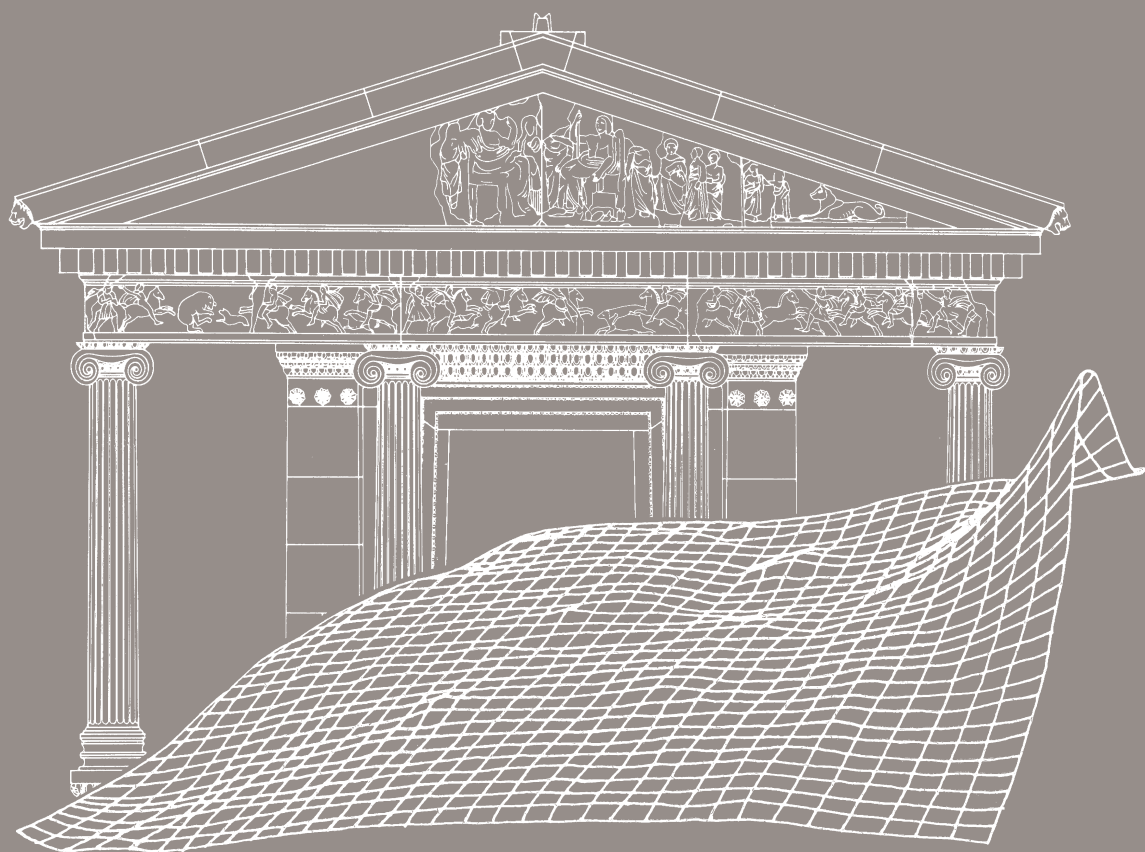




ARCHEOLOGIA E CALCOLATORI

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NETWORKS AND QUANTITATIVE METHODS
IN ARCHAEOLOGY AND ART HISTORY:
ESSAYS FROM THE VENICE SYMPOSIUM
(5-6 DECEMBER 2024)

edited by
Myriam Pilutti Namer, Andrea Auconi, Giulia A.B. Bordi



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PREFACE

The ongoing development of quantitative methods in the study of cultural heritage has become an increasingly significant avenue for scholarly exploration across disciplines, particularly in the fields of archaeology and art history. One of the most notable advancements in this domain has been the convergence of these traditional humanities disciplines with tools and methodologies derived from the sciences, such as data analysis, statistical modeling, and machine learning. This cross-disciplinary dialogue is at the heart of contemporary research, as it fosters innovative approaches to understanding and interpreting the past, while also addressing the complex nature of historical and archaeological evidence.

In this context, the international symposium titled *Exploring the Legacy of the Past in Venice: Networks and Quantitative Methods in Archaeology and Art History* – held at the Ca' Foscari University of Venice on December 5th and 6th, 2024 – served as an essential milestone for scholars working at the intersection of these fields. The symposium was part of the activities of the PNR, Spoke 8, Unit Ca' Foscari Venice, and aimed to present some of the preliminary results of ongoing research within the framework of national and international projects that are testing the potential of quantitative methods in archaeology and art history. Venice, with its unique documentary, art-historical, and archaeological assets, is an ideal setting for such an exchange. As a city whose historical layers stretch back centuries and whose monumental heritage has made it a focal point of cultural significance worldwide, Venice serves as both a case study and a laboratory for experimentation with innovative research methodologies. Its architectural splendor, vibrant artistic tradition, and layered history have attracted scholars from all over the world for centuries, yet the sheer complexity of its heritage – comprising countless objects, monuments, archival records, and artworks – poses significant challenges for traditional research methods. The integration of quantitative tools has thus emerged as a promising way to unlock new insights and facilitate a deeper understanding of this multifaceted city. Indeed, by leveraging methods such as network analysis, spatial modeling, digital mapping, and machine learning, we are able to analyze vast datasets, reconstruct historical connections, and generate visualizations that would have been previously unthinkable.

The symposium, which brought together specialists from archaeology, art history, and physics, exemplified the potential for collaboration across disciplines. Not only did the event provide a platform for presenting cutting-edge research, but it also encouraged a wider reflection on the broader impact of these methodologies on the way we understand the past. In this sense, the

symposium represented more than just a gathering of experts – it was an opportunity to rethink and reframe the very nature of heritage scholarship, by asking how the combination of quantitative approaches and traditional humanities can enrich our interpretations of historical data.

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INTRODUCTION

Venice's extraordinary wealth of documentary archives, architectural monuments, and artistic legacy provides a fertile ground for exploring historical networks and cultural dynamics. At the same time, the city's layered complexity presents challenges for traditional methods of historical and archaeological inquiry. This thematic section of the journal brings together contributions from scholars across disciplines to investigate how the application of quantitative methods and network analysis can transform our interpretations of cultural heritage and historical data.

At the heart of this section is the belief that quantitative methodologies – ranging from network analysis and spatial modeling to digital mapping and machine learning – offer crucial innovations for the study of cultural heritage. These tools enable scholars to manage and interpret vast datasets, visualize complex historical connections, and address questions that would otherwise remain inaccessible. Venice, with its dense archival records and enduring artistic tradition, offers an ideal testing ground for such methodologies. By engaging with these new tools, the studies collected here demonstrate how the integration of quantitative approaches and traditional humanities scholarship can generate fresh insights into the cultural heritage of the past.

The structure of this section reflects both the diversity of methodologies employed and the richness of the case studies investigated. The opening chapter, *The New Science of Long Data* by Guido Caldarelli and Alessandro Codello, introduces the concept of 'Long Data' – a framework that emphasizes the deep historical context embedded in meticulously preserved archival records. Using artificial intelligence and data modeling techniques, the authors explore how this approach can revolutionize the study of Venice's State Archive (ASVe), one of the world's most extensive and historically significant collections. By harnessing new technologies in harmony with traditional archival methods, Long Data enables the analysis, transcription, and modeling of historical information on an unprecedented scale, paving the way for innovative insights into social and cultural evolution.

The subsequent chapters delve into specific applications of quantitative methods in archaeology and art history. Paolo Carafa, Niccolò Cecconi, and Francesco Di Stefano's contribution on the CHANGES Project emphasizes the importance of integrated advanced technologies in promoting sustainable heritage management. Their work illustrates how geolocated data and interdisciplinary collaboration can transform fragmented historical information into cohesive systems of knowledge. The case studies from ancient *Latium*, Amendolara, and Syracuse demonstrate how data-driven

approaches foster a more systematic inventory, classification, and dissemination of cultural assets.

The volume also includes studies focused on digital modeling and the reconstruction of lost heritage. Indeed, George Bruseker, Kathleen Christian, and Denitsa Nenova discuss recent innovations in the *Census of Antique Works of Art and Architecture Known in the Renaissance*, a long-running research project established in 1946 that traces the knowledge and reception of antiquities during the Renaissance by linking them with early modern visual and textual records. Over its history, it has evolved from an analog system to one of the earliest digital art history projects and now to an online database. Recent innovations (2021-2023) have transformed the database into semantic data using the CIDOC-CRM ontology, aligning it with FAIR principles and encouraging broader engagement with its rigorously-researched dataset. By using the X3ML language and the 3M tool for mapping and verification, the database ensures consistency and compatibility with other datasets, such as those in the CORDH network. This semantic transformation opens new avenues for research, enabling advanced queries through SPARQL and extending the database's utility beyond its original scope in art history and archaeology.

In addition, the 'Sacra Absentia' project, presented by Simone Piazza and Giulia A.B. Bordi, documents the lost furnishings of medieval Venetian churches, using archival documents, historical texts and iconographic evidence to compile a comprehensive database. The interactive map system developed for this project offers an essential tool for reconstructing the original appearance and historical context of these sacred spaces, with a particular focus on the church of Sant'Agnese. The chapter on the church of San Fantin in Venice by Carlotta Zaramella, Myriam Pilutti Namer and Giulia A.B. Bordi similarly combines digital modeling, archival research, and material analysis to reconstruct the building's architectural evolution and its reuse of ancient marbles, highlighting the significance of spolia in the city's material culture. The article by Ruggero Longo and Elisabetta Scirocco explores the integration of quantitative methods and digital approaches in art historical research, focusing on the 'Mapping Sacred Spaces' project investigating medieval sacred architecture in southern Italy. It emphasizes the need to reconcile scientific and humanistic disciplines through data-driven analysis, digital tools, and interdisciplinary collaboration for more accurate reconstructions.

Innovative digital methodologies also play a key role in the study of architectural heritage beyond Venice. Carlo Bianchini and his co-authors explore the church of San Lorenzo in Miranda in Rome, demonstrating how tools like GIS, BIM, and integrated large-scale surveys can foster a more accurate understanding of ancient structures and their transformations. This approach underscores the importance of shared digital infrastructures and open-access policies in cultural heritage research, enabling the integration

of heterogeneous data and the development of interoperable systems that connect historical, architectural, and graphic sources.

Finally, the section turns to the application of advanced scientific techniques for the analysis of artworks. The study of the painting *Saints Peter and Stephen* at the Fondazione Giorgio Cini by Mauro Missori and his co-authors showcases the potential of remote reflectance spectroscopy to identify pigments and material choices while preserving the integrity of fragile artworks. This non-invasive method, inspired by astronomical techniques, offers new insights into the artist's material practices and demonstrates the feasibility of remote diagnostic tools in heritage science. As a final contribution, Myriam Pilutti Namer's review of two recent volumes on archaeological network research underscores the current state of the field and situates the discussions within broader theoretical and methodological debates.

Together, these contributions illustrate the transformative potential of quantitative methods and interdisciplinary collaboration in the study of cultural heritage. By embracing innovative approaches and fostering dialogue across disciplines, this thematic section aspires to provide valuable models for heritage research on a global scale.

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THE NEW SCIENCE OF LONG DATA: PRESENTATION OF THE VENICE LONG DATA PROJECT

1. WHAT IS LONG DATA?

Our shared European history is preserved in an infinite variety of documents stored in historical archives scattered across the continent. These state, municipal, institutional, industrial, and private archives form the backbone of our cultural heritage and serve as the primary source of knowledge about our past. Yet, this collective memory remains largely out of reach—difficult to access and scarcely interconnected. As Italian and European scientists and humanists, our duty is not only to document and safeguard this heritage for future generations but, more importantly, to make it accessible and explorable for all. To achieve this, we must develop a new science of Long Data – a groundbreaking approach to historical sources and archival information that enables both an unprecedented cultural heritage experience and a more integrated capacity for scientific research on this vast, largely uncharted database.

In an era overwhelmed by the rapid production of digital data, our ability to coherently organize Long Data spanning thousands of years is a unique asset. Moreover, historical archives contain highly structured and verified information that encodes the true, multifaceted history and cultural heritage of Italy, Europe, and the Mediterranean. Long Data represents the intangible record of our past, complementing the tangible reality of archaeological sites, monuments, museums, and cities. In this respect, Italy stands out as one of the most – if not the most – Long Data-rich countries in the world. The Long Data approach seeks to establish a foundation for studying history from a macroscopic perspective, complementing the traditional microscopic approach. It always begins with original sources while leveraging the most advanced techniques available for analysing and transcribing historical records.

This emerging science integrates Artificial Intelligence Network Theory and Big Data—while respecting and incorporating traditional archival and historical methodologies—to accomplish tasks once thought impossible. These include transcribing and analysing entire archival series or even interlinking and modelling all the information contained within one or more historical archives. By combining methods from Digital Humanities and quantitative sciences, such as Complex Networks and Economics, Long Data enables a deeper understanding of the historical development of societies, as well as the evolution of language and culture over centuries. There are two key distinctions between Big Data and Long Data that must be kept in mind.

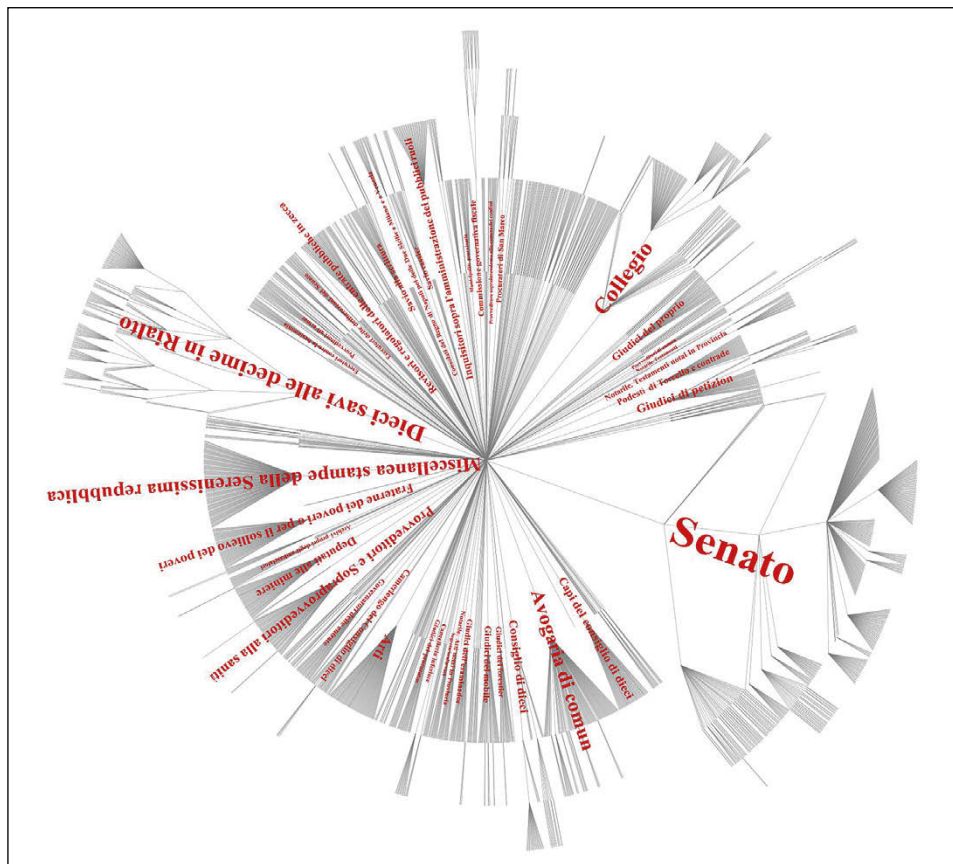


Fig. 1 – Hierarchical structure of Archives. Archives are generally structured in a hierarchical way that reflects the underlying operation and organisation of the institutions that created them (except for archives that have been, a posteriori, completely reorganised according to a different organising principle). Here we show a dendrogram map of the ASVe with over-impressed the names of the major archival fonds (the map shows only those fonds initiated under the rule of the Republic of Venice).

First, Big Data is wide—it consists of vast amounts of information generated daily—but thin, as it spans only a few decades since the advent of the Internet. In contrast, Long Data is relatively small in volume but extremely deep in the temporal dimension, containing records that stretch back over a thousand years and archival series that remain uninterrupted for centuries. Second, Long Data is far more valuable and rare than Big Data. Much of it is encoded in centuries-old manuscripts and concentrated in a limited number of archives. This rarity demands a significantly greater effort in its preservation, management, and analysis. Long Data is processed following rigorous

humanities standards for historical sources and represents a tangible form of cultural heritage in its digitised state. Due to the vast quantity of historical records in our archives, the complexity of transcription, and the constraints of traditional methods, only a small fraction of archival documents has been systematically integrated into our collective knowledge base. For example, in the case of the Senato collection at the Venice State Archive (ASVe), less than 1% of the documents have been transcribed (Fig. 1). This suggests that our understanding of the past may be far less complete than we assume, particularly regarding quantitative historical data, which remains largely unexplored.

The primary scientific goal of Long Data is to bridge this gap, providing historians and researchers across disciplines with comprehensive access to archival sources. By doing so, it enables the construction of a more complete and data-driven picture of our past.

2. WHAT IS COMPLEX NETWORKS THEORY?

The science of complex networks provides a powerful framework for analysing relationships and structures within vast and intricate datasets. Originally developed in fields such as physics, biology, and social sciences, network theory has proven to be an essential tool for uncovering hidden patterns and correlations in seemingly unstructured information. By representing data as a network of interconnected elements – whether individuals in a society, genes in a biological system, or historical figures in archival records – complex networks allow for a systematic and quantitative approach to studying connectivity and influence across different domains. One of the most significant contributions of complex network science is its ability to measure correlations and define a metrical space within a dataset. By quantifying the strength of connections between elements, it becomes possible to assess distances and similarities in a structured and mathematically rigorous way. In the humanities, this capability is particularly transformative, as it enables the mapping of relationships between historical entities, such as people, institutions, and events, based on archival sources (Fig. 2). This approach goes beyond traditional qualitative analysis, allowing for a quantifiable understanding of historical and cultural dynamics that were previously difficult to measure.

In the context of archival texts, network analysis can reveal latent structures and thematic clusters, providing a new way to interpret historical documents. By modelling texts as networks – where words, concepts, or entities are nodes connected by linguistic or contextual relationships – it is possible to identify patterns of influence, textual similarities, and the evolution of ideas over time. This application of complex networks in the humanities represents a paradigm shift, offering a mathematical foundation for exploring cultural heritage, much like how it has revolutionised other scientific fields.

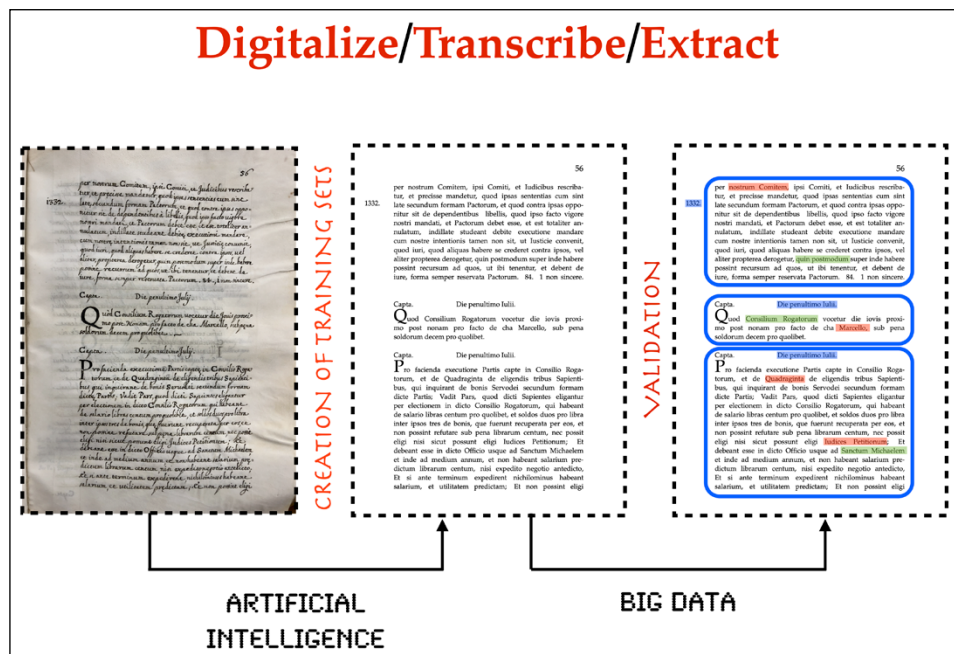


Fig. 2 – Long Data in action. After digitalisation, Artificial Intelligence is first trained on sample pages prepared by expert palaeographers and then used to automatically transcribe all compatible documents, which are successively validated by historians; feature extraction (people and locations in the example) follows document segmentation and dating (Big Data techniques); the resulting data is organised in a temporal multi-layer network that fully represents the information contained in the archival documents considered (Science of Networks approach).

3. VENICE LONG DATA

On a broader scale, Italy is one of the most Long Data-rich countries in the world, with more than fifty state archives holding an invaluable wealth of historical records that remain largely untapped. The Long Data revolution presents a unique opportunity to transform the study of history and cultural heritage, breathing new life into archival research and elevating it to a cutting-edge, data-driven discipline for the 21st century. In particular, Venice, with its vast historical archives, libraries, museums, and private collections, along with its unique role in European and Mediterranean history, is the ideal starting point for the systematic development of the new science of Long Data. Among its many treasures, the Venice State Archive (ASVe) stands out as one of the richest Long Data repositories in the world. Spanning over 80 km of shelves and preserving more than a thousand years of uninterrupted records, ASVe offers an unparalleled depth and continuity of historical data, meticulously

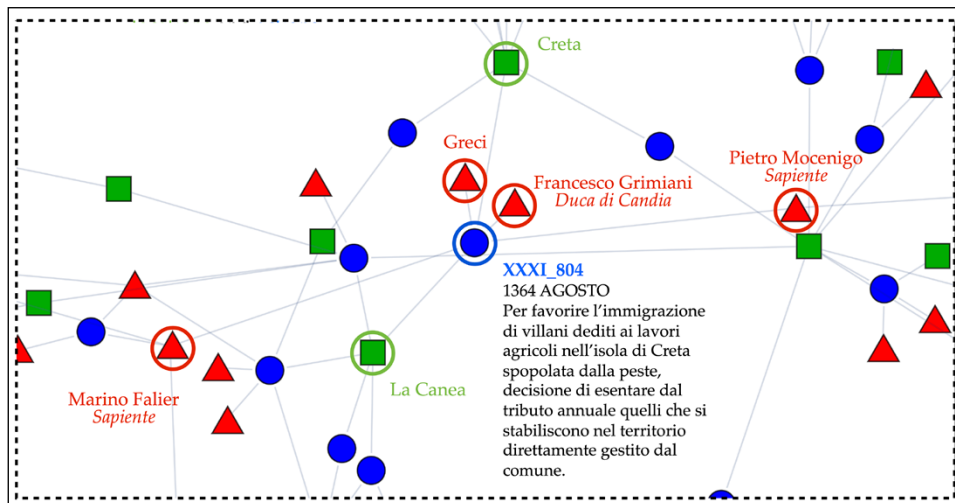


Fig. 3 – Temporal multi-layer network. The information contained in archival documents is naturally described by a temporal multi-layer network linking documents, people, locations and any other relevant quantitative or semantic data; this network structure is the basis for new integrated instruments for scientific studies and cultural experiences. In the Fig. deliberations from the Senato-Misti series (represented as blue dots) are connected to the people (red triangles) and locations (green squares) they (implicitly or explicitly) mention. The ‘registro’ of deliberation n. 804 of register XXXI (August 1364) is shown as an example of additional data characterising a node.

conserved over centuries. This unprecedented richness allows us to propose an interdisciplinary research project that approaches historical inquiry from a quantitative perspective.

Rooted in the wealth of historical data provided by ASVe and other archives in the Venetian lagoon, the project integrates methodologies from Artificial Intelligence, Big Data, and Network Science. Its dual objective is to develop a historical meta-database, a fully transcribed, interconnected, and searchable digital version of the Venetian archives, and to establish the foundation for a quantitative study of the history of Venice, Europe, and the Mediterranean (Fig. 3).

4. TIMES ARE MATURE FOR LONG DATA

We can now realise the promises of the Long Data revolution because the time is ripe to integrate several cutting-edge technologies in the Digital Humanities, which have been evolving over the past two decades. First, digitisation has become standard practice in most archives, driven by the advancements of the Fourth Industrial Revolution. Second, automatic transcription of historical texts has significantly improved, thanks to the rapid progress in Artificial

Intelligence. Third, Natural Language Processing (NLP) and Semantic Web technologies have matured to the point where they can effectively handle the complexity of centuries-old archival sources. Beyond these advancements, we can also apply quantitative analytical methods from Network Science, which, for instance, propose the use of temporal multi-layer networks as a natural way to represent the rich, interconnected information encoded in historical archives. This approach enables a structural and dynamic understanding of archival data, revealing patterns and relationships that were previously difficult to analyse. The urgent task now is to coherently integrate these technologies to revolutionise how we study and preserve history. The time has come to adopt a quantitative, document-driven approach to our past, to systematically ‘back up’ our archives for better preservation, and to develop new ways of sharing and interpreting the invaluable stories they contain.

5. MULTIDISCIPLINARY

Long Data has the potential to empower a new generation of humanists and scientists, fostering an interdisciplinary approach to history where network science, economics, social sciences, and historical studies converge to offer a new perspective on the past. By integrating diverse fields, Long Data provides a framework for collaboration between disciplines that traditionally operated in isolation, opening the door to innovative methodologies and a deeper, data-driven understanding of history. Several key domains contribute to the Long Data approach. Cultural Heritage Studies (*Beni Culturali*) play a crucial role in the management, preservation, and organisation of archives and artistic sources. Digital Humanities and Archival Sciences oversee digitisation, access, and storage while also setting the standards for digital preservation. Informatics provides the backbone for Artificial Intelligence applications in automatic transcription, as well as techniques to transform language into structured data and manage the databases encoding cultural heritage. History defines and oversees Long Data methodologies, ensuring the accuracy of transcriptions and the validation of metadata and extracted features. Network Science and Economics supply modelling tools and quantitative analysis techniques, while Linguistics enables the study of language and cultural evolution over time. Lastly, Communication Sciences and Information Design play a key role in dissemination and outreach, combining state-of-the-art infographics, compelling storytelling, and modern media to make historical insights widely accessible.

This (necessarily incomplete) list of interdisciplinary synergies demonstrates that Long Data stands as a powerful bridge between the humanities and quantitative sciences. It has the potential to revolutionise the way we approach, analyse, and share our collective cultural heritage, marking a paradigm shift in historical research and public engagement.

6. OUTCOMES AND BENEFITS OF LONG DATA

In conclusion, the benefits and outcomes of an extended Long Data treatment of our historical archives are manifold and affect positively the whole system of cultural heritage as well scientific research in the humanities. The most relevant points are summarised as follows:

- Long Data techniques allow the extraction of all qualitative and quantitative information contained in our archives, including non-numeric language data and implicit information encoded in the structure and interlinking of the archives;
- Long Data offers a way to make a digital backup of our unique sources (just imagine the irreparable cultural heritage loss if fire or flooding affects an archive like the ASVe) and a way to construct online infrastructures for research that go beyond mere photographic digitalisation;
- Long Data allows the reconstruction of missing information by exploiting the inherent redundancy built into archives and ways to overcome the language barrier in the humanities (for example by automatic translation of meta-data and document summaries);
- Long Data stands as a candidate to incarnate the convergence of humanities and quantitative sciences, which will unleash a revolution in how we approach, think and disseminate our past and common cultural heritage;
- Long Data is a solution to the limitations imposed by global pandemics like Covid-19 that hamper scientific and historical research allowing complete online access to archival sources;
- Long Data fosters touristic and creative industries by making accessible to the general public the richness of our cultural heritage through innovative storytelling and engagement;
- Long Data offers lessons from the past that are relevant to our decisions on topics like climate change, pandemics and migrations.

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ABSTRACT

The article introduces the concept of ‘Long Data’ as an innovative approach to enhancing the cultural heritage preserved in historical archives. This concept distinguishes itself from Big Data by focusing on the deep historical context found in meticulously preserved archives, revealing valuable insights into cultural heritage. By using new Artificial Intelligence technologies in harmony with traditional archival methods, Long Data aims to analyze, transcribe, and model historical data on an unprecedented scale. This approach promises a more comprehensive understanding of history, improving studies on social and cultural evolution. A key example of Long Data’s application is the Venice State Archive (ASVe), which holds documents dating back over a millennium. The initiative seeks multidisciplinary collaboration to make this vast archive accessible, thereby safeguarding cultural heritage and paving the way for a revolution in historical research.

SHARING ASSESSED KNOWLEDGE, SHARING HERITAGE

1. PREMISE: TANGIBLE CULTURAL HERITAGE AS SYSTEMS OF CONTEXTS AND PROCESSES

Within the CHANGES Project (Cultural Heritage Active Innovation for Sustainable Society), Spoke 8 focuses on integrating advanced technologies and scientific approaches to increase knowledge and enhance sustainability and resilience of Tangible Cultural Heritage (TCH). This Spoke thoroughly addresses the impact of anthropogenic, natural, and climatic factors on TCH, promoting integrated conservation strategies that consider the interconnection between cultural, social, and economic aspects. Furthermore, it focuses on the development of knowledge infrastructures and the promotion of participatory governance models that actively involve both public and private entities, as well as local communities, to ensure a sustainable and inclusive management of cultural heritage. The underlying premise of this research is that Tangible Cultural Heritage (TCH) can be conceptualized as a network of material entities – ranging from individual objects to structures and architectural complexes – distributed across space.

As physical entities identified (also) by specific spatial coordinates, elements of TCH inherently establish relationships with their surrounding environment. These relationships may be functional in nature or dictated by spatial proximity. Moreover, they are not static but subject to transformation over time. Similarly, the material entities themselves undergo modifications, as exemplified by architectural restorations or interior refurbishments that alter the fabric of a building. The interplay between these elements and their evolving relationships gives rise to contextual frameworks, which can be further aggregated into broader, more complex systems.

When applied to the past, this contextual-processual approach must contend with the fragmentary nature of the archaeological record. The original integrity of material entities and their relational networks has largely been lost, leaving only dispersed remnants. Objects often survive in an incomplete or deteriorated state, while architectural remains are typically reduced to ruins, stripped of the furnishings, decorative programs, colours and structural elements that once defined them. Moreover, the relational networks that once underpinned these contextual entities have been irrevocably disrupted.

Given this premise, the study of TCH necessitates a dual methodological approach (Fig. 1). The first objective is ontological, seeking to systematically document the fragmented remains of contexts and contextual systems. This process extends beyond the direct archaeological record to incorporate a

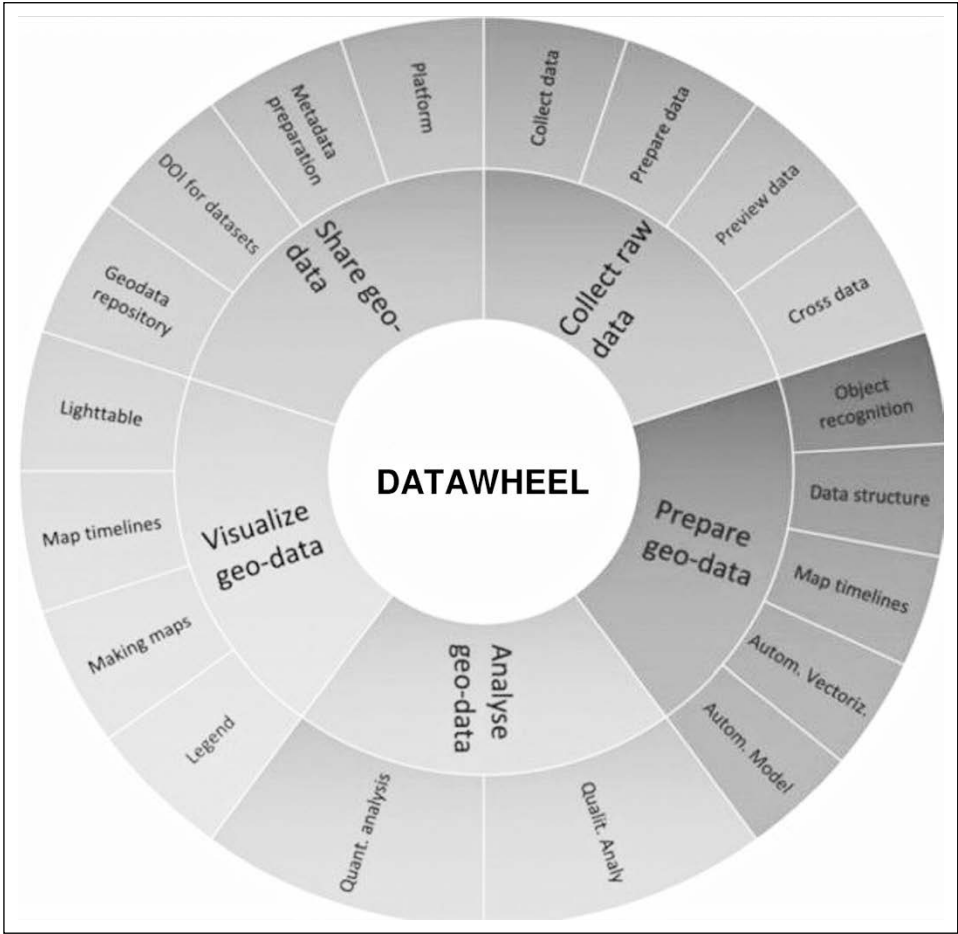


Fig. 1 – Datawheel methodology (el. Authors from HEIN *et al.* 2022, fig. 31.1).

diverse range of historical sources, including literary accounts, ancient images (such as e.g. reliefs, images on coins), historical cartography, and post antique visual representations such as paintings, prints, drawings, and photographs from the Renaissance to the modern era. Any of these documents/sources of information can be located somewhere and dated – that is ordered spatiotemporally – thereby enabling the integration of many different kinds of information into topographical reconstructions.

The second objective is reconstructive, aiming to reassemble past contextual entities by examining the interrelations among fragmented

elements of TCH. Through the systematic cataloguing, classification, and spatiotemporal contextualization of these fragments, separate datasets can be transformed into systems of structured knowledge facilitating the reconstruction and dissemination of historical processes and cultural frameworks. This paper presents a selection of case studies that illustrates scientific approaches, common rules, methods, technologies and preliminary outcomes developed by the project.

2. PROCEDURES FOR THE CREATION OF INTEGRATED ARCHIVES AND INFRASTRUCTURES OF KNOWLEDGE

2.1 *Sharing rules for assessing TCH data*

The first outcome of Spoke 8 has been to establish common methodological and operating rules which include: sharing both two-dimensional and three-dimensional information sources within a georeferenced geographic space; using the RDN 2008 coordinate system; integrating one-dimensional (textual), two-dimensional (graphic and topographic processings), and three-dimensional (3D models) data; adopting sustainable technologies already developed by other software designers; managing and assessing datasets composed of varied information sources; and developing best practices to enhance the understanding of TCH contexts while implementing strategies for their protection, enhancement, and communication of the associated historical and cultural contexts.

2.2 *From the Knowledge Map to contexts*

All the data have been collected in specific relational databases, which are part of an Information System. All archaeological, architectural, and topographical evidence, either visible or not but of certain location, can be georeferenced within an absolute coordinate system. In contrast, evidence related to epigraphic, textual, cartographic, iconographic, palaeobotanical, and paleoanthropological sources can be georeferenced either in relation to a fragment of the already mapped TCH (either visible or attested/documentated) or to areas or sectors of the territory lacking archaeological, architectural, and topographical evidence. The first topographic representation of these data constitutes the Knowledge Map. Within it, where the information accumulates significantly or where it is few but sufficiently detailed, we can identify contexts that can be defined as UTs (Topographical Units; CARANDINI, CARAFA 2017; CARAFA 2021).

The UTs have a dual informational value and must be considered from two perspectives: topographical/morphological – as their position and architectural shape define the space in which they are located – and chronological, as each TU can be characterized by transformations that have

occurred over time. Topographical Units (UTs), when aggregated, can define large topographical ensembles that constitute complex realities, forming the different structures of the ancient landscape. For example, multiple UTs can constitute a complex (such as a boundary wall, altars, and temple of an extra-urban sanctuary) or a site, meaning a place considered and perceived as a unified entity in the landscape (for example: all the tombs of a necropolis, or all the buildings and infrastructures of a city), ultimately shaping the landscape.

3. ASSESSMENT AND PILOT CASES

Such an assessment creates a series of cadastres in which all the documents have been (re-) connected to places. Thus, triggering a process of reconfiguration, reconstruction, and communication of monuments, ancient settlements, and, more generally, past (either ancient or post antique) architectural and topographical realities. These reconstruction activities push forward the assessment process, leading to different levels of analysis, from the reconstruction of frameworks to the storytelling and communication of the histories of the territories. This will be highlighted by the following case studies. They have been identified on the following criteria: readability of architectural and topographical features, along with their potential for geolocation and graphical representation; large-scale representation; extension no smaller than at least an extended urban area; multi-layered historical context; diversity and complexity of sources.

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3.1 *Ancient Latium project*

Ancient Latium project involves the mapping, classification, and reconstruction of the features that shape Lazio's landscape from prehistory to the Middle Ages (Fig. 2). This project builds upon the work carried out between 2018 and 2022 as part of an inter-institutional agreement between the Lazio Region and Sapienza University of Rome. The project aimed at the digital mapping of archaeological sites and assets dating from the 9th century BCE to the 6th century CE, located in the southern Lazio region, between the Tiber and Garigliano rivers (<http://www.lazioantico.it/>; CAPANNA, CARAFA 2018; CARAFA, DE PAOLIS 2021; CARAFA *et al.* 2021; CARAFA 2022, 2024; IPPOLITI 2023). The Ancient Latium project, in this context, served as a 'good practice' that connected the key players in scientific knowledge with the digital infrastructure that had been developed and enhanced in previous years through various innovative tools (such as the Single System for Cataloguing and Using the Cultural Heritage of the Lazio Region, the Regional Information System, the Regional Technical Map, and the open data portal).

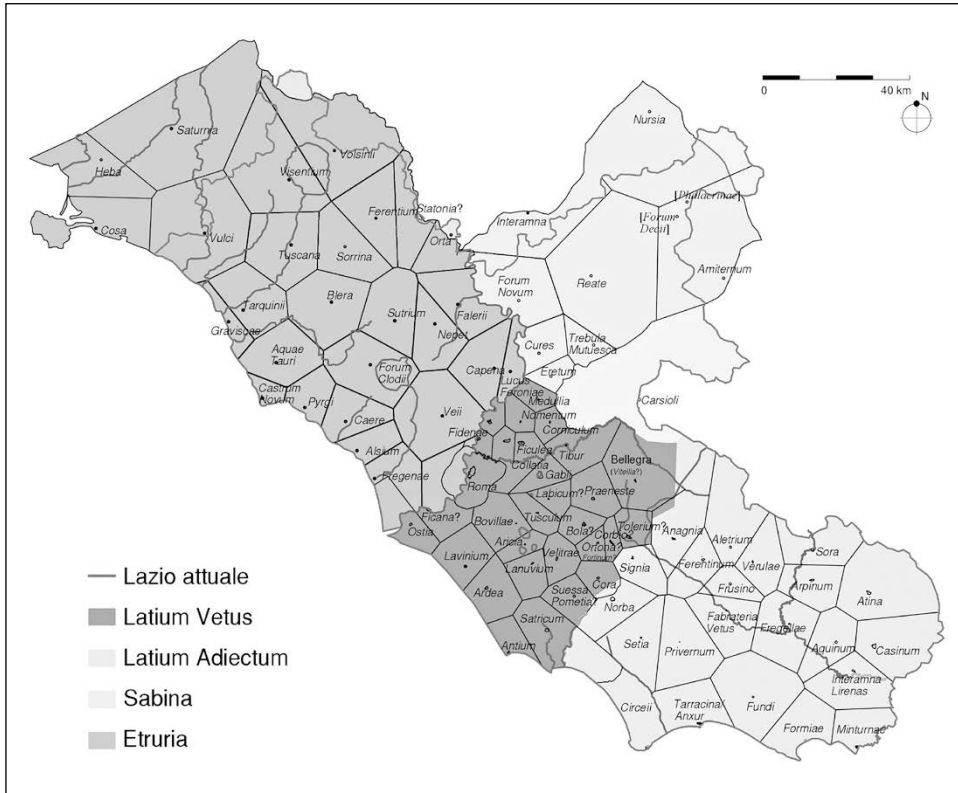


Fig. 2 – Map of ancient *Latium* with main sites and territories within the boundaries of Lazio Region.

The project promoted by Spoke 8 expands the disciplinary analysis by including epigraphical, archaeobotanical and paleoanthropological data, while also broadening its scope chronologically, covering a period from prehistory to the medieval era, and geographically, focusing on northern Lazio, which includes the provinces of Rieti and Viterbo, corresponding to the ancient territories of Southern Etruria and Sabina (including the Faliscan and Capenate areas). The research aims to present a historical narrative of the transformation of this region, analysed through the changes in its urban and rural landscapes. The vast amount of collected and standardized information will allow for a wide range of analyses aimed at defining regional and transregional processes, focusing on various topics such as the emergence, development, and eventual collapse of settlement systems. All of this aims to define different stages of cultural, social, and political complexity in the analysed territories.

The Ancient Latium project, in addition to having specific objectives, also enables the development of various thematic analyses from chronological, geographical, and topographical perspectives. In this regard, the first analysis has been focused on settlement patterns and their relationship with

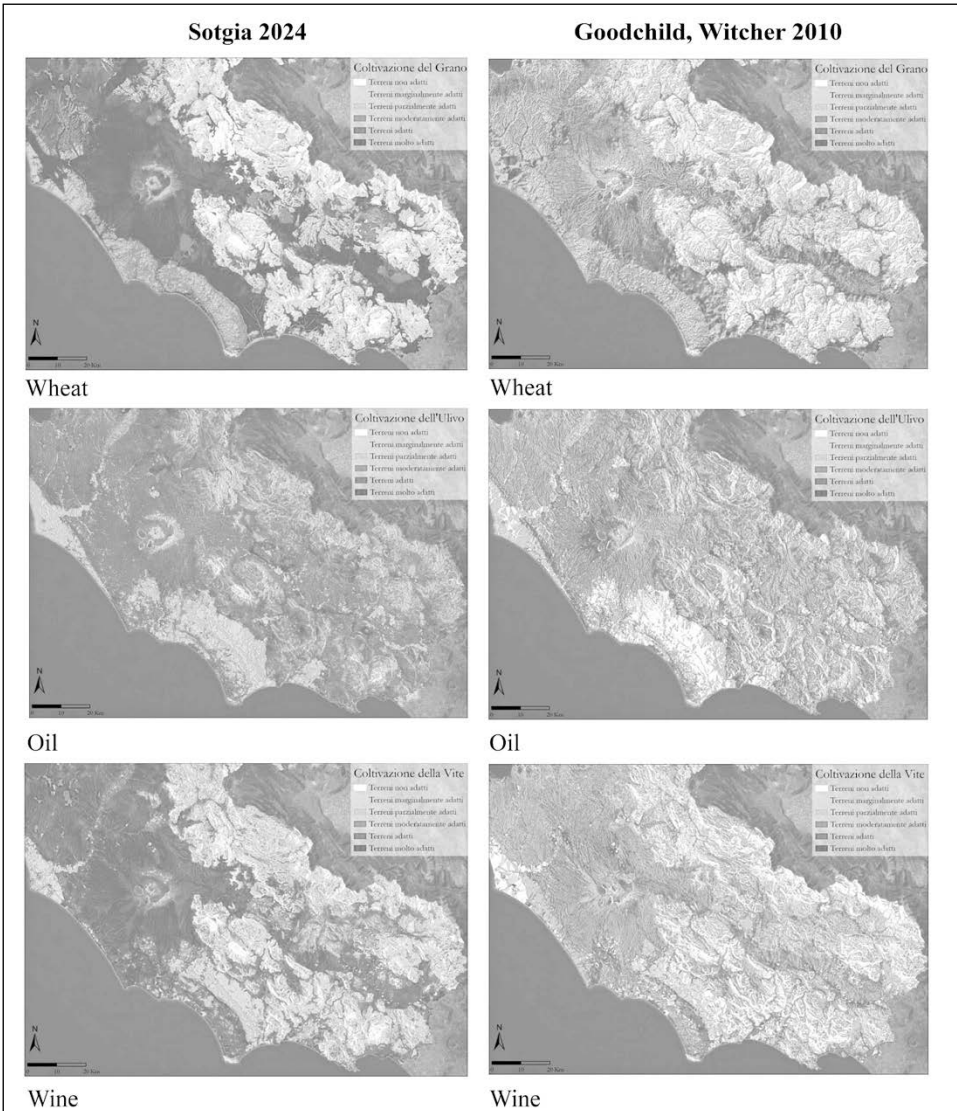


Fig. 3 – Land exploitation patterns and agricultural landscapes in Roman ancient *Latium* according to GOODCHILD, WITCHER 2010 and SOTGIA 2024 models.

environmental contexts during the prehistoric periods, examining how human settlements interacted with and adapted to their surrounding landscapes throughout time (RECCHIA, MARCONI in press).

The second analysis investigated land use and agricultural productivity in Roman times, exploring how communities exploited and managed the land. It explores agricultural techniques, crop production, and the broader economic and social consequences of land use. The goal is to understand the connection between agriculture and the Roman economy, highlighting how natural resource exploitation played a role in the communities' growth and stability. Analyses of soil productivity have been conducted for vineyards, olive groves, and cereals, considering factors like geology, slope, exposure, elevation, humidity, soil fertility, erosion, and proximity to watercourses. These analyses are based on the *Atlante dei suoli del Lazio*, literary sources (notably works by Marcus Porcius Cato, Marcus Terentius Varro, Lucius Junius Columella, and Pliny the Elder), and GIS-based calculation methods (GOODCHILD, WITCHER 2010; SOTGIA 2024; CARAFA, DE PAOLIS 2025; Fig. 3).

A third level of analysis focuses on the environmental and historical-topographical study of a sub-regional area between Lazio and Umbria, falling across the northern border of ancient Sabina. This analysis examines the interaction between the natural environment and historical developments in the region, aiming to uncover the topographical features and how they influenced settlement patterns, cultural practices, and the broader historical context of the area. Specifically, the analysis focuses on the territory corresponding to the municipalities in the province of Terni, within the Valnerina region (Arrone, Ferentillo, Montefranco, Narni, Polino, Stroncone, Terni/*Interamna Nahars*). This area, which currently lacks a comprehensive assessed historical and territorial analysis, is a culturally rich and stratified context, shaped by the succession of different populations over time. It is a region where settlements and sanctuaries are found in low-density urban areas, and the relationship between archaeology and the natural and hydrogeological landscape highlights the region's territorial significance and uniqueness.

Given the complexity and multi-layered nature of this context, the analysis of this territory has been structured as an independent pilot case, named the Valnerina project, yet connected to the Ancient Latium project. Due to the largely rural nature of the area under study, it has been deemed essential to reconstruct and spatially analyse the physical landscape using a dataset that includes all the geo-environmental information required to reconstruct various geomorphological contexts. These physical landscapes, as parts of the cultural landscapes, include hills and valleys, exposed and subterranean rock, as well as deposits left by glaciers, rivers, and lakes that are perennial, seasonal, or now dried up. They are environmental contexts

subject to varying and modest degrees of change compared to anthropogenic contexts, yet they still evolve over time and influence settlement patterns and land use (McKNIGHT, DARREL 2008).

Starting from a heterogeneous data set, it is possible to reconstruct the physical landscapes that characterized the study area from prehistory to the medieval period. To fill this dataset, various sources of information were gathered, including literary, toponymic, palaeobotanical, palynological, paleoenvironmental, and iconographic data, as well as landscape reports, regional technical maps, soil maps, geological maps, and digital elevation models (DTM, DSM, and DEM). This approach will enable the reconstruction, classification, and characterization of paleo-environmental

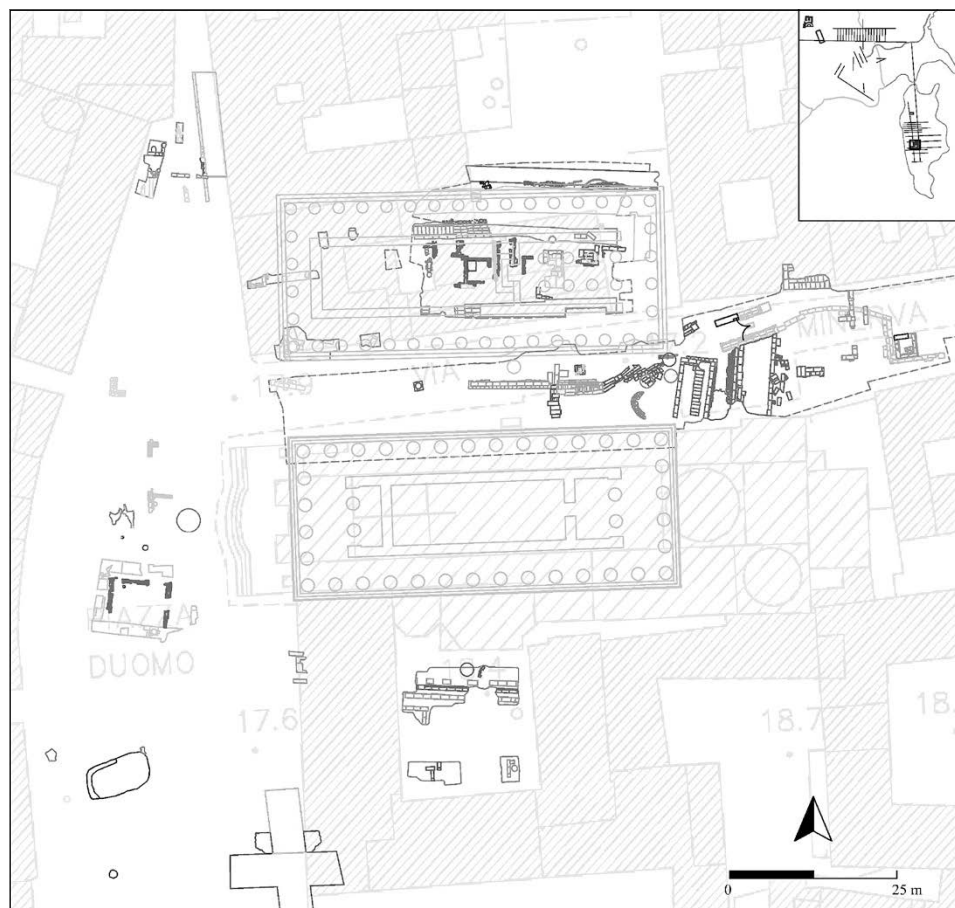


Fig. 4 – Syracuse, piazza Duomo area. Archaeological map of the evidence pertaining to the ancient city.

transformations, as well as the identification of forest resources, mining areas, and wetlands within the geographical space. Moreover, it will allow for the calculation of solar exposure and the examination of seasonal landscape changes, shedding light on how these factors influenced past human activities and settlements. The analysis of these information sources will enable the creation of digital orographic models, spatial analyses, and the definition of physiographic classes, all integrated within the historical and archaeological landscape context.

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3.2 Syracuse - Toward an Atlas of an ancient Mediterranean metropolis

Atlases represent a powerful instrument for cultural communication, enabling the narration of a place's history. The use of specifically designed cartography to illustrate the evolution of a landscape – whether a territory, an urban area, or a specific sector – contributes to visually reconstructing the key stages of historical, urban, and architectural transformations. We have previously employed this narrative approach to trace the changes in the urban landscapes of Rome within the Aurelian Walls, spanning from the 8th century BCE to the 5th century CE (CARANDINI, CARAFA 2012, 2017).

As part of the CHANGES Project, we have started a new endeavour dedicated to the creation of an *Atlas of Ancient Syracuse*, following in the footsteps of the work created by Cavallari more than a century ago (CAVALLARI, CAVALLARI 1883). Since that time, the enormous amount of archaeological, architectural, and epigraphic data that has emerged in the city has never been systematized and transformed into a system of knowledge aimed at the narration of the history of the changing urban landscapes of Syracuse. Consequently, the Ancient Syracuse Atlas Project aims to pursue this goal covering a chronological span from pre/protohistoric evidence predating Greek *polis* to the de-structuring of the Roman urban framework. This work has been made possible through an Agreement between the Dipartimento di Scienze dell'Antichità of Sapienza University of Rome, the Assessorato Regionale dei Beni Culturali e dell'Identità Siciliana and the Soprintendenza per i Beni Culturali e Ambientali di Siracusa.

A significant contribution to this project derives from the integration and systematic reassessment of legacy data through specific classification procedures. These data, produced by scholars in vastly different historical and methodological contexts, require careful re-examination using contemporary archaeological and epistemological approaches. In this specific case, the access to the archive of excavation notebooks and diaries from Paolo Orsi's archaeological investigations has provided new and crucial insights into the urban and architectural organization of several sectors of Syracuse.

A preliminary outcome of the research is the assessment of a particularly significant sector of the ancient city, corresponding to present piazza Minerva and the Archbishop's Palace on the island of Ortygia. In antiquity, this area was part of the major central sanctuary of the island. Published documentation from excavations conducted in this sector by P. Orsi, G.V. Gentili, P. Pelagatti, and L. Guzzardi (ORSI 1910, 1918; GENTILI 1967; PELAGATTI 1973, 1982; GUZZARDI 2012), has been critically re-examined alongside unpublished documents from Orsi's investigations in piazza Duomo (1922). This reanalysis has enabled the correlation, phasing, and chronological attribution of stratigraphic sequences and architectural structures. As a result, the historical development of this part of Syracuse's urban landscape has been articulated into five major chronological periods, further subdivided into ten phases, spanning from the Bronze age to the Roman era. Additionally, for each chronological phase, specific contexts and monuments have been identified and classified in UTs (see above): their construction, modification, and destruction marked the transformation process of this area (Fig. 4).

3.3 Assessment for museums of local community. Amendolara and landscapes of ancient Sybaritides

The historical narratives of different sites within a given territory, when examined through the lens of contexts and processes within a holistic framework, generate increasingly complex layers of assessment and provide critical insights for both museums and local communities. A compelling example of this methodological approach is the ongoing research in the territory of Amendolara, in the Upper Ionian region of Calabria. Here, a multi-scalar investigative strategy – ranging from sub-regional territorial analyses to the detailed study of individual contexts and assemblages of material culture – has been implemented through a formal collaboration agreement with Soprintendenza Archeologia, Belle Arti e Paesaggio per la provincia di Cosenza and Museo e Parco Archeologico di Sibari.

Within the broader scope of this research, encompassing the entire Upper Ionian area, a systematic study has been undertaken to gather and analyze all available data concerning past human settlement patterns, the diachronic distribution of habitation sites, and their functional classification (e.g., primary centers, villages, farmsteads, villas, necropolises, and production areas). This investigation has significantly benefited from datasets compiled during an extensive archaeological survey program conducted between 2000 and 2005, which aimed to reconstruct the ancient agrarian landscapes within the current municipal boundaries of Amendolara and Castrovillari (CARAFA 2019, 2025 with previous bibliography; CAPANNA, CARAFA 2021). The systematic surface survey – covering the entirety of the

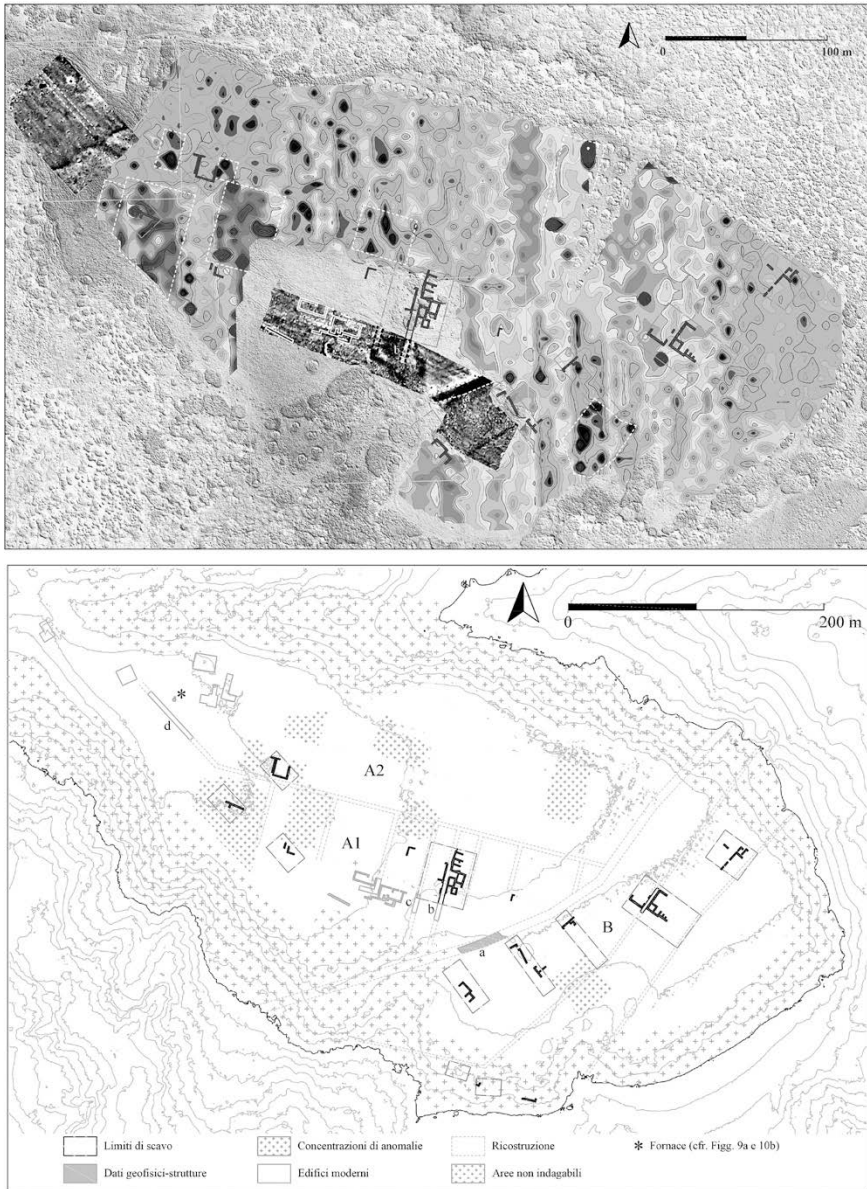


Fig. 5 – Amendolara (CS), Distribution of anomalies detected through magnetometric survey and identification of profiles and orientations detectable and compatible with buried archaeological remains. Above, in black, the archaeological remains identified during stratigraphic excavations; below, restitution of the distribution, extent, and configuration of anomalies compatible with buried archaeological remains and the main orientations detected.

Amendolara municipal territory and approximately 40% of that of Castrovillari – has yielded a substantial body of data, allowing for the reconstruction of settlement dynamics, the processes of demographic expansion and contraction, and the strategies employed for the exploitation and management of agricultural resources.

In parallel, a comprehensive cataloguing and analysis of artifacts and material culture assemblages recovered through stratigraphic excavations and field surveys has been initiated. These materials have been classified according to their respective settlements and chronological frameworks to reconstruct the networks of production and exchange that characterized this territory in antiquity.

A more targeted investigation has been dedicated to the topographical structure of a particularly significant settlement located on the plateau of San Nicola di Amendolara (CS) and to the socio-cultural identity of the community that once inhabited this site.

Archaeological research on the San Nicola plateau has been conducted through multiple field campaigns between 2021 and 2022. The methodological approach has integrated: 1) aerial mapping of the site and its surrounding landscape using drone technology and 2) geophysical prospections. The aerial survey aimed at generating a high-resolution three-dimensional digital terrain model (DTM) of the plateau, providing a detailed geomorphological framework within which to contextualize the spatial distribution of previously documented archaeological features (DE LA GENIÈRE 1970, 1991; DE LA GENIÈRE, NICKELS 1975). Additionally, multispectral surface analysis was conducted to enhance the identification of potential archaeological anomalies.

Geophysical surveys, carried out over two distinct campaigns (2021 and 2022, CARAFA *et al.* 2023; CARAFA, DE STEFANO *in press*), initially focused on selected sample areas to test the diagnostic potential of different survey techniques, specifically magnetometry and ground-penetrating radar (GPR). The objective was to assess the comparative effectiveness of these methods in preparation for a broader-scale investigation. Both techniques detected anomalies consistent with buried archaeological remains; however, comparative analysis demonstrated that magnetometry provided a clearer and more interpretable dataset. Consequently, during the 2021 campaign, a large-scale magnetometry survey was extended across the entire San Nicola plateau, with the exception of areas rendered inaccessible due to dense vegetation or challenging topographical features.

The research conducted thus far on the San Nicola plateau has yielded significant preliminary results, contributing to a more refined understanding of the ancient settlement (Fig. 5). The integration of archaeological data with remote sensing and geophysical survey results has enabled the reconstruction

of the site's spatial organization and the identification of key structural patterns across different sectors of the promontory. These findings will serve as a foundation for the strategic planning of future excavation and research initiatives.

Alongside investigations focused on the built environment, a parallel line of inquiry has been dedicated to examining the community that inhabited the site through the analysis of associated necropolises. The funerary contexts of San Nicola di Amendolara have been the subject of only partial and systematic publication (DE LA GENIÈRE *et al.* 1981; DE LA GENIÈRE 2012), with the eastern sector of the so-called Paladino necropolis remaining unpublished. Within the framework of the ongoing research agreement, the study of this sector has now commenced. This area corresponds to a funerary zone utilized primarily between the late seventh and early sixth century BCE and the late sixth century BCE, a period that coincides with the peak expansion and political dominance of the Greek colony of Sybaris. This chronological correspondence suggests the likely integration of the San Nicola settlement within the broader territorial sphere of Sybaris. The findings from this study, soon to be published, have facilitated a preliminary reconstruction of the social composition of this community and have shed light on evolving funerary practices and cultural customs during a pivotal phase in its historical development.

The various research approaches employed – spanning multiple investigative scales – have generated new cultural content that has been directly incorporated into the curatorial design of the newly conceived exhibition at the Museo Archeologico Nazionale della Sibaritide and the development of the forthcoming Museum of Prehistory of Sibaritide in Amendolara.

F.D.S.

4. CONCLUDING REMARKS

The Spoke 8 project is aiming at the creation of a multidisciplinary unit dedicated to enhancing the understanding, actualization, management, and dissemination of contexts, territories, and assets within TCH. The project's cultural and scientific premises are supported by a well-tested workflow, applied across several case studies. Therefore, isolated and fragmented data are turned into shared systems of knowledge. More than this, suggested procedure is basically oriented towards an innovative operating track inspired by the Datawheel methodology by Carola Hein and a group working on Maritime Heritage at Delft University of Technology (HEIN *et al.* 2022). Different datasets are implemented thanks to advanced disciplinary philologies and approaches, thus validating trans-disciplinary assets available for the first time at abroad scale for the TCH management, at least in this country.

Such assets are also related to places and space transforming landscape in the main hub for the knowledge of the Heritage itself. Locating information will help in focussing our ‘scientific knowledge’ on specific problems and contexts in the perspective of a data driven management system.

P.C.

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ABSTRACT

Within the CHANGES Project, Spoke 8 focuses on integrated advanced technologies and scientific methods to enhance the sustainability and resilience of Tangible Cultural Heritage (TCH). The project fosters the creation of a transdisciplinary unit aimed at improving the knowledge, understanding, management, and dissemination of TCH contexts and assets, supported by innovative workflows and methodologies. It emphasizes transforming fragmented data into shared systems of knowledge. By geolocating information, the project

directs scientific focus toward specific problems, promoting data-driven, interdisciplinary approaches for sustainable heritage management. The case studies, including the Ancient Latium, Amendolara (CS), and Syracuse projects, represent preliminary outcomes of this methodology, encompassing the systematic inventory and classification of diverse data, the assessment of knowledge frameworks, and the implementation of cultural narratives.

THE SEMANTIC CENSUS: A NEW EXPRESSION OF THE CENSUS OF ANTIQUE WORKS OF ART AND ARCHITECTURE KNOWN IN THE RENAISSANCE AS OPEN DATA

1. INTRODUCTION

The Census of Antique Works of Art and Architecture Known in the Renaissance is a research project that has developed continuously since 1946. For over 75 years, it has attempted to answer a specific question: which antiquities were known in the Renaissance? Its objective has remained that of matching ancient artifacts with Renaissance visual representations and texts that depict or reference them. The Census project initially took shape as an analog system of index cards and photographs. Beginning in the early 1980s, it was digitized with the support of the Getty's Art History Information Program. It is among the first digital art history projects and possibly the oldest still in active use (BARTSCH 2008). The Census database has undergone numerous technological advancements – from UNIX, to the Dyabola MS-DOS system, to CD-ROM, to an open-access database on EasyDB – and, since 2023, has been accessible on fylr, the latest iteration of EasyDB, at <https://database.census.de>.

Recently, between 2021 and 2023, the Census has taken further steps: its dataset was modeled according to the CIDOC-CRM ontology, creating a set of Semantic Census models that explicitly represent the knowledge and data contained within it. It was transformed into RDF following these models and made available first on Zenodo (NENOVA, BRUSEKER 2023c) and subsequently on the eDoc server of the Humboldt-Universität (most recently, CHRISTIAN 2024). With this latest shift, the Census has progressed toward the goal of FAIR data representation, delivering a corpus of rigorously researched, curated art historical data for new investigative programs beyond its original scope¹.

When it began, the Census was focused on figural antiquities and was guided by an interest in the origins of the Renaissance (1400-1527), when classical antiquity was once again 'known'. In the 1980s, the project expanded to include architecture and to encompass the whole of the sixteenth century. Now, the Census continues to evolve both methodologically and technically. At a time when born-analog research projects are being integrated into large-scale national and international research infrastructures and knowledge

¹ The semantic modeling of the Census data took place between 2021 and 2023 as a collaborative effort among the authors and was supported by generous funding from the Berlin University Alliance.

graphs, what opportunities does linked data offer for utilizing, challenging, or expanding this historic dataset? This article provides background to the Census project and its development over time, then describes the rationale and method of Semantic Census, which aims to meet the needs of the present digital landscape while laying the groundwork for future developments. It outlines how the Semantic Census builds upon the scholarly tradition of the analog Census, opening it to broader contexts, and concludes by addressing structural challenges.

2. CENSUS HISTORY

The origins of the Census can be traced to a letter of September 1945 by the art historian Richard Krautheimer, who with his wife, Trude Krautheimer-Hess, was writing a monograph on Lorenzo Ghiberti (1378-1455). In correspondence with Fritz Saxl, director of the Warburg Institute, Krautheimer complained about a lack of basic research on the antique objects that might have inspired Ghiberti. He asked if they should organize «a corpus of antiquities known to the 15th century». Saxl responded enthusiastically, agreeing that «it is time that somebody, either at New York University or with us, tackled the subject» (TRAPP 1999; *75 Years*). In the spring of 1946, Krautheimer and Saxl formulated their plans for a project that would correct a vague and inexact sense of the classical influences absorbed in the Renaissance, replacing it with hard facts about which antiquities were known, when, and where.

From its inception, the Census was not concerned with Renaissance adaptations of the antique, but with a corpus of antique artifacts that could be matched with Renaissance artistic or textual representations. Krautheimer and Saxl, with the support of Karl Lehmann at NYU, appointed the American archaeologist Phyllis Bober to develop the Census, which would occupy her from the 1940s to the 1980s. In devising a methodology, Krautheimer and Saxl followed a project developed in the 1930s by another exiled German art historian, Ludwig Burchard, who had compiled index cards at the Warburg Institute about the antiquities known to 17th-century artists (LU 2023). The approach taken by the Census was, moreover, fundamentally shaped by a type of archaeological cataloging of Renaissance drawings first pioneered by Otto Jahn and developed by Adolf Michaelis and Christian Hülsen.

Whereas studies like Michaelis's catalog of the drawings of Maarten van Heemskerck (MICHAELIS 1891; Fig. 1) began with Renaissance works of art and compiled lists of the antiquities they depicted, the Census would reverse this approach by starting with specific antiquities and listing the Renaissance visual and textual descriptions that documented 'knowledge' of them. The

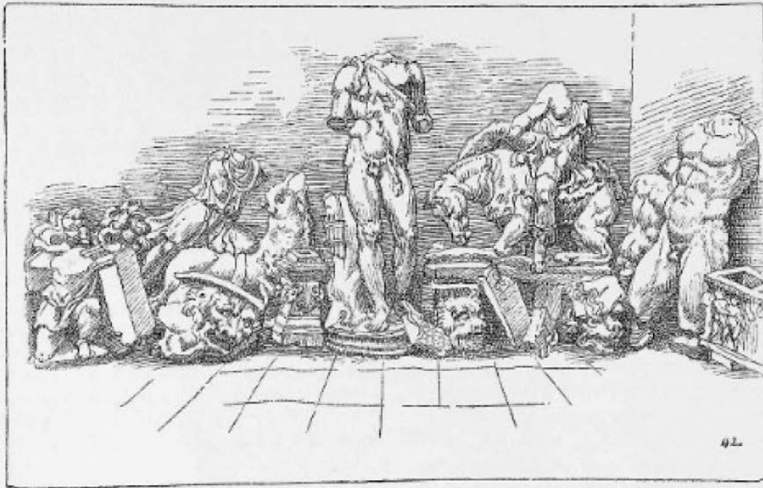


Fig. 3. In Casa Santacroce.

- f) Kleiner Sarkophag, nur z. Th. sichtbar; vorne links eine Sonnenuhr(?), zwei stehende Knaben oder Jünglinge ringend(?), Andeutung einer weiteren Figur.
 g) Links von a Mithras auf dem Stier kniend, an dem vorne, der Hund sichtbar wird.
 h) Kleine viereckige Basis mit Widderköpfen und Guirlanden.
 i) Stück eines ovalen Sarkophags mit großem Löwenkopf, anscheinend Stück eines ganzen Löwen (vgl. I, 26 v, b).
 k) Löwenkopf, ähnlich.
 l) Kleine auf dem r. Knie kniende Figur, in Motiv und Gewandung nicht unähnlich der Amazone bei Cavall. III. IV, 43, doch scheint sie nicht identisch (vgl. zu I, 47, a) und ist vielleicht eher männlich. Von den attalischen Weihgeschenken?

Fig. 1 – Page from MICHAELIS 1891, 142.

Census method was to create index cards, each labeled at the top with the name of an antique monument. Information about the object's excavation, restoration, and Renaissance documentation (such as drawings, statuettes, prints, or texts) followed, along with relevant bibliography. The index cards were matched in the Warburg Institute's Photographic Collection with images (Fig. 2) and, through transatlantic cooperation, two analog Censuses of index cards and photographs grew in parallel: one in NYU and one at the Warburg Institute (TRAPP 1999; 75 Years). Those familiar with the handbook *Renaissance Artists and Antique Sculpture* by Bober and Ruth Rubinstein (BOBER, RUBINSTEIN 1986) will recognize the origins of this reference guide in the working methods of the analog Census.

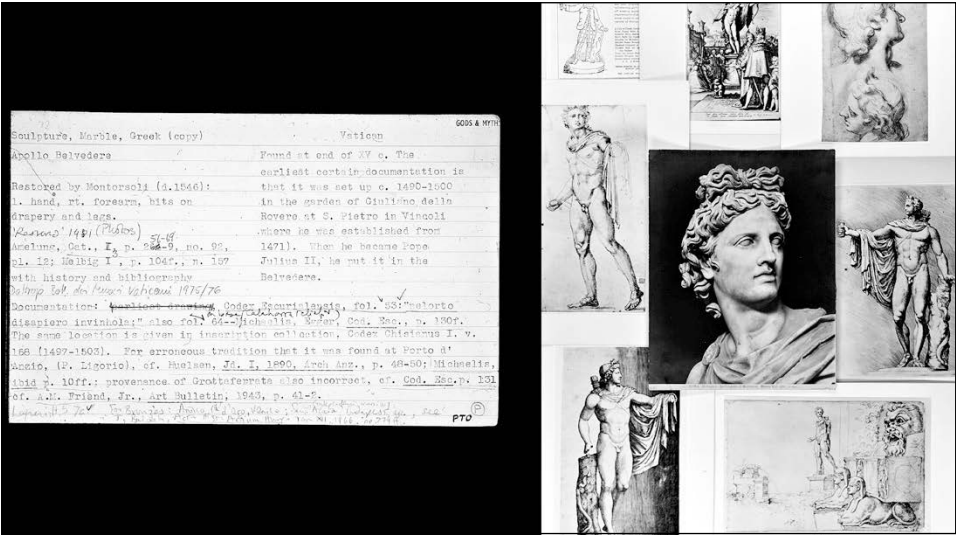


Fig. 2 – Warburg Institute, Photographic Collection, the Analog Census: Census card and photographs related to the Apollo Belvedere.

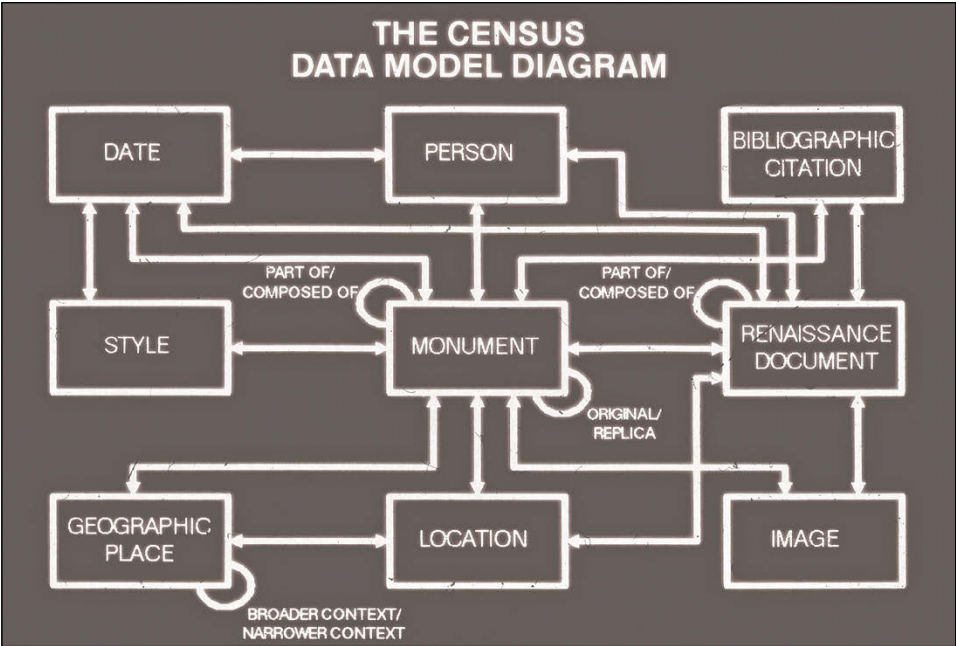


Fig. 3 – Original Census data model.

In the early 1980s, the Bibliotheca Hertziana joined the Census as a supporting partner, and the project was expanded to encompass architecture and the entirety of the sixteenth century. Starting in 1982, the Getty's Art History Information Program sponsored the development of a database system to access and search materials both in the Census and in the Witt photo archive of the Courtauld Institute. Arnold Nesselrath and the computer scientist Rick Holt developed a data model for the Census that linked two primary files: monuments (antiquities) and documents (the Renaissance texts and images that demonstrate knowledge of these antiquities). An additional set of 'authority files' (places, persons, bibliography, dates, and styles) was linked to these primary files (NESSELRATH 1993; BARTSCH 2009) (Fig. 3).

The digital representation of the Census put it on the cutting edge and gave it a more prominent profile at a time when art-historical interest in the reception of the antique was broadening (e.g. SETTIS 1984-1986). Its ordered data model provided the project with a systematic organization, which was preserved and adapted to new formats. The project moved to Berlin in the 1990s with Nesselrath's appointment as a Professor at the Humboldt-Universität, and further expansion of the content of the database was achieved through the addition of the Corpus Winckelmann and through collaboration with focused projects (*Linked Projects - Census*, <https://www.census.de/en/linked-projects/>).

As the Census database grew in content and became increasingly accessible, it served as a roadmap of antiquities and their Early Modern representations, filling a significant gap in research caused by the fact that antiquities in the Early Modern period were traditionally not a core concern of either archaeology or art history. At the same time, the early adoption of a fixed data model and a hierarchical, relational database format locked in a structure that could not be easily changed. Reservations about dryness and rigidity had followed the Census project since its origins (BOBER 1989; TRAPP 1999) and in 1982, at the earliest stages of digitization, Bober expressed hope that a computerized Census could retain a sense of flexibility and openness suited to individual use. The Census should be programmed in Pascal, she proposed, or another language likely to be taught in free evening courses, so that researchers could «make up their own program to use the data base in new searches we might not have anticipated» (75 *Years*, room 3).

The Census data model developed during an era of significant technical restrictions, when the digitization of images (originally stored on laserdisc) was highly resource-intensive. The structural and technical limitations of the systems available in the 1980s guided the database's rules of admission as well as its strict focus on its principal aim, which was to connect genuine

antique monuments with Renaissance images or texts that documented them. Defining one-to-one links between antique monuments and Renaissance documents has remained over decades the core work of the Census database, yet by today's standards, such a data model seems rigid and restrictive, prohibiting the type of flexibility that Bober hoped to achieve. Over the years, proposals have been made to expand its functionality, specifically to transform the Census into a graph database to allow it to function as a complex network (SCHICH 2009).

The use of databases in the humanities generally has, in numerous ways, been called into question, and much research has been invested in more nuanced, more adaptable alternatives (OLDMAN 2021). Although a new representation of the Census data in an entirely different format has so far remained out of reach, since 2020 the first steps have been taken to make the dataset more dynamic and more open. For example, with the relaunch of the Census in fyhr (in April 2023) the categories 'Monument' and 'Document' were renamed 'Antique Monument' and 'Postclassical Work'. This change acknowledges the integrity of drawings, sculptures, and texts as creative works in their own right, while complicating their status as straightforward 'documents' proving Renaissance knowledge of antiquities (SAWATZKI 2023). 'Antique Monument' is now also redefined as a more ambiguous category, which «may also include deliberate falsifications of antiquities, or objects which were judged incorrectly in the Early Modern period to be antique» (*Census Data Model Documentation*: https://census-antiquity-renaissance.github.io/census_csdm/; MANTILLA 2023; MILLER 2024). Another key focus, as is detailed below, has been the transformation of Census data into semantic data in order to expand the project's reach, enable its data to be utilized beyond its original framework, and open it up to broader scholarly engagement.

3. FROM DIGITAL RESOURCE TO LINKED DATA

As a long-lived and successful project, the Census has spanned multiple technological shifts during the course of its existence. Moving through several analog stages and embracing the digital shift early on, it has had to evolve in dialogue with the advancement of information management technologies. Doing so, as has been detailed above, has meant both reaping the benefits and experiencing the limitations of those technologies as they arose. One approach to information management that has emerged over the later period of the Census's history is the proposal of the semantic web and Linked Open Data (BERNERS-LEE *et al.* 2001; BIZER *et al.* 2023). This method offers an opportunity to create an additional representation of the Census data that would not only preserve its original value but would also simultaneously free

it from the particular research perspective of its origin, to act as raw data for new research questions and methods, in art history, in archaeology, and also potentially outside of these disciplines entirely.

The idea of the semantic web proposes that data be encoded in a way that is not only human-readable but also machine-processable (ANTONIOU, VAN HARMELEN 2004). By adopting agreed common data structuring methods – formal ontologies – it proposes expressing data through a lingua franca for data encoding that is both recognizable and usable for members of a common domain, such as art history, while also being logically processable by algorithms and queries (GUARINO 1997). The notion of Linked Open Data builds on this by ensuring that data is assigned unique resource identifiers, making unique items in the common data web referenceable and potentially discoverable. Linking the data by semantically meaningful predicates aims to make it fully accessible without the barrier of an idiosyncratic data structure. Together, these proposals form a key part of the concept of FAIR data (CARBALLO-GARCIA, BOTÉ-VERICAD 2022), which has become a primary objective of the collaborative research community and, increasingly, a requirement for publicly funded research. FAIR data ensures that publicly funded data is accessible and reusable, while enabling research results to be integrated across projects over time.

Curated over several generations of scholarship, the Census dataset offers a rich seam of research data for representation in the semantic web. Moreover, its evolution as a project and dataset parallels many of the core aims of such a diachronic research effort. While the Census, as outlined above, began with targeted scholarly goals, shifts in methodology and changing interactions of scholars stretched its capacities, expanding the scope of the original data structure and of the data collected. The demands of the research, moreover, made interinstitutional data gathering and sharing a necessity. Its early digitization program, supported by the Getty, provided the Census with its first data model and engaged it in the question of how to explicitly document and share data over time. Thus, while the Census could be caricatured as a so-called data silo, its evolution shows how, in pursuing its aims, it has naturally transitioned from rigid curation criteria – dictated in no small part by the recording methods then available (index cards, early database systems) – to an international effort advancing scholarship on the reception of antiquity and on Early Modern visual culture more broadly. Thus the creation of a Semantic Census – an expression of the Census data that provides an open and reusable version of the dataset for scholars – continues the project's broadening over time and constitutes an important adaptation to the changing digital scholarly landscape. The Linked Open Data approach offers an alternate representation that removes the limitation of the record boundary, aiming to create an open network of knowledge.

4. ANALYSIS AND SEMANTIC DATA MODELING

The first step in creating a Semantic Census was to initiate an analysis of the Census database in the first place. The case of the Census data model was particularly interesting for this process. While many data structures grow organically from the needs of research projects or are imposed top-down from the adoption of softwares which dictate an extant data structure with little or no ability to alter it, the Census data model was deliberately devised with the scholarly intent of the data recording in mind. The Census data model, devised already in the 1980s by Nesselrath and Holt, had features anticipating a semantic database already, without the formalized semantic encoding. At the heart of the data structure lay the division between Monument and Document and the relation between them. The primary focus of cataloging in the information system was monuments in antiquity. Criteria for inclusion as instances of this class were their being (a) genuinely antique and (b) referenced in a Renaissance document. The other most important class of the original data structure was the document. A document was defined as a Renaissance work, such as a drawing, print, text, or sculpture, which provided a response to the antique monument. The key relationship mapped in the Census is one of witnessing or giving evidence of an awareness, knowledge, or perception of antique monuments in the Renaissance era. Supporting these were a series of models recording persons, images, bibliography, dates, and locations.

The initial work of understanding the model for its semantic representation involved reviewing the extant documentation in sessions between Census staff and the semantic modeling team. These sessions aimed to clarify both the original intent of the models and their actual use over time. To generate a semantic dataset, a formal ontology – a high-level semantic language suitable for the dataset – must be chosen, and the original data must be translated from regular tabular format into a semantically encoded and meaningful information structure. To approach the modeling of this data, the CIDOC CRM (BEKIARI *et al.* 2021) was selected as the base formal ontology for semantic representation. This decision was grounded in considerations of both adequacy and practicality. In terms of adequacy, the scope and range of the CRM ontology – which models cultural heritage and historical facts over time – aligned with that of the Census data. In terms of practicality, the CRM is a widely adopted standard in cultural heritage data projects, facilitating broader uptake and reuse.

Beyond adopting the CIDOC CRM as the semantic framework, the project aimed to create semantic translations of the original data according to commonly used patterns to ensure maximum compatibility with potential overlapping datasets. It anticipated future collaborations with like-minded

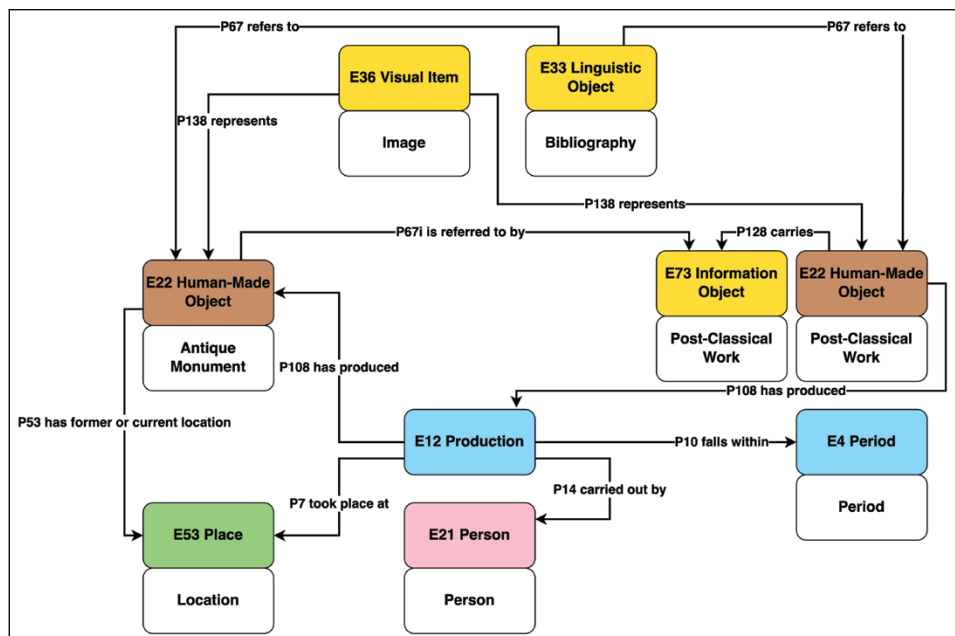


Fig. 4 – Overview of the Census ontology.

research initiatives such as those represented in the CORDH network (<https://www.cordh.net/>) of which the Census is a member. The Swiss Art Research Infrastructure's Semantic Reference Data Models (SARI Documentation, <https://docs.swissartresearch.net/>), offered within this network, serve as guidelines for basic modeling decisions in art and architectural semantic modeling using CIDOC CRM, which made them an ideal starting point. These models offer common semantic modeling patterns for basic entities in the cultural heritage sector, as well as common patterns for translating atomic elements of information, such as names or identifiers. Adopting such patterns streamlined the modeling process by providing ready-made solutions to potential problems, so that modeling efforts could concentrate on difficult areas of documentation where the ontology or the patterns did not have a predefined solution.

This process resulted in the development of eight Semantic Census models. These models provide an expression of the data captured by the original Census data structure, now aligned with the CIDOC CRM ontology. Fig. 4 provides an overview of the top-level modeling and the main connections between the models. The semantic modeling process was not unidirectional, but resulted in a reconsideration of the original models themselves. Thus with

the relaunch of the Census database in fylr in April 2023, ‘Monument’ and ‘Document’ were renamed ‘Antique Monument’ and ‘Postclassical Work’, respectively, to better describe the contents of the Census. These categories are represented neutrally as instances of E22 Human-Made Object in the CIDOC CRM ontology. Additionally, to reflect research taking place in the field of classical reception, the category of ‘Antique Monument’ was expanded to include not only works dated by archaeology to antiquity, but also works that were perceived as being antique during the postclassical era. Individual time spans previously documented in the ‘date’ model were reassigned to the relevant items and events which they temporally delineate. Periods and styles were recognized as reference data in their own right, requiring their own documentation, and were matched to the class E4 Period.

Each of the models is based on the data contained in Census records. But these models also allow the data to transcend the confines of the Census data model, aligning it with the CIDOC CRM framework. Integrating the data into an open semantic web enables reanalysis and reuse according to questions and concerns that extend beyond the original cataloging function. It allows the thoroughly-researched data of the Census to serve as authoritative reference data for other projects, facilitating both appropriation and critique.

5. SEMANTIC DATA MODEL DOCUMENTATION

The adoption of the semantic reference data model technique (BRUSEKER *et al.* 2025) offered a significant advantage to the Semantic Census project. It provided not only for a semantic translation of the data, but also for a standardized documentation of that model accessible to scholars, who may not be well-versed in semantic data, thereby supporting the potential reuse of Semantic Census data. The uptake in digital skills which Bober imagined in 1982 is still not realized in the fields of archaeology and art history in 2025. Bridging this technological gap requires the development of accessible pathways that enable individuals to understand and manipulate data. This goal motivated the adoption of an intensive work plan to document the Semantic Census data models in a way that is understandable to both scholars and engineers.

The semantic reference data model methodology suggests documenting semantic data projects in units of models, collections, and fields. Each unit corresponds to familiar data patterns, such as forms and tables, with which scholars are acquainted. They are defined using terminology oriented to the scholar but linked to explicit formal representations in the target ontology. The outcome of adopting this methodology was the elaboration of a rich documentation detailing the meaning of the semantic models for their long term reuse (NENOVA, BRUSEKER 2023a), which can be accessed here:

Model Name	CRM Class	Documentation Link
Antique Monument	E22 Human-Made Object	https://tinyurl.com/46hpxs3e
Post Classical Work	E22 Human-Made Object	https://tinyurl.com/bdhub3nh
Person	E21 Person	https://tinyurl.com/9xp4ckm7
Location	E53 Place	https://tinyurl.com/3kwbu8d7
Image	E36/D9 Visual Image	https://tinyurl.com/3n4sp9ke
Period / Style	E4 Period	https://tinyurl.com/d5cmh5yp
Bibliography	E33 Linguistic Object	https://tinyurl.com/ahfe64wk

Moreover, by adopting the Semantic Reference Data Model methodology, we were able to reuse many patterns from the SARI SRDM while explicitly documenting the new fields, collections, and models proposed by the Semantic Census. In total, the Semantic Census added 95 fields and three collections, and it built eight new models. This documentation provides a guide to understanding the Semantic Census data, creating data from scratch that would integrate with it, and transforming existing data into a compatible form.

6. MAPPING AND TRANSFORMATION

After developing an ideal set of documented SRDMs, the target model for a semantic data transformation was set. In keeping with the goal of making the Semantic Census data FAIR, an explicit and reusable process to transform the extant data to a semantic format was created. For this process we used the X3ML mapping language and the 3M (Mapping Memory Manager) tool (MARKETAKIS *et al.* 2017). This technology was chosen because X3ML is a declarative mapping language that enables explicit mapping instructions to transform data from a source to a target semantic

The screenshot displays a semantic mapping interface with a hierarchical tree structure. The root node is 'Myron [E21_Person]'. It branches into several properties, each with its own set of sub-properties and values. The interface uses color-coding: pink for person-related properties, blue for time-span and birth/death events, and yellow for notes. Expandable nodes are marked with a minus sign, and collapsed nodes with a plus sign.

Property	Value / Sub-property
Myron [E21_Person]	-
P1_is_identified_by	Myron [E33_E41_Linguistic_Appellation]
	Census Record Identifier 10194253 [E42_Identifier]
P98i_was_born	Birth Event of Myron [1st half of 5th cent. BC] [E67_Birth]
P4_has_time-span	Time-span of Birth Event of Myron [1st half of 5th cent. BC] [E52_Time-Span]
	P82a_begin_of_the_begin: -0499-01-01
	P82b_end_of_the_end: -0450-12-31
P1_is_identified_by	1st half of 5th cent. BC [E33_E41_Linguistic_Appellation]
P129i_is_subject_of	Note Concerning Myron [E33_Linguistic_Object]
L54_is_same-as	Myron [ULAN Record: 10192478] [E21_Person]
	Myron [VIAF Record: 146218593] [E21_Person]
P100i_died_in	Death Event of Myron [2nd half of 5th cent. BC] [E69_Death]

Fig. 5 – Semantic mapping.

#	SOURCE	TARGET PATH NAME	TARGET	CONSTANT EXPRESSION
1	D ☒ easydb:cs_person		☒ E21_Person	
1.1	P ☒ easydb:name	fe_5_Name	↓ P1_is_identified_by E33_E41_Linguistic_Appellation ↓ P190_has_symbolic_content XMLSchema:string	[P2_has_type] [E55_Type = "preferred terms"]
1.2	R ☒ easydb:name		☒ XMLSchema:string	
1.2	P ☒ ..easydb:cs_person_aliases	fe_10_AlternativeName	↓ P1_is_identified_by E33_E41_Linguistic_Appellation ↓ P190_has_symbolic_content XMLSchema:string	
1.2	R ☒ ..easydb:cs_person_aliases		☒ XMLSchema:string	
1.3	P ☒ ..easydb:cs_alias_type	fe_11_AlternativeNameType	↓ P1_is_identified_by E33_E41_Linguistic_Appellation ↓ P2_has_type E55_Type	
1.3	R ☒ ..easydb:cs_alias_type		☒ E55_Type	
1.4	P ☒ easydb:system_object_id	fe_1_Identifier	↓ P1_is_identified_by E42_Identifier P190_has_symbolic_content XMLSchema:string	[P2_has_type] [E55_Type = "record identifiers"]
1.4	R ☒ easydb:system_object_id		☒ XMLSchema:string	
1.5	P ☒ ..easydb:verbatim_dates	fe_cen_64	↓ P98c_was_born E67_Birth ● [73_1] ↓ P4_has_time-span E52_Time-Span ● [73_2] ↓ P1_is_identified_by E33_E41_Linguistic_Appellation ● [C64_1] ↓ P190_has_symbolic_content XMLSchema:string	
1.5	R ☒ ..easydb:verbatim_dates		☒ XMLSchema:string	
1.6	P ☒ ..easydb:earliest_date	fe_73_BirthDateEarliest	↓ P98c_was_born E67_Birth ● [73_1] ↓ P4_has_time-span E52_Time-Span ● [73_2] ↓ P82a_begin_of_the_begin XMLSchema:dateTime	
1.6	R ☒ ..easydb:earliest_date		☒ XMLSchema:dateTime	

Fig. 6 – RDF visualizer.

data model. In this way, we were able to generate a mapping for each model from the original source data, expressed in relation to the semantic reference data patterns, which directly shows how each source field is translated into its corresponding target field (Fig. 5). An additional advantage of the 3M mapping tool was its integration of an RDF Visualizer (<https://www.ics.forth.gr/isl/rdf-visualiser?lang=en>) (Fig. 6).

This particular software provides a compact representation of RDF data structures. In terms of creating mapping instructions, as well as testing and explaining the outcomes between the data engineer and the researcher, this tool was highly important for verifying that the data transformation successfully expressed the primary data in the new semantic format. The mapping files created to generate this transformation were published as a paradigm for further transformations of data which could align to the Semantic Census data (NENOVA, BRUSEKER 2023d).

7. QUERYING AND RESEARCH QUESTIONS

While the aim of the semantic representation of the Census data was to open it to a wider audience, a key challenge of using semantic data in humanities research is that, while it has been adapted in numerous projects, basic familiarity with its creation, maintenance, or querying is far from a core skill taught to students. It was therefore considered a priority to establish an access point for researchers to begin to understand how to query the data and to envision the kind of responses it could provide. The modeling and

documentation structure of the semantic data models offered a foundation for systematically describing the types of queries that could be formulated using the semantic models. These queries were documented both as SPARQL query code and as English language questions corresponding to the types of inquiries researchers might pose of the data. Equivalences were made such as: ‘Show me the monuments with creator information’.

The complete set of queries for the models was documented and published (NENOVA, BRUSEKER 2023b). Using the field system of the SRDM approach, these queries not only represent a way to access data for a particular topic in the Semantic Census dataset, but also serve as primary material for constructing richer, more complex questions that are the result of multiple cross-model queries to the knowledge base.

8. CONCLUSION

The Semantic Census project aimed to build upon the scholarly tradition of the Census project by providing it with a new data expression, opening it to the Linked Open Data world and new lines of inquiry. Achieving this goal required the creation of a fully documented set of semantic reference data models for the Census, a set of explicit mapping files that can be used in a pipeline to transform and update the semantic representation of the Census on a regular basis (NENOVA, BRUSEKER 2023e), and a systematic set of SPARQL queries to explore this data in relation to real world questions that researchers might pose. The Semantic Census is a resource that expands the project’s scope, enabling its reuse across broader disciplinary contexts while adhering to the principles of FAIR content. This transformation is especially significant since the Census occupies a unique position as a bridge to the early history of art history and the early history of digital humanities. The Census is a distinctive case, moreover, given its long-standing position at the intersection of art history and archaeology, where it has been shaped by the diverse methodologies of these fields.

The Semantic Census project lays the groundwork for future research, while highlighting institutional and infrastructural challenges as well as fundamental research and pedagogical concerns. Regarding the former, a key issue is building infrastructure and identifying stable institutional homes for semantic data. Enabling partnerships and long-term collaborations – both at the software level and the institutional level – is essential to realizing FAIR principles and unlocking the potential of research across semantic datasets. In the case of the Census, while semantic data is generated regularly and stored for researcher access, it is not hosted as a live dataset, and the need for supporting software that enables interactive relationships with semantic data must be addressed. A broader issue of training is also relevant: while

the promise of Linked Open Data is to provide explicit and openly available scholarly datasets for analysis and reuse, the dissemination of fundamental skills necessary to work with this data within the humanities remains limited. Much remains to be done, since historic databases such as the Census stand to gain considerably by connecting their resources in a way that empowers not only institutions, but also individual researchers and early career scholars, to leverage open research.

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ABSTRACT

The Census of Antique Works of Art and Architecture Known in the Renaissance, established in 1946, is a research project that traces the knowledge and reception of antiquities known during the Renaissance by linking them with Early Modern visual and textual records. It has over its long history evolved from an analog system, to one of the earliest digital art history projects, to an online database (<https://database.census.de>). Recent innovations (2021–2023) have transformed the database into semantic data using the CIDOC-CRM ontology, aligning it with FAIR principles and encouraging broader engagement with the Census's rigorously-researched dataset. The modeling process involved creating eight Semantic Census models, supported by extensive documentation. The semantic transformation of Census data

used the X3ML language and 3M tool for mapping and verification, ensuring consistency and compatibility with other datasets, such as those in the CORDH network. Queries can now be performed using SPARQL, with documented query examples to guide researchers unfamiliar with semantic data. The Semantic Census models have the ability to facilitate new research purposes for Census data, not only in the fields of art history and archaeology, but also beyond the project's original scope.

THE 'SACRA ABSENTIA' DATABASE ON THE LOST FURNISHINGS OF MEDIEVAL CHURCHES IN VENICE: FROM THE OVERALL FRAMEWORK TO THE CASE STUDY OF SANT'AGNESE

1. A GLIMPSE INTO THE VENETIAN CONTEXT AND THE ORIGIN OF THE PROJECT

During his second pilgrimage to the Holy Land, in the years 1483-1484, the Swiss Dominican Felix Fabri of Ulm stopped in Venice (BRAVI 2015). In his travel diary, he extols the Serenissima as «più bella e più pregevole di ogni altra città da me veduta», listing thirteen characteristics that made it famous, ranked by importance (FABRI DA ULMA 1881, 21). Midway through this ranking, he highlights the marvellous appearance of the liturgical furnishings in sacred buildings: «Seventhly – he writes – Venice is renowned for something associated with holy relics, namely, the preciousness of its treasures. How much gold, silver, and gemstones there are in all the churches and monasteries, in the cabinets, sarcophagi, monstrances, reliquaries, crosses, images, and so on, can be partially seen by those who, astonished, observe the processions. As for the chalices and sacred furnishings, one sees them every day» (FABRI DA ULMA 1881, 82). More than five centuries after this Northern European traveller's time, the interiors of Venetian churches – except for a handful of cases – have been radically transformed due to Renaissance or Baroque reconstructions (DORIGO 1983, 2003; ZORZI 1972). The furnishings used in religious functions up to that point – many likely of medieval origin – have been almost entirely lost.

The 'Sacra Absentia' project aims to trace any type of evidence related to the lost furnishings of medieval churches in Venice. The idea stems from a previous study dedicated to the memory of the city's lost wall mosaics, which led to identify around fifteen cases based on data from local scholarly texts, ancient chronicles, and archival documents (PIAZZA 2020). These sources occasionally shed light on other decorative elements, including architectural components such as floors, columns, ciboria, and altars, as well as movable artworks like liturgical furnishings and icons.

Jacopo de' Barbari's famous map, created around the year 1500 (SCHULZ 1978; HUFFMAN 2024), serves as a valuable tool for understanding the original appearance of the numerous religious buildings – approximately two hundred (DORIGO 1995, 814) – scattered across the various districts of Venice. At that time, their structures had not yet been altered by modern renovations and thus largely retained their basilical layout, featuring three naves, a portico, and a bell tower, which had been adopted during the Romanesque period

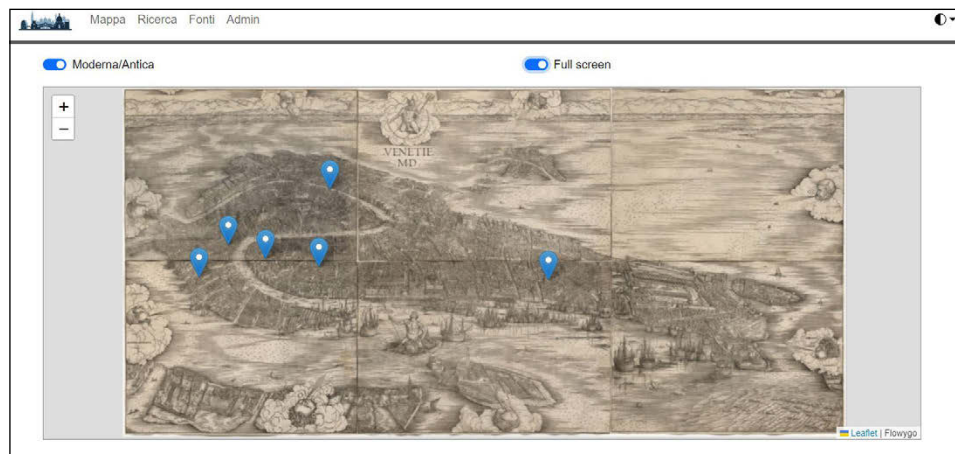


Fig. 1 – Screenshot of the ‘Sacra Absentia’ database with location some of the catalogued churches on the Jacopo de’ Barbari map (1500).

or even earlier (Fig. 1). De’ Barbari’s perspective view captures the medieval configuration of many buildings, some of which would soon undergo radical transformations, such as San Salvador near Rialto and the cathedral of San Pietro di Castello (PIAZZA 2020, 69, 72-74). The same view also documents churches that were later demolished, such as Sant’Angelo in the San Marco district and Santa Chiara in Santa Croce (ZORZI 1972, 309-311, 323-324; FRANZOI, DI STEFANO 1975, 87-88, 344-346).

But what do we know about the interiors of medieval churches? In his *De situ urbis Venetae*, a late 15th century description of Venice, Marco Antonio Sabellico states that all the churches in the city were paved with marble slabs or *opus tessellatum*, had columns of ‘foreign stone’ (*peregrini lapidis*), both at the entrance and in the choir, and many (*pleraeque*) featured vaults adorned with golden *tesserae* (SABELLICO 1722, 20). As for the *vasa sacra*, icons, and reliquaries that were once kept within them, apart from a few exceptions – such as the Treasury of San Marco, which has survived in a significant proportion, and a small number of objects that have remained in their original locations or have been moved to museums – our only knowledge comes from sources, primarily written texts, and, to a lesser extent, iconographic testimonies. The former include pastoral visits, inventories, wills, account books, local chronicles, and pilgrim diaries, some of which have been published while others are preserved in archives. The latter category consists of depictions of church interiors, which may be more or less accurate, and copies of individual objects.

Among the illustrations of monumental interiors is, for example, a canvas from the early 16th century, now in the Gallerie dell’Accademia, depicting

The Apparition of the Crucifixes of Ararat, an evocation of the vision experienced by the prior of the convent of Sant'Antonio at Castello, Francesco Ottobon, in 1511 (ZORZI 1972, 313-314; FORTINI BROWN 1988, 186-189, pls. XVIII-XIX). The work, executed by Vittore Carpaccio and dated to 1515, portrays the event in the actual location where it allegedly occurred, namely, the church of Sant'Antonio (Fig. 2). The painter thus sets the scene within

CHIESA																																																			
LOCALIZZAZIONE	Indirizzo																																																		
	Dati di geolocalizzazione																																																		
INTRODUZIONE AL CONTESTO MONUMENTALE	Fasi storiche																																																		
BIBLIOGRAFIA	Stato di conservazione																																																		
FONTI																																																			
TESTIMONIANZE RELATIVE ALL'ARREDO PERDUTO																																																			
1. Decorazioni parietali																																																			
2. Pavimenti																																																			
3. Coperture																																																			
4. Sculture architettoniche	4.1. Colonne (fusti, basi, capitelli) 4.2. Portali (architravi, stipiti, soglie) 4.3. Finestre 4.4. Rilievi in parete																																																		
5. Arredo liturgico	5.1. Altari 5.2. Cibori 5.3. Recinzioni presbiteriali (plutei, pilastri, transenne) 5.4. Coro 5.5. Fonti battesimali 5.6. Pulpiti 5.7. Lettorini 5.8. Tabernacoli 5.9. Campane																																																		
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Fig. 2 – 'Sacra Absentia' database card structure example.



Fig. 3 – Venice, Gallerie dell'Accademia, Vittore Carpaccio, *Apparition of the Crucifixes of Mount Ararat in the Church of Sant'Antonio di Castello*, 1515 (after Russo 1991).

the 14th century structure, making his testimony invaluable since the entire building was demolished during the Napoleonic era. Moreover, his work meticulously captures several late medieval furnishings (SANDRELLI 1996): two gilded wooden altarpieces featuring saintly effigies and a tall rood screen separating the nave from the choir.

To visually document the memory of liturgical artifacts from medieval Venice, there is also the large canvas depicting the *Procession in Piazza San Marco*, by Gentile Bellini, dated to 1496 (FORTINI BROWN 1988, 60-66, pl. XII; RODINI 1998). In the foreground, protected by a baldachin, is the sacred focal point of the city's parade, the reliquary of the 'True Cross' from the church of San Giovanni Evangelista (ZORZI 1972, 19). In the painting, the shape of the *staurotheca* is barely discernible, as the artist depicts it in profile, yet it is still identifiable with the example made of gold and rock crystal, which has survived to this day and is still preserved in its original location (FREEMAN 2011, 161-162, fig. 25; MEZZACASA 2019, 122-124). However, the golden case carried on the shoulders beneath it, with its Gothic style, parallelepiped shape, and the four golden angel candlestick holders, has been lost. Its



Fig. 4 – Venice, Correr Museum Library, Jan Grevembroch, *Reliquary with the head of Saint Mary Cleophas* (Gradenigo Dolfin ms. 65.3, 12, 1764; after MEZZACASA 2023).

appearance suggests it may have been an actual object, perhaps symbolically evoking the Ark of the Covenant (PIAZZA 2021, 666).

We also have the watercolour copies by Jan Grevembroch, a Dutch-born painter who lived in Venice, who in the second half of the 18th century reproduced a series of liturgical objects from Venetian churches (pissidi, chalices, crosses, and reliquaries), many of which have since been lost (ZORZI 1972, 352-353, figs. 284-290). Among these illustrations, found in the manuscript titled *Varie venete curiosità sacre e profane* (1755-1764) (BMC, Gradenigo Dolfin ms. 65.3, 12), is the particularly interesting case of the chalice from Santa Maria dei Servi in Cannaregio (MEZZACASA 2023, 214-215, fig. 95) (Fig. 4). The object has been lost, and the church itself, of 14th century origin, was demolished at the beginning of the 19th century (TRAMARIN 2023). In Grevembroch's work, the object, made of gold and silver with translucent enamels, is depicted in minute detail with great precision, to the point that it can confidently be attributed, due to its resemblance to a series of similar examples, to 15th century Venetian production.

However, the significance of the 18th century copy lies in the fact that the designer has depicted the upper part of a crowned skull inside the chalice, which the caption beneath the illustration explains is «the Head of Saint Mary Cleophas» none other than the head of the woman whom the Evangelist Matthew mentions as ‘the other Mary’ (Mt. 27:61; 28:1). The first record of the presence of this legendary relic in Santa Maria dei Servi dates back to the late 15th century: in the aforementioned description of Venice, SABELLICO (1722, 11) notes the «Virginis templum cum numeroso servorum cœtu [...] ad aram maximam Mariæ Cleophae caput». It is possible that when the scholar saw the saint’s head on the high altar of the cited church, it was already inside the chalice copied by Grevembroch. This is suggested by a similar version reproduced by Fra Giovanni da Verona at the end of the 15th century in the choir of the Neapolitan abbey of Santa Maria di Monte Oliveto (MEZZACASA 2017, 168, figs. 7-8; 2023, 214). The choice to display a skull inside a chalice may seem rather macabre, but upon closer reflection, it aligns with a phenomenon of theatricalization of the relics of saints, particularly widespread in the late medieval period and especially in Venice, a city that represented the first stop for European pilgrims awaiting departure to the holy sites of Palestine (BACCI 2020).

It is no coincidence that Felix Fabri from Ulm, cited at the beginning of this paper, ranks the display of relics sixth among the wonders of the lagoon city, even before the ‘sacred vessels’: «The sixth reason for the fame of Venice is the quantity of holy relics. Indeed, since the power of the Venetians expanded over the sea and the land, all the holy bodies that they obtained were brought to Venice» (FABRI DA ULMA 1881, 79). This statement is followed by an extensive list of sacred remains scattered across numerous Venetian churches, linked by suggestive visitation routes that foreigners followed, motivated by both faith and superstition. A century earlier, the Florentine Simone Sigoli attested to this in his travel account from Venice to Sinai (1384-1385): «Next, we shall mention all the holy relics we saw in the city of Venice. We saw the body of Saint Lucy, and it is a beautiful relic [...]. And we also saw [...] the knee of Saint Christopher [...] a finger of Constantine the Emperor [...] a molar of the giant Goliath [...] killed by King David» (SIGOLI 1862, 266; BACCI 2020, 114). These were exceptional relics, artfully displayed to impress visitors, sometimes of superhuman size, as in the cases of Saint Christopher and Goliath, and other times of infant proportions, such as the collection of presumed bodies of the Massacre of the Innocents: «In Murano, – continues the naïve Simone – in the church of San Donato, [...] we saw in an altar one hundred and ninety-eight innocent little children all small in swaddling clothes; and they are all intact, and they all have knife wounds, some in the throat, some in the chest, some in one place and some in another, and some with their throats slit [...] their

wounds are bloody and fresh, almost as if they had died very recently» (SIGOLI 1862, 265).

Whether from figurative contexts or written texts, evidence such as the ones just analysed allow us to develop theories and reasonings that help formulate hypotheses about the physical appearance of lost works and contexts. But the memory of the medieval furnishings in the churches of Venice can also be recovered through the lists of pastoral visits, which from the 15th century onwards provided brief descriptions of the inspected places of worship, with systematic lists of altars, ambones, relics, icons, and all types of liturgical furnishings. The archival material in this regard is considerable, and to enhance the large amount of information, the 'Sacra Absentia' project has created a database capable of acquiring any type of information found in published and unpublished documents¹. To proceed systematically and in an organized manner, a board template has been developed that includes a brief description of each monument, the indication of sources, and the various types of objects, without overlooking possible information regarding the monumental contexts (floors, columns, paintings, mosaics) (Fig. 2).

The input of data into the system will allow searches by object categories, monuments, or saints' names associated with various places of worship, altars, statues, altarpieces, reliquaries, and relics. For the most effective use of the collected materials, an interactive mapping system has been created based on the de' Barbari perspective map, geolocating the churches to identify their locations in current cartographic systems (Fig. 1). The decision to use the famous Venetian view is due to the fact that it is a representation rich in architectural details that have now disappeared, many of which still have a medieval layout.

S.P.

2. IMPLEMENTATION OF THE DATABASE AND THE CASE STUDY OF SANT'AGNESE

Our work on cataloguing the lost furnishings of Venetian churches has so far counted nearly ninety contexts. However, our investigation is clearly still in progress, and the database will continue to grow. To provide an example of how the records in the database are being developed, we will use the church of Sant'Agnese, in the Dorsoduro district, as a case study (for bibliography, see the most recent studies: ZORZI 1972, 487; FRANZOI, DI STEFANO 1976, 213-214; DORIGO 1983, 392, 480, 603 n. 1, 611, 616-617, 619, 623; 2003, 956).

¹ The technical and informatics setup of the database and the interface with both ancient and contemporary maps, required for georeferencing, were carried out by Dr. Alessandro Fiori (PhD, researcher and professor of Data Science and Database Technology at the Polytechnic University of Turin).

The first section of each database entry is dedicated to briefly reviewing the architectural phases and the historical-artistic events of each church under analysis (Fig. 2). For Sant'Agnese, the parish is first documented in 1081 (CORNER 1749, 153, 155); scholars have therefore hypothesized that the church was founded between the late 10th and early 11th centuries (DORIGO 1983, 611; 2003, 956). The building that has come down to us is the result of various interventions that took place over the centuries on a structure that probably corresponded to the one that had to be rebuilt following an extensive fire spread in 1106 (MARTINIONI 1663, 24; DORIGO 1983, 480). Scholars attribute the phase of rebuilding certain architectural elements traceable to the medieval period still observable, such as the series of paired arches on brick columns along the external perimeter, the pillar supports that divide the three naves internally, and the semicircular apse (Figs. 5b-6). However, the portico on the façade of the church no longer exists, while only the lower part remains of the ancient bell tower, possibly dating back to the 13th century, having undergone significant alteration between 1837 and 1838 (CICOGLIA 1834, 624; DORIGO 1983, 392, 623; 2003, 255, 258, 260, 956). The building currently retains almost nothing of the ancient decorative features (Fig. 6).

During the 14th century, work was undertaken in the church, and a reconsecration ceremony was held in 1321 (DORIGO 2003, 255), mentioned in an inscription preserved in the church (ZORZI 1972, 487, note 2; DI LEONARDO 2014, 34, note 4). Recently, Matteo Ceriana has emphasized the chronological and figurative proximity of some fragments of frescoes that still survive inside the church with the altarpiece depicting the *Coronation of the Virgin*, commissioned from Michele Giambono in 1447 for Sant'Agnese, a subject to be discussed further later (CERIANA 2016a, 46).



Fig. 5 – a) Jacopo de' Barbari, *Perspective view of Venice*, 1500, part., church of Sant'Agnese; b) Venice, Dorsoduro, church of Sant'Agnese, current exterior, southern side (photo G.A.B. Bordi).



Fig. 6 – Venice, Dorsoduro, church of Sant'Agnese, current interior.

It seems that the most significant transformations to the sacred space occurred during the 17th century, starting from the early years of the century, when the church boasted eleven remarkable altars. Stringa confirms that at that time: «questa chiesa anch'ella viene abbellita, et ornata all'uso moderno» (STRINGA 1604, 181r). Around 1670, the construction benefited from interventions promoted by the benefactor Lodovico Bruzzoni; later, in 1733, the atrium was also restored at the expense of the priest Salvatore Bertella (CICOGLIA 1824, 197, 200-201, 202-203, 205-206). The following century marked a period of severe decline for the parish, as it was suppressed on 18th September 1810 (CICOGLIA 1824, 197; ZORZI 1972, 487). Around the mid-19th century, the church was reopened for worship but following a complete renovation that preserved nothing of the original decor. Further restorations, which scholars believe contributed to altering the original character of the building, also took place in 1939 (FRANZOI, DI STEFANO 1976, 213). Nevertheless, it is possible to get an idea of the original appearance of the ecclesiastical building, including its attached portico and bell tower, thanks to its representation in the aforementioned bird's-eye view of the city by Jacopo de' Barbari (1500) (Fig. 5a). As regards its ancient internal appearance, however, it is possible to take advantage of manuscript traditions and descriptions by erudites (see, for example, CICOGLIA 1824, 197-209).

As already mentioned, in 1447, Michele Giambono was commissioned to create an altarpiece depicting the *Coronation of the Virgin* for the main altar of the church of Sant'Agnese (CERIANA 2016a, 40, 79-80; 2016b, 186-188). The central panel of this altarpiece, which has not survived intact, has been identified as a painted panel in the Gallerie dell'Accademia in Venice (CERIANA 2016a, 39-70; 2016b, 186-188). Neither this work, nor others, is unfortunately mentioned by Marcantonio Sabellico in his description of the lagoon city, compiled towards the end of the 15th century. Sabellico describes the church as «vetusta ædes» that «modice assurgit». The altar of the saint must have appeared quite old, as the scholar states that the «divæ ara» was «vetustissima» (SABELLICO 1722, I, 5). A «pala del Paradiso di assai eccellente mano» is, however, mentioned at the beginning of the 17th century by Giovanni STRINGA (1604, 181r; CERIANA 2016a, 41).

The consultation of some unpublished documents has allowed for the enrichment of the information currently available regarding the liturgical arrangement of the church and its decorative apparatus. An indication by Wladimiro DORIGO (2003, 566, n. 4, 570; 2004, 59, 63 note 74), later taken up by Devis VALENTI (2019, 51) and Simone PIAZZA (2020, 77 note 148), highlighted the probable existence of a mosaic work within the basilica. In his will from May 1291 – which has been revisited by the author –, Matteo Bondumier, the procurator of San Marco, stated: «[...] volo que fiat opus mosaicum in Ecclesia Sanctæ Agnesis [...]», commissioning the work to the mosaic artist Pietro Zapparino (ASVe, registry of Matteo Bondumier, unnumbered pages). However, based on current research, it is not possible to determine whether this testamentary provision was actually carried out.

Considering that the most significant interior renovation interventions took place during the 17th century, the reports by the prelates tasked with verifying the state of the parish towards the end of the 16th century become even more significant. Particularly rich in data are the Apostolic Visitation of 1581, carried out by the nuncio Lorenzo Campeggi and the Bishop of Verona Agostino Valier (ASPV, *Visitationes apostolicæ*. Very useful is TRAMONTIN 1967), and the Pastoral Visit of Patriarch Lorenzo Priuli, between 1591 and 1593, who inspected the Church of Sant'Agnese on 10th January 1593 (ASPV, *Visitationes ecclesiarum*, 371r-375v).

In this contribution, we will not review all the categories of furnishings listed in the aforementioned testimonies – these are instead systematically and organized in the database – but we will focus on some information that seems particularly interesting in light of the current state of the building's interior. Regarding the support system, it is worth noting that, unlike the current structure of the church, where the aisles are separated by pillars, the Apostolic Visitation mentions the presence of wooden columns (ASPV, *Visitationes apostolicæ*, 258v). There is also a wealth of valuable information

from the surveys of all the altars that were once in the church and which no longer exist today due to the 17th and 18th century renovations and the various changes the building underwent, especially in the 19th and 20th centuries.

We will not review all the altars inspected during the two Visits, as they are also included in the database's records, but we aim to highlight some information that has seemed most noteworthy. In the case of Sant'Agnese, it is noted that there were two altars dedicated to the Blessed Virgin Mary: one was located on the Epistle side (ASPV, *Visitationes ecclesiarum*, 372v), also referred to as 'left' (ASPV, *Visitationes apostolicae*, 256r), while the other is described as being entirely made of wood and situated on the Gospel side (ASPV, *Visitationes ecclesiarum*, 372v). The main altar was not dedicated to Saint Agnes, the church's eponym, but to All Saints, and had what is described as a «buco nell'antipetto» (ASPV, *Visitationes apostolicae*, 257v; ivi, *Visitationes ecclesiarum*, 371v, 374r), a term which would suggest the presence of an opening, similar to a small window, on the front of the altar. The altar of Saint Agnes, on the other hand, was located behind the choir, where there was also the altar of Saint Mathias (ASPV, *Visitationes ecclesiarum*, 372v). The same choir and the *Pergolo dell'Evangelio* however, were considered too large for the liturgical needs at the time of the pastoral visit of 1593. It was therefore ordered that the pulpit be completely removed «et all'hora si facciano dui pergoleti, proportionati, uno per parti nelli pilastri d'essa capella maggiore» and that «il choro si riduca nella cappella grande serrandola con colonnelle» (ASPV, *Visitationes ecclesiarum*, 372v, 374v). The church was also equipped with a baptismal font, which «ritrovò essere un bellissimo vaso [...] se bene non è totalmente ridotto à perfettione» located near the Gospel pulpit, which was placed on one of the choir's pillars (ASPV, *Visitationes apostolicae*, 256v; ivi, *Visitationes ecclesiarum*, 371r, 374r). From the survey of the icons on the sacred altars it is possible that the «palla d'ogni santi» recorded above the main altar corresponds to the work commissioned to Michele Giambono in 1447 (ASPV, *Visitationes ecclesiarum*, 371v).

Among the numerous types of liturgical books and sacred goldsmithing catalogued by the visitors there is one annotation of particular interest concerning a 'peace' (i.e., a tablet with a sacred image shown for the kiss of peace before Communion during the liturgical celebration, in use from the 13th to the 18th century: MEEHAN 1911), as a visual record of it was found in a graphic evidence: a watercolor by Jan Grevembroch, found in the Gradenigo Dolfin manuscript 65.3 dated 1764, where the caption notes its custodianship at the parish of Sant'Agnese (BMC, Gradenigo Dolfin ms. 65.3, 4) (Fig. 7). This 'peace' depicted the central figure of a blessing Christ, surrounded by a frame of vegetal scrolls recorded in Patriarch Priuli's pastoral visit as «a pace d'argento con il Cristo di Avolio» (ASPV, *Supplemento*, 6r).

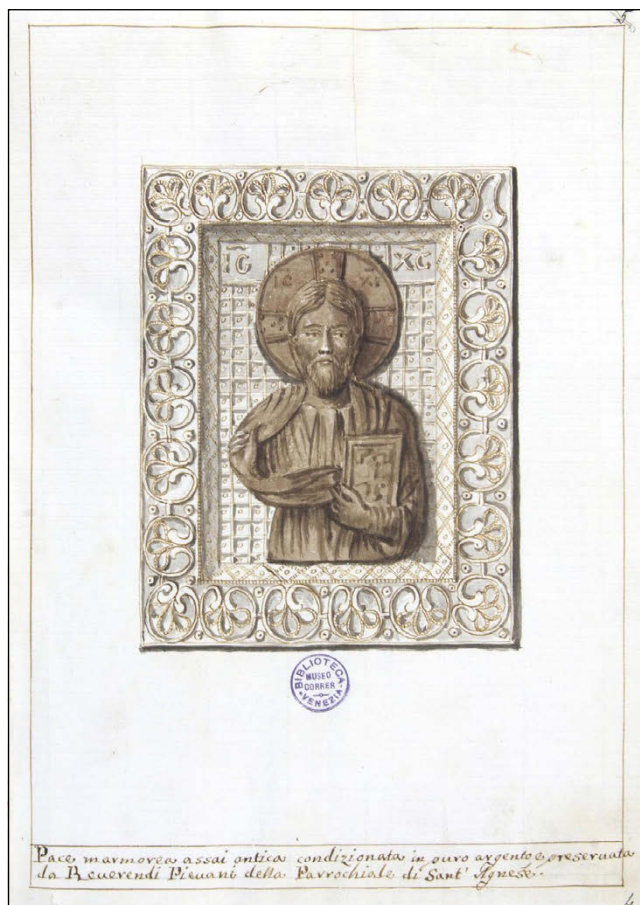


Fig. 7 – Venice, Correr Museum Library, Jan Grevembroch, *Ivory and silver 'pace' with Christ*, watercolor drawing (Gradenigo Dolfin ms. 65.3, 4, 1764; courtesy of the Correr Museum Library).

Of great importance, for the purposes of this project, are the information gathered from the sources regarding the relics held by the churches surveyed. In our case, it is noted that the altar of Saint Jerome housed sacred relics of saints referred to as 'old' (ASPV, *Visitationes ecclesiarum*, 372r, 374v), possibly from a very ancient time, while the 1581 Apostolic Visitation records the presence of relics of Saint Agnes and Saint Mary Magdalen «in vasculis inauratis, sine aliquo documento sed ex vetera traditione» (ASPV, *Visitationes apostolicae*, 257v).

G.A.B.B.

3. FINAL REMARKS

In conclusion, some brief methodological reflections are offered on our work. For each piece of data recorded in the database, it is possible – as is logical and correct – to trace it back to its source. In this way, when the application's implementation is completed, it will be possible to identify the most informative sources to be further used for in-depth research. Moreover, general comments and reflections on the types and purposes of the sources, and the categories of information they provide could also be developed. Furthermore, the linguistic aspect related to the systematisation of the data within the platform must be considered: for the different categories of recorded works, Italian terms have naturally been chosen (for example: 'altare', 'pala', 'icona', etc.), but it is of our interest to also keep track of the various expressions used in Latin or vernacular languages which sources refer to the elements of our study. For this reason, most of the time, we have opted to directly report the words from the documentary occurrences in quotation marks.

Another aspect where general, quantitative, and taxonomic considerations can be developed concerns the material nature of the decorative elements: by the end of this work, statistical evaluations can be made on the recurrence of specific materials used in liturgical furnishings. It will also be possible to check the frequency of certain materials in relation to types of furnishings. Furthermore, we will need to reflect on the reasons for the use of specific materials in relation to the production systems of the medieval city.

The core issue that arises from the systematic review of the aforementioned sources is primarily the difficulty in identifying, among the lost furnishings, those that can certainly be ascribed to the medieval era, as most of the usable archival documents were produced from the 15th century onward, and the data they contain are often quite essential and lack detail. Significant clues for a possible assignment to the Middle Ages, although general, sometimes emerge from references to the materials of the works or from certain phrases regarding their inadequacy or old age. Very often, the documents provide information on the arrangement of altars, pulpits, and choir screens before the liturgical adjustments prompted by the Council of Trent, but just as often they reflect the 'image' of sacred spaces in which changes had already occurred in the early Renaissance period. Therefore, it will be necessary to cross-reference the data from the sources (both published and unpublished) with studies on the history and architectural phases of the buildings.

S.P., G.A.B.B.

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ABSTRACT

The 'Sacra Absentia' project, led by Simone Piazza (PI) with Giulia Anna Bianca Bordi (research fellow), is part of the PNRR (2022-2025) within the CHANGES program, Spoke 8, at University Ca' Foscari Venice. This study examines medieval and early modern pilgrims' accounts of Venice's religious heritage, informing the cataloguing and spatial reconstruction of lost or recontextualized liturgical furnishings. An online database georeferences these objects using contemporary maps and Jacopo de' Barbari's 1500 Venice view. A case study on Sant'Agnese, integrating published and unpublished sources, demonstrates the methodology's effectiveness in uncovering new historical insights.

THE CHURCH OF SAN FANTIN IN VENICE: DIGITAL MODELING, ARCHIVAL RESEARCH, AND THE REUSE OF ANCIENT MARBLES

1. INTRODUCTION

The church of San Fantin in Venice stands as a testament to the city's rich architectural and historical evolution. While its origins in the High Middle Ages remain uncertain, the current structure reflects its Renaissance transformation, shaped by successive phases of construction and renovation. Despite the lack of definitive evidence regarding its earliest form, a multidisciplinary approach combining digital modeling, material analysis, and archival research has provided new insights into its development.

This article is structured into three sections, each offering a distinct perspective on the church's architectural history. The first section, by Carlotta Zaramella, presents a reconstruction of San Fantin's architectural phases through digital modeling and the creation of a Building Information Modeling (BIM) model, enabling a clearer understanding of its structural transformations over time. The project has been led at the University of Padua under the supervision of prof. Gianmario Guidarelli as part of a broader initiative funded by the European Social Fund (FSE), focused on the historical, urban, and architectural reconstruction of the San Fantin *insula* and its digital representation. The second section, by Myriam Pilutti Namer, examines the reuse of materials in Venetian architecture, with particular attention to the types of marble incorporated into the church's fabric. The third section, by Giulia A.B. Bordi, investigates medieval material evidence and archival sources related to two water basins, shedding light on their functional and historical significance.

M.P.N.

2. DIGITAL MODELING OF THE CHURCH OF SAN FANTIN: OBJECTIVES AND METHODOLOGY

The study we present aims to explore the historical and architectural evolution of the church of San Fantin by developing a descriptive digital model. This research adopts an innovative approach that integrates traditional historical investigation with modern digital modeling technologies. The digital reconstruction seeks to make historical changes and developments more comprehensible through a scientific methodology, transposing historical views and cartographic sources into a digital system. This approach facilitates the analysis of urban transformations in relation to chronological progression.

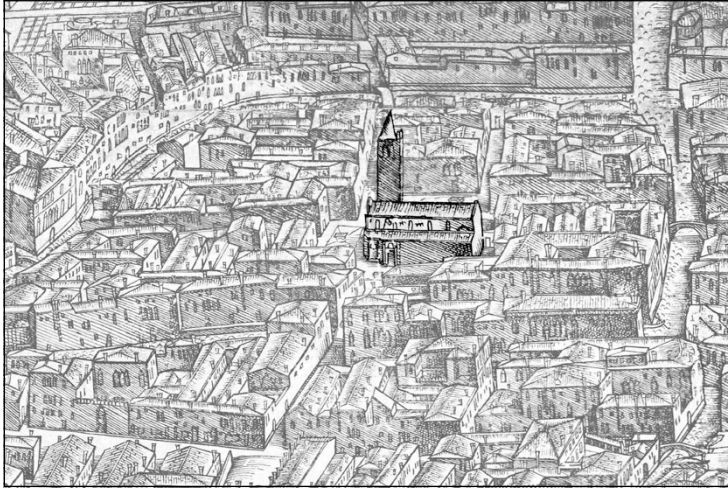


Fig. 1 – De Barbari's *Veduta* (1500) indicating the location of the church of San Fantin (reworked by C. Zaramella).

2.1 Cartographic sources

This study examines the period from 1500 to the present. To digitize the current state of the site, the regional technical map was utilized; however, this source provides only building boundary data without height information. Consequently, a detailed visual analysis and on-site photogrammetry of the church were necessary to complete the model. The study begins in the year 1500 with an analysis of the first primary source depicting Venice: De' Barbari's *Veduta*, which represents the city with remarkable precision through a bird's-eye view (Fig. 1). A perspective study revealed significant distortion along the E-W axis, while a geometric analysis, based on the alignment of buildings and streets, allowed for the delineation of the church in Revit. The second cartographic source selected is the Napoleonic Cadastre, the first of three cadastral maps produced for Venice, dating back to 1808. As a primary source used for taxation purposes, it was required to be highly accurate. The subsequent cadastral maps depict an urban configuration similar to that of today. While the Napoleonic Cadastre does not provide height data, it precisely represents building boundaries with continuous lines, and the pink shading indicates their surface area.

2.2 The church of San Fantin: the three architectural phases

For decades, scholars have debated the configuration of the earlier churches on this site. For the first time, through an innovative approach integrating

historical research and digital modeling, it has been possible to provide concrete answers. Over time, the building has evolved into three distinct churches. The first was founded and constructed in 996, financed by the Molin family (PIVA 1960, 86). Little information exists regarding this structure, but it was likely aligned along the same E-W axis as the present-day church, as was customary in Venice. However, no details about its architectural configuration have been preserved. The second church was built during the 12th century, funded by the wealthy Pisani family. Its architectural structure corresponds to the one depicted in Jacopo De' Barbari's *Veduta* of 1500. The third and final church is the one that stands today. Its construction was made possible through the generous bequest of Cardinal Zen.

2.3 A reconstruction hypothesis based on De' Barbari's Veduta

De' Barbari's perspectival *Veduta* depicts the second church, identifiable by the inscription 'Fantin' on its side. However, a definitive interpretation of this church remains challenging due to the way it is represented; the northern part is entirely obscured from view. Through geometric analysis, it is plausible to assume that the main façade of the 15th-century church was positioned exactly where the present façade stands. By examining the alignment of Calle de la Verona, despite perspectival distortions, it becomes evident that the façade in both *Veduta* and its current state is aligned with this street. A similar approach applied to Calle Minelli reveals that the church's enclosing wall extends slightly off-axis toward the east. This corresponds to the location where the presbytery and crypt were later added in the current structure. By observing the present position of the well located S of the vestibule and its alignment with Calle del Caffettier, it is possible to deduce that the lateral entrance was situated in the same location as today but on a wall positioned further forward toward the campo.

2.3.1 The third architectural phase

The second reconstruction of the church was financed by Cardinal Zen with a bequest of 10,000 ducats, as stipulated in his will dated 1501. Construction officially began on March 25, 1507, the 'zorno de la Madona' (SANUDO 1879-1903, 369), with the laying of the foundation stone during a ceremony attended by Doge Leonardo Loredan. The initial phase of construction was entrusted to «mistro Sebastian proto» (ASPV, San Fantin, '*Tomi*' di atti diversi, XXXVIII, 160v, in VIO 1977, 226), identified as Sebastiano Mariani da Lugano. He worked on the project for approximately a decade (VIO 1977), though progress was slow, as he was also engaged in the fortification of Padua during this period (ZOVATTO 1970, 130). On August 14, 1522, records indicate the first appearance of Scarpagnino at the construction site, referred to as «mistro Antonio proto» (ASPV, San Fantin, '*Tomi*' di atti

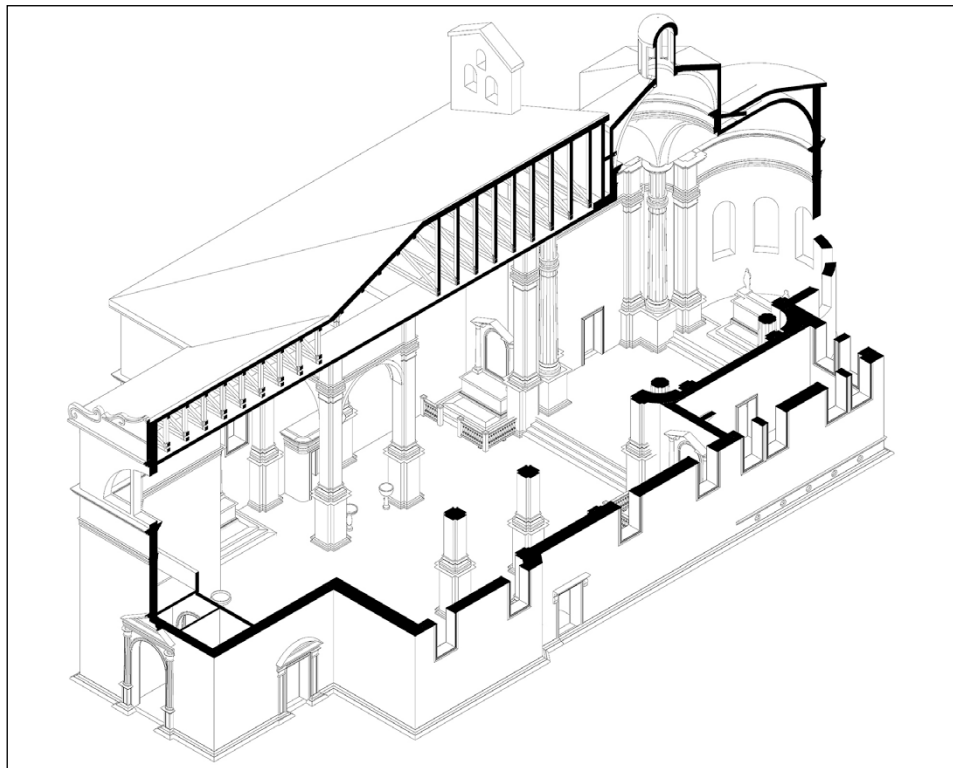


Fig. 2 – Axonometric section of the church of San Fantin (reworked by C. Zaramella).

diversi, XXXVIII, 172, in VIO 1977, 226). He worked on the project from 1522 until his death in 1549, and he is credited with erecting the church walls (PAOLETTI 1893, 298). In 1543, Antonio Sorella took over and completed the roofing. Scarpagnino did not live to see the final structure, leaving the project to another *proto*, possibly Jacopo Sansovino, who completed the church by constructing the presbytery. However, the authorship of this final phase remains uncertain, both historically and stylistically. The construction officially concluded in 1564, as evidenced by the presence of two marble *coretti* flanking the presbytery, dated 1562-1564 (ASPV, San Fantin, ‘*Tomi di atti diversi*, XXXIII, 166, in VIO 1977, 229).

2.3.2 The current architectural structure

The church consists of a central nave and two side aisles, characterized by alternating barrel and groin vaults, harmoniously following the Byzantine *quincunx* model (Fig. 2). The main nave is preceded by a square vestibule that



Fig. 3 – Interior view of the church of San Fantin (photo C. Zaramella; courtesy of the Patriarcato di Venezia, Ufficio Beni culturali ed edilizia di culto).

protrudes into the ‘campo’ toward La Fenice Theatre. Externally, the church is defined by simple, regular lines devoid of ornamentation. The interior maintains an overall austere appearance, free from excessive decoration (Fig. 3). The spacious square presbytery is covered by a dome, which ends in a lantern that softly illuminates the space. The dome rests on four monumental, fluted Corinthian columns with recessed panels, evoking the structure of a funerary monument. At the four corners of the floor beneath the presbytery, sections of the original terracotta pavement remain visible. A distinctive feature of the church is its semi-subterranean crypt, ventilated by 17 perimeter *oculi*, some of which have been partially sealed. These openings were likely once covered with grates, which may have been anchored to the eight holes still visible around each aperture.

C.Z.

3. REUSE OF ANCIENT MATERIALS IN VENICE

The reuse of ancient materials in Venice was a fundamental practice that shaped the city’s architectural development from its early medieval

origins through the Renaissance and beyond. This phenomenon was largely influenced by the scarcity of natural stone in the Venetian lagoon, leading to the systematic recovery, transportation, and repurposing of materials from abandoned Roman sites in the *Venetia* and other Mediterranean regions. The practice was not merely a matter of economic necessity, but also reflected cultural attitudes toward the past, a pragmatic approach to construction, and Venice's evolving role as a major maritime power (LAZZARINI *et al.* 2024). The origins of material reuse in Venice date back to the early medieval period, when the settlement was expanding within the lagoon. With no local quarries available, Venetians turned to the nearby abandoned Roman city of *Altinum* and other mainland sites as sources of building materials. These materials, including marble and stone, were either repurposed directly or reworked into new architectural forms. Inscriptions and sculptural elements from earlier periods were frequently incorporated into new structures, demonstrating both a continuity with and a reinterpretation of the Classical tradition (LAZZARINI *et al.* 2024, 2-25).

From the 11th century onward, as Venice's wealth and technological capabilities grew, the city expanded its sources of reclaimed materials to include regions across the Adriatic and the broader Mediterranean. The conquest of Constantinople in 1204 during the Fourth Crusade played a crucial role in intensifying these practices. Large quantities of Proconnesian marble and other valuable stones were systematically looted from Byzantine buildings and transported to Venice, where they were integrated into civic and religious structures. The Basilica of St. Mark, one of the most emblematic examples of this phenomenon, features an extraordinary array of reused materials, including columns, capitals, and friezes of varied origins, demonstrating the craftsmen's ability to synthesize diverse artistic influences (LAZZARINI *et al.* 2024, 90-181). The organization of spoliation efforts in Venice suggests a high degree of coordination among merchants, patrons, and artisans. Unlike earlier, opportunistic reuse, which relied on nearby sources, the later medieval and Renaissance periods saw a more systematic approach to acquiring materials. Venetian merchants, who travelled extensively for trade, often brought back stone and architectural elements as ballast for their ships. This practice not only ensured a steady supply of building materials but also reinforced Venice's architectural grandeur by incorporating prestigious elements from across the Mediterranean world.

By the Renaissance, reuse remained a defining characteristic of Venetian architecture, though attitudes toward ancient materials evolved. The appreciation for classical antiquity led to more selective reuse, often emphasizing the aesthetic and symbolic value of spolia. The presence of ancient elements in Venetian buildings was not merely functional but became a marker of prestige and continuity with the classical past. This shift is evident in both

public monuments and private residences, where columns, reliefs, and decorative elements from earlier periods were deliberately displayed to emphasize historical depth (LAZZARINI *et al.* 2024, 30-65). Even into the 19th century, the reuse of materials remained an active practice, particularly in restoration projects. More than six hundred stonemasons were documented working in Venice during this period, involved in demolition, reuse, and reconstruction efforts that continued the city's long-standing tradition of material recycling. This ongoing reliance on *spolia* highlights the resilience of Venetian architectural strategies and the craftsmen's ability to adapt its built environment to changing economic and political circumstances (PILUTTI NAMER 2016).

3.1 *Ancient marbles in the church of San Fantin*

Among the various types of reused marbles in Venice, three stand out for their historical and symbolic importance: verde antico, red porphyry, and proconnesian marble. These materials, originating from different regions of the ancient Mediterranean, were often repurposed in Venetian churches and palaces, serving both decorative and ideological purposes. The Church of San Fantin in Venice is an important example of this practice. One notable element is the use in tondos of verde antico, a green-colored marble highly prized in antiquity for its rarity and beauty. This marble, originally sourced from Greece, was commonly employed in Byzantine and then Venetian architecture due to its appreciation from the emperors of Constantinople (LAZZARINI *et al.* 2024, 153, with further bibliography). Red porphyry, another highly significant stone in Venetian architecture that was often employed in the decoration of basilicas and palaces, is particularly notable in San Fantin for its use in the tondos placed under the tomb of Vinciguerra Dandolo. Red porphyry was among the most prestigious materials in antiquity, reserved for emperors and high-ranking officials due to its association with power and divinity. Quarried in Egypt, it was extensively used in Rome and Constantinople and since Medieval time it has been transported to Venice through trade and conquest (LAZZARINI *et al.* 2024, 150-151).

Finally, it is worth mentioning the Proconnesian marble, sourced from the island of Marmara in present-day Turkey, that was the most widely used marble in Venice. Unlike the rarer verde antico and red porphyry, Proconnesian marble was easily accessible and available in large quantities, making it the primary material for architectural elements such as columns, capitals, and facades. In San Fantin, the imitation of Proconnesian marble in wood panels plays a crucial role in the church's counter-facade, contributing to the structure's overall architectural composition (LAZZARINI *et al.* 2024, 67-88, 147-148).

M.P.N.

4. THE BAPTISMAL FONT AND THE HOLY WATER STOUP OF THE CHURCH OF SAN FANTIN

The church of San Fantin must have been adorned with precious marbles even in the *facies* preceding the reconstruction of 1507 (for which see ZARAMELLA, *supra*; on the history of the church: BALDINI *et al.* 2024, 63-78; PILUTTI NAMER, BORDI 2024, 79-90, with much more extensive references), since Marco Antonio Sabellico, in his *De situ urbis Venetae*, composed at the end of the 15th century, describes it as having «frons ædis nitida, candidoque saxo nuper instaurata» («chapel with a clear façade and recently restored with white stones») (SABELLICO 1722, II, 18; also quoted by CORNER 1749, 15, 319). In the second half of the 15th century, therefore, the building must have undergone renovations that must have added new marble to its decoration. In this regard, it cannot be ruled out that it was precisely during the renovation and then reconstruction of the sacred building that took place between the 15th and 16th centuries, or perhaps even with later acquisitions, that the two medieval works that are the subject of this section of the paper arrived. So far, in fact, it has not been possible to



Fig. 4 – Proconnesian marble baptismal font in the church of San Fantin (photo G.A.B. Bordi; courtesy of the Patriarcato di Venezia, Ufficio Beni culturali ed edilizia di culto).

find any evidence in the sources that could ensure their original provenance from the medieval church of San Fantin. These are, in particular, a baptismal font currently at mid-height of the right aisle (Fig. 4), and a holy water stoup (or possibly another baptismal font) at the foot of the left central pillar of the main nave of the church (Fig. 5).

The basin of the baptismal font (h ca. 34 cm, diam. ca. 64 cm, depth ca. 30 cm, thickness ca. 3.5 cm), made of Proconnesian marble, has smooth walls both internally and externally, with a double simple moulding with a rounded profile running just below the upper outer rim. The font is supported by a squat cylindrical shaft of the same marble. The artefact rests on a tripartite base articulated in *torus*, *scotia* and *torus* decorated with plain leaves at the four corners, placed on a high plinth of Istrian stone, perhaps not originally belonging to the artefact (Fig. 4) (ZARAMELLA 2022/2023, 91-92; AMODIO 2024/2025, 306, 310). On the left side of the nave of the church, at the foot of the central pillar, is a polylobate basin of a very fine-grained marble – perhaps Luni marble (h 37 cm, max. diam. 55 cm, depth 22 cm, thickness 2.5 cm) – supported by a fragment of a marble column (h 62 cm), characterised by an upward tapering that stands on an octagonal base (Fig.



Fig. 5 – Holy water stoup or baptismal font in the church of San Fantin (photo G.A.B. Bordi; courtesy of the Patriarcato di Venezia, Ufficio Beni culturali ed edilizia di culto).

5) (lastly: TIGLER 2009, 144; 2013, 234 note 553; CALUGI 2014, 25 note 53; AMODIO 2024/2025, 305-310, with previous bibliography).

The basin has a profile articulated in eight lobes of different lengths, along which sculpted reliefs of anthropomorphic and zoomorphic figures alternate. The high level of wear of these does not allow them to be easily read. If, therefore, for the zoomorphic elements it is possible to recognise the silhouettes of pairs of leaning back felines and small birds with intertwined tails and joined beaks, placed above what appear to be small basins, the identification of anthropomorphic subjects is much more difficult. In fact, there are four almost identical figures, placed in a frontal position, with arms stretched across the chest and faces too corroded to be able to specify their gender, characterised by smooth hair with a central parting and a length that almost reaches the shoulders, ending in curls. As already mentioned, one of the problematic aspects concerning this sculptural work is the lack of data regarding its origin (AMODIO 2024/2025, 306).

In the Apostolic Visitation of 1581 there is mention of a baptismal font «bene custoditus cum sua clavi» in the altar of Saint Jerome (ASPV, *Visitationes apostolicae*, 139r) that should have been removed for the liturgical adaptation of the altar (as ordered in ASPV, *Visitationes apostolicae*, 140r, where the furnishing is called «vas lapideum»). However, the order was not carried out immediately, since during the Pastoral Visit in 1593 the basin was still found at the sacred table. From the description it seems, moreover, that the font was in some way connected to the altar, since it is reported: «[...] proseguendo la Visita andò nella cappelletta di san Girolamo, et nella mensa dell'altare ritrovò il Batisterio molto indecente» (ASPV, *Visitationes ecclesiarum*, 457r).

In the current state of research, it is not possible to establish whether the furnishings mentioned in the ecclesiastical inspections can be identified with one of the two basins in the church today. However, considering that the above-mentioned reports would seem to indicate that the baptismal font was connected to the altar of Saint Jerome, one could reflect on this notation in relation to the singularly deep recesses at the base of four of the eight lobes of the figured holy water stoup, which would lead one to hypothesise its function as a housing for interlocking supports (Fig. 5). On the other hand, we should also consider the object's dimensions, which might have been too small for it to serve as a baptismal font. To attempt a preliminary interpretation of the iconography of the artefact, one can observe how the articulation of the basin could perhaps be read as a reference to the octagon that, in Christian symbolism, alludes to the Resurrection of Christ, in reference to the eighth day of Holy Week (BASSAN 1995, 283). Regarding the iconography, the animals represented in pairs along the shorter lobes of the basin, according to Christian exegesis, lend themselves to an ambivalent reading. The two felines,

in fact – but only hypothetically due to the heavily abraded surface – could be identified with a pair of lions or lionesses, which in the biblical text and in the interpretations of Christian writers are the expression of both mighty and courageous creatures, who bring their strength to bear against the wicked, and ferocious and cruel creatures, who unjustly persecute the weakest (CICCARESE 2007, 11-48).

So also the two birds joining in their beaks could be likened to the ‘sparrows’ of the biblical vocabulary. These animals, in the Holy Scriptures, sometimes symbolise defenceless creatures, easy prey to pitfalls, but also, at the same time, capable of rising up towards Heaven, thus away from the iniquities of earth, nesting in the Kingdom of God; at other times, on the other hand, the flight of the sparrow is an allegory of the lightness of an inconstant soul, of intemperance, pride and yielding to worldly flattery that lead these animals to fall into a trap. The sparrow may, however, also be the personification of the risen and ascended Christ (CICCARESE 2007, 125-145). Interesting, however, is what Maria Pia Ciccicarese points out, namely that sometimes the symbolism of the sparrows is clarified by the number they are depicted. In particular, according to the scholar, the presence of the birds in the number of two would recall the passage from the Gospel of Matthew in which the example of two sparrows sold for a penny is given: «Are not two sparrows sold for a small coin? Yet not one of them falls to the ground without your Father’s knowledge» (Mt, 10, 29), representing, therefore, the soul redeemed by Christ (CICCARESE 2007, 128-129). This reading would therefore seem to be in keeping with the interpretation of the depiction of pairs of birds on a holy water stoup or baptismal font, as in our case.

As for the anthropomorphic sculptures, it is not possible to determine whether they were originally conceived as monstrous beings. What is noticeable, despite the state of wear and tear, is that the four figures appear to have their wrists restrained by something overlapping them, in a manner perhaps similar to what can be seen on the holy water stoup in the parish church of Santa Maria Assunta of Rubbiano, in the province of Parma – dated at the beginning of the 12th century –, where two figures with human features are restrained by the paws of the monstrous creatures that flank them (MORETTI 2019, 82, with previous bibliography). One could, therefore, perhaps hypothesise that in the San Fantin font, below the anthropomorphic figures, there were originally fantastic beings that would have been completely abraded.

Otherwise, our four figures could have been depicted in the pose of holding bifid-tailed mermaids with their hands; in that case, however, they would not have been depictions of sirens, who are almost always represented with bare chests and uncovered breasts, since it is quite clear that the figures in the San Fantin basin wear a sort of tunic with a circular cut at the base of the neck. In this regard, one might then recall – but only as a suggestion

that we intend to explore in a forthcoming study – the bifid tritons wearing a sort of cape from the baptismal font at Saint George's in Anstey, County Hertfordshire, dated between the late 12th and early 13th century (MORETTI 2019, 84, fig. 16; 86-87, fig. 19). However, it does not seem to be possible to go any further with the hypothesis at present, due to the complete removal of the decoration of the lower register of the bowl. As the areas of abrasion occur in the same register as the deep recesses, it cannot be ruled out that the chiselling of any parts emerging from the body of the basin and the creation of the recesses occurred at the same time, for the same reason.

In Venice or in Northern Italy, at least to the writer's current knowledge, there do not seem to be any other holy water fonts/baptismal fonts that could serve as a fitting comparison for San Fantin's work. A small holy water stoup with eight lobes, bearing on its four sides figures of archangels holding a globe, can be found in St. Mark's Basilica, but it is a much smaller one than San Fantin's basin, which has been hypothesised to have been readapted as a lustral font by reworking a small capital. The date, placed at the 11th century (POLACCO 1990), is also likely much earlier than that of the San Fantin bowl, which could perhaps be placed between the 12th and 13th centuries. An eight-lobed stoup in 'Greek marble', dated to the second half of the 13th century, is now preserved in the church of Santa Maria degli Angeli in Murano, although it has been hypothesised that it came from the monastery of San Lorenzo on the lagoon island of Ammiana, which was suppressed and incorporated into the aforementioned parish of Venice in 1438 (FANTONI 1990). However, the stoup, not much smaller in diameter than the one in San Fantin, has completely plain sides, devoid of decoration. Similarly articulated in eight lobes is the white Verona marble stoup placed along a wall of the church of San Benedetto in Gonzaga, in the province of Mantua, dated to a period after the construction of the building, i.e. after 1330. In this case, however, the lobes are uniformly decorated with vertical bullae interspersed along the upper margin with small ovoli, and there are no figured elements (MARCHI 1994).

An alternation of longer and shorter lobes, according to a scansion more similar to that found in the lustral pile of San Fantin, occurs, on the other hand, in the eight-valves basin from the Albertian temple of San Sebastiano in Mantua, built from the seventh decade of the 15th century. The presence on the artefact of the Gonzaga enterprise of Olympus, also depicted in Mantegna's *Camera degli Sposi* (1465-1474), would constitute a further clue for the chronological placement of the work in the late 15th century and, therefore, at too low a chronological height to constitute a term of comparison for the basin of the church of San Fantin (BAZZOTTI 1979).

What we can note in conclusion is that perhaps in the holy water stoup now preserved in San Fantin – the origin of which we still do not know –, the possible symbolic meaning alluding to eternal life through the Resurrection,

inherent in the choice of a polylobate form articulated in eight lobes, could have been reinforced by the subjects that were sculpted in it, which perhaps, in the overall representation, staged a contrast between symbols of Good (the animals?) and symbols of Evil (the potential monstrous beings) or depicted a series of figures alluding to the necessity, for access to Salvation, of purification, ensured by the blessed water that had to be contained in the lustral pile.

G.A.B.B.

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ABSTRACT

The church of San Fantin in Venice embodies the city's architectural and historical evolution, with its origins in the High Middle Ages still uncertain. This article explores the church's transformation through a multidisciplinary approach, combining digital modeling, material analysis, and archival research. Carlotta Zaramella reconstructs San Fantin's architectural phases using a Building Information Modeling (BIM) model. Myriam Pilutti Namer analyzes the phenomenon of reused materials in Venice, with particular focus on the types of ancient marbles incorporated into the church's fabric. Giulia A.B. Bordi investigates medieval material evidence and archival records of the baptismal font and the holy water stoup.

FRAGMENTED OBJECTS/FRAGMENTED DATA.
QUANTITATIVE METHODS AND DIGITAL APPROACHES
IN THE PROJECT MAPPING SACRED SPACES: FORMS, FUNCTIONS,
AND AESTHETICS IN MEDIEVAL SOUTHERN ITALY

1. INTRODUCTION

The theme of the symposium *Exploring the Legacy of the Past: Networks and Quantitative Methods in Archaeology and Art History* provides an opportunity to reflect, albeit briefly, on a long-standing epistemological problem. This problem is related to the dialogue between scientific and humanistic disciplines, and thus between matter and form, or analyses of materials versus analyses of artistic forms. In other words, to paraphrase the philosopher of logic Bertrand RUSSELL (1914), between logic and mysticism. As early as 1940, Erwin PANOFSKY (1938) had begun questioning the dignity of Art History in his famous essay titled *The History of Art as a Humanistic Discipline*. Art History, like all humanistic disciplines – especially those related to visual culture and thus to aesthetic processes of interpretation – should be considered, as KANT (1790, 43) declared, a field intrinsically linked to the subjectivity of the observer. One of the possible definitions of the ‘qualitative’ method or analysis is that of «an elemental method of research, neither statistical nor numerical, used to characterize the constituent elements of matter and describe their properties; in the social sciences, a method employed to examine subjective human experience using non-statistical methods of analysis» (CARDANO, ORTALDA 2020, 49). Following this definition, this approach is descriptive by nature, related to language and based on interpretation. By contrast, in the so-called ‘hard sciences’, methods of analysis of physical and concrete matter are primarily, if not solely, quantitative, based on numerical measurements that are objectively computable and quantifiable.

Two examples will help elucidate these concepts. In the hard sciences – meaning those that pertain to the nature and physics of matter and not to human phenomena and their related cultural production – quality matters less than quantity. In other words, quality is subordinate. For instance, knowing the elemental quality of atoms (for example, Hydrogen and Oxygen) in a molecule is not sufficient to identify the given molecule until the two atoms are understood in a numerical, quantifiable relationship. Only after ascertaining that hydrogen and oxygen are present in a 2:1 ratio, that is, having counted the atoms to find that two Hydrogen atoms exist for every one of Oxygen, can we say that it is an H₂O molecule, in other words, water. Thus, quality, in the natural sciences, is always determined after an analysis of quantities.

The second example is closer to the humanities. Looking at mosaics, we can appreciate their qualitative aspects, such as shape, color, iconography, iconology, ornament, and style. Combining formal observations with other data, particularly from coeval sources, allows the work to be contextualized and dated. A pertinent example would be the mihrab of the mosque of Córdoba commissioned by the Umayyad caliph al-Hakam II in 961, traditionally attributed in literature to craftsmen from the Byzantine empire (ETTINGHAUSEN *et al.* 2001, 84). Only recently has an archaeometric investigation directed by Nadine Shibilile confirmed the Byzantine production of some of the glass used in the mosaic *tesserae*. To determine these Byzantine origins, conservators analyzed the glass using highly sophisticated quantitative methods. This enabled the identification of the quantity, quality, and percentage of elements contained in the glass with a resolution of 1 part per million. The techniques adopted (laser ablation coupled with mass spectroscopy) determined the percentage ratio between oxides and identified specific concentrations of Boron that correspond to those in glass produced from raw materials found only on the Anatolian Peninsula (GÓMEZ-MORÓN *et al.* 2021).

From this example, we can understand well the epistemological limitations to which Panofsky alluded, namely the subjective value of purely aesthetic interpretations. At the same time, as Panofsky also noted, quantitative archaeological or taxonomic methods enable us to broaden our interpretive horizons, add more data to our research, and construct a more solid and reliable «organic situation». In other words, quantitative methods make it possible to objectify subjective analyses and perform what PANOFSKY (1938, 108) wittily termed «intuitive aesthetic re-creation». Accordingly, we also understand why Panofsky contrasted Archaeology with Art History, placing archaeological disciplines in the scientific realm (as the study of matter) rather than in the humanistic realm (as the study of cultural production).

With this text, we hope to strengthen the conviction, expressed throughout this volume, that Art History would benefit enormously from quantitative methods. Moreover, we believe that Art History, like Archaeology, should be considered equal to any scientific discipline, by virtue of the methods it employs. We aim to prove that the apparent dichotomy between the two disciplinary realms, scientific and humanistic, is baseless and that the scientific method is the only valid epistemological approach for any investigation. Indeed, this is true not only for the disciplines in the so-called hard sciences, aimed at the study of nature, but also for the humanities, which analyze man-made objects, whether archaeological or artistic.

When integrating qualitative, interpretive methods typical of the humanities with quantitative, computational methods typical of scientific disciplines, we must also consider the digital revolution. Digital methods

have productively encouraged the adoption of quantitative methods even in humanistic disciplines such as Art History, especially now when databases are gradually replacing more traditional *corpora*. Furthermore, Digital Humanities emerge as an effective bridge between scientific and humanistic disciplines. In the current historical moment, digital methods not only foster greater permeability between disciplinary approaches but also offer enormous potential and new challenges.

In what follows, we will pursue large-scale quantitative methods and digital approaches from two different perspectives. First, starting with the greatest amount of potential data available for our field of investigation (i.e. liturgical furnishings of medieval sacred spaces throughout Southern Italy), we will reduce the scale to concentrate on a qualitative analysis of a single object, whether whole or in fragments. Second, we will again analyze and manage a large amount of data, but this time based on a single case study in order to determine its quality.

2. SCALING AND DATABASE APPROACHES

We will begin with the first point, introducing the scope of investigation and objectives of the Project Mapping Sacred Spaces: Forms, Functions and Aesthetics in Medieval Southern Italy (<https://www.biblhertz.it/en/dept-michalsky/sacred-spaces>). This project investigates Christian sacred spaces and liturgical practices in medieval Southern Italy (11th-14th centuries), under the direction of the authors with Manuela Gianandrea (Sapienza University in Rome) and Tanja Michalsky (Bibliotheca Hertziana – Max Planck Institute for Art History). The Bibliotheca Hertziana and Sapienza University have collaborated on this project since 2018, and most recently were joined by the University of Siena. Since 2020, the project has offered a collaborative platform for an international group of specialized scholars, comprising art historians, architects, and digital scientists. Our colleagues are based at universities in Rome, Naples, Salerno, Venice, Heidelberg, and Cambridge.

Historical research on medieval sacred architecture requires an investigation that reconstructs an important component of its space, as many liturgical areas, their furnishings and decorations have been lost. Of course, such reconstructions by nature necessitate some speculation, though they should be carried out as reliably as possible using scientific methods. This preliminary reconstruction also enables us to investigate the perceptual dimension of the sacred in its original historical setting, comprised of spatial-sensory experiences that both included and excluded different actors through barriers, screens, and curtains. Other experiences involved the interaction of ritual and devotional practices with sensory stimulation aided by images, materials, colors, lights, sounds, and scents (PALAZZO 2014; PENTCHEVA 2017; BEDROS, SCIROCCO

2019). Moreover, only through this contextual analysis is it possible to reconstitute the intrinsic and extrinsic relationship between architectural spaces and their artifacts, a crucial aspect that art historical research has begun to consider only in recent decades (PIVA 2006).

The remarkable role liturgical furnishings such as altars, ambos, ciboria, and enclosures had and still have in the art historical sphere should not be underestimated. Southern Italian liturgical furnishings have always enjoyed special attention as distinctive, local products since the advent of the discipline of Art History (SCIROCCO 2020). This is thanks to the large amount of extant documentation, despite much physical displacement, transformation, and destruction, and because of their formal and material qualities. Medieval architecture is quite difficult to see in its original state after having undergone so many transformations and restorations, and a very high percentage of Italian medieval liturgical furnishings are now lost or decontextualized. For a variety of reasons, including the Catholic Church's reforms throughout the Italian Peninsula and the functional and aesthetic demands of the Renaissance and Baroque periods, most medieval furnishings have not survived or have been dismantled and rendered fragmentary. In many cases, these decontextualized elements have been recombined in other ensembles or repurposed (GIANANDREA, SCIROCCO 2018; LONGO, SCIROCCO 2022).

Thus, one of the first objectives of the Mapping Sacred Spaces Project is to analyze the scattered evidence pertaining to eleventh- through fourteenth-century liturgical installations and to reconstruct the more monumental furnishings, such as enclosures, ambos, altars, and ciboria. These structures defined the sacred space of Southern Italy in terms of its form, function, and aesthetic values. This project promotes an approach based on established methodologies in Archaeology and Art History. Our approach also exploits the potential offered by the Digital Humanities and includes liturgical studies, archaeometrical approaches, and scientific investigations of materials (LONGO 2011; LONGO, GIARRUSSO 2011, 2014; GIANANDREA, LONGO 2020; LONGO, SCIROCCO 2021, 2022).

Our census of monuments and sites documenting the locations and material traces of medieval liturgical furnishings held in Southern Italy currently counts 338 records. A digital map displays all this data (Fig. 1), which in its full implementation can be queried from the macroscale (territorial) down to the microscale (architectural components, fragments and decorative patterns). Already, the systematic collection and mapping of this data forms the basis for a research corpus dedicated to liturgical furnishings produced in Southern Italy between the eleventh and fourteenth centuries (a tool that may also prove useful in the future for institutions dedicated to conservation and preservation). This, however, is not the primary objective of the project and does not exhaust its potential for present and future research.

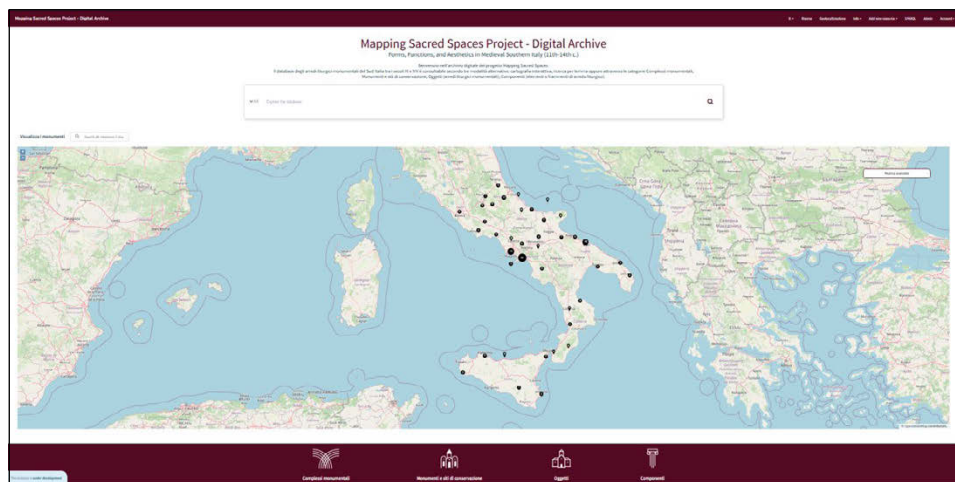


Fig. 1 – The Mapping Sacred Spaces Digital Archive. Homepage: graphic interface showing the map displaying the census of monuments and sites and documenting the locations of medieval liturgical furnishings material traces held in Southern Italy (currently 338 records).

The need to collect and compare a considerable amount of data on scattered or decontextualized objects and fragments at different spatial and temporal scales required systematic organization. We organized our data according to the project's research questions and created a digital archive connected to an interactive map. Its main functions and outputs are:

1. Organize knowledge:
 - a. Collect and organize conserved and/or documented material with historical and technical data, and localize this information;
 - b. Organize new data that emerges from research results;
 - c. Trace or suggest relationships among objects and/or sites.
2. Answer research questions:
 - a. Show and map data according to specific queries;
 - b. Visualize meaningful relationships among entities.
3. Raise new research questions.

Combining interpretative complexity with quantitative methods is obviously the challenge we are dealing with. Using the monumental complex of the Cathedral of Saint Andrew the Apostle in Amalfi as an example, we briefly show how the database is organized on different scales corresponding to three hierarchical levels, ranging from monument to fragment (Fig. 2). The first level (Level A - Monuments and Collections) concerns monuments, museums, or other sites of historic preservation that contain objects and

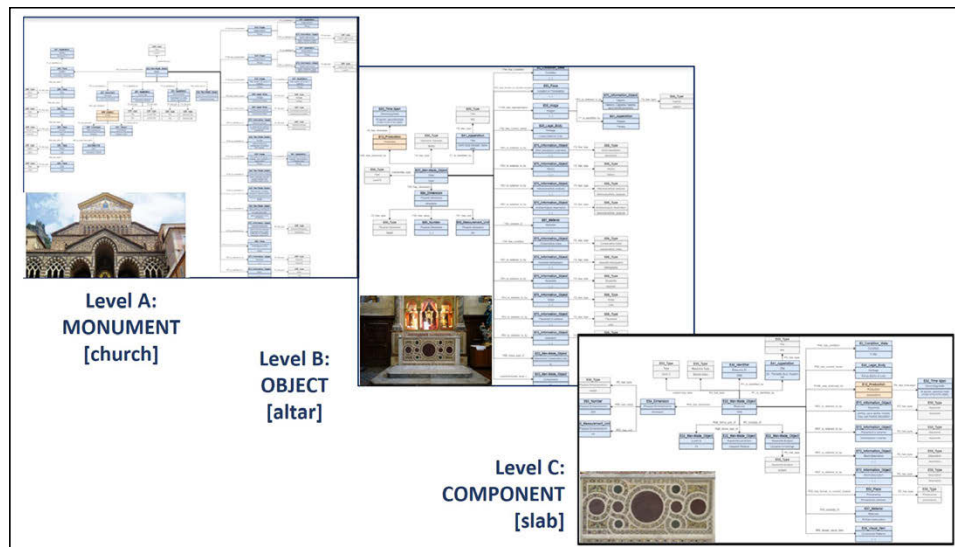


Fig. 2 – The hierarchical organization of the MSS-Digital Archive corresponding to three different ontologies and scales, ranging from monuments to components.

fragments, whose location is mapped in the building's plan. The second level (Level B - Objects) includes monumental objects, by which we mean preserved medieval liturgical installations (pulpits, ciboria, etc.), or post-medieval monumental assemblages made by reusing fragments of medieval furnishings. In the Amalfi case, this level includes two Counter Reformation pulpits, Baroque and neo-medieval altars, and contemporary liturgical furnishings. Our Level B example is an early twentieth-century neo-medieval altar made with elements from late twelfth-century furnishings. The third level (Level C - Components) catalogs the *in situ* components of these monumental objects or fragments that have scattered, placed on the same scale. In this case, we consider a marble screen reused in the altar that is likely to have come from a medieval ambo.

Together with digital scientists working on the project, we implemented different ontologies based on CIDOC-CRM for each level (A - B - C). These ontologies respond to the descriptive, historical, and relational matters at the center of our investigation. The database, created with the support of an outside firm (Advance Service, Crete) and implemented by and integrated into the data management system of the Bibliotheca Hertziana - MPI by Dr. Alessandro Adamou with the collaboration of M.A. Polina Voronova, provides a series of semantically modeled fields for specific research questions. These include the provenance of objects and fragments, the techniques used, the

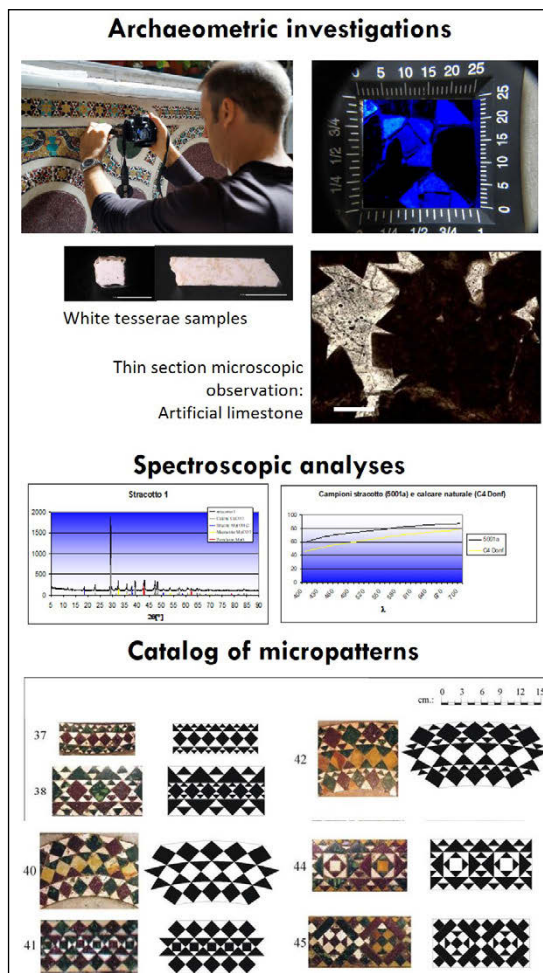


Fig. 3 – Archaeometric investigations, including UV observation, petrographic, colorimetric and multispectral analysis to identify employed materials, and cataloguing of *opus sectile* ornamental patterns.

ornamental patterns employed, documented but lost objects and fragments, and different types of relationships among objects and historical actors.

The slab fragment embedded in the neo-medieval altar underwent different types of archaeometric investigations to identify and distinguish its materials, including UV observation, petrographic analysis, and colorimetric and multispectral analysis. We also took reliefs, surveyed, and catalogued the

ornamental motifs (Fig. 3). This information enabled us to create horizontal relationships between different artworks and sites, again permitting a consideration of geography beyond individual case studies. The investigation considers, on the one hand, the chronology of the object, its original and current functions, visual forms and style, and historical context. On the other hand, it also factors in measurements, mapping, the analysis of the materials used, and processing techniques. As already noted, the integration of the qualitative analysis with the quantitative data represents one of the most ambitious challenges of the Mapping Sacred Spaces Project.

In its fullest development, the digital archive will provide large scale critical and scientific cataloging of thousands of artifacts scattered throughout Southern Italy. It already provides smaller scale tools for single case studies while also offering all available data to attempt the most reliable reconstructive hypotheses possible.

3. CASE STUDY: THE RECONSTRUCTION OF THE CHOIR AND AMBO OF MONREALE CATHEDRAL IN THE LATE TWELFTH CENTURY

Turning now to a single case study involving complex data, we will focus on liturgical spaces in the cathedral church of Monreale, the center of a Benedictine complex founded by the Norman King William II in 1172 and elevated to an episcopal see in 1183 (KRÖNIG 1965; DITTELBACH 2003) (Fig. 4a). We focus here on the fragmentation and substantial disappearance of a key component of the medieval building, namely the double choir screen with its attached ambo, dismantled in 1658 at the behest of Archbishop Ludovico Alfonso de Los Cameros. Corresponding to this void is a considerable amount of data to systematize, consisting of either extant material evidence or textual and graphic sources related to the lost elements. This amount of data requires the implementation of an appropriate system for its management and interpretation, which will then facilitate the formulation of one or more reconstruction hypotheses related to the lost objects.

In addition to collecting all available fragmentary evidence pertaining to medieval liturgical furnishings (Fig. 4b), we conducted several archaeological and archaeometrical observations on-site. This included the analysis of materials used in the mosaics and in the *opus sectile* floor and wall coverings. Such work made it possible to verify the authenticity of large segments still *in situ* and to identify the original floor elevations and the precise topographical areas in which the monumental twelfth-century liturgical furnishings had been located prior to their dismantling in the mid-seventeenth century (LONGO, SCIROCCO 2020, forthcoming). Remnants of the Norman period liturgical furnishings include marble fragments from the wall coverings of the two screens and from the supports of the pulpit, a large number of red porphyry

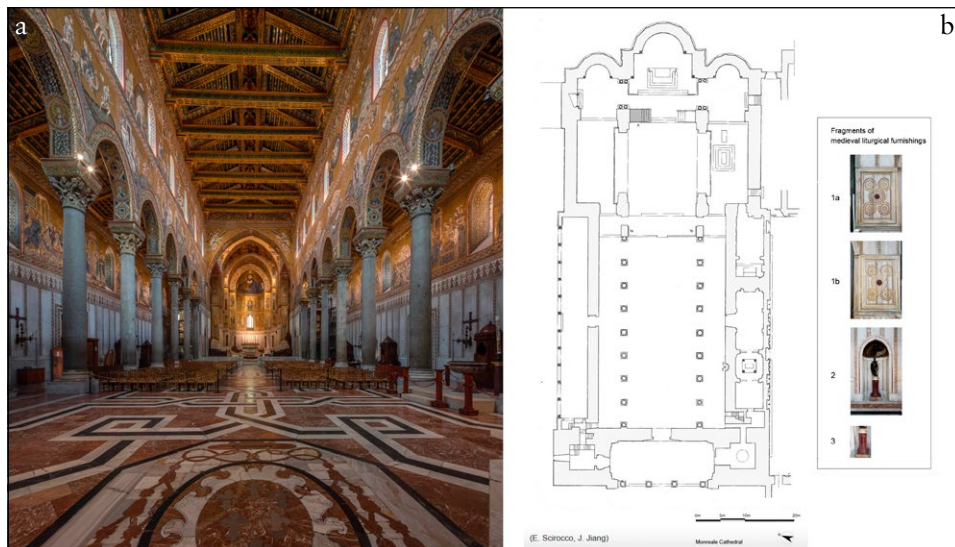


Fig. 4 – a) Monreale (Palermo), Santa Maria La Nuova cathedral, interior view looking East (Bibliotheca Hertziana – MPI, Roberto Sigismondi); b) plan of Monreale cathedral (elab. E. Scirocco, J. Jiang from KRÖNIG 1965), with mapping and numbering of the extant remaining components and fragments of the medieval liturgical installation.

fragments, and two cipollino marble panels with a quincunx motif in the walls at the entrance to the presbytery (Fig. 4b, 1a-1b). Indeed, the cipollino panels are not far from their original location, where they once decorated the western facade of the choir's second wall. The preservation of a niche with mosaic decoration, now relocated on the wall of the southern nave, is exceptional (Fig. 4b, 2). It was once the apsis of a small chapel dedicated to Saint John the Baptist, which was situated beneath the ambo and hosted the baptismal font. This font consisted of a now-lost Roman *labrum* made in Spanish *brocatello* and supported by a sculpted porphyry column, which is still next to the aforementioned niche in the southern nave (Fig. 4b, 3). This, in sum, represents the state of the existing material data. From here, we had to begin an attempt to recover the sumptuous apparatus of liturgical furnishings of the church founded by William II of Sicily.

The research was initiated in 2009 (SCIROCCO 2010, 2016). Beginning 2018, it has been developed, enhanced, and perfected through the joint study of the two authors of this text (LONGO, SCIROCCO 2020). Our research has demonstrated the unreliability of prior reconstruction proposals, which were widely accepted by subsequent studies (Figs. 5a-b). One is the graphic reconstruction (1698) developed by Gaetano Lazzara about forty years after the

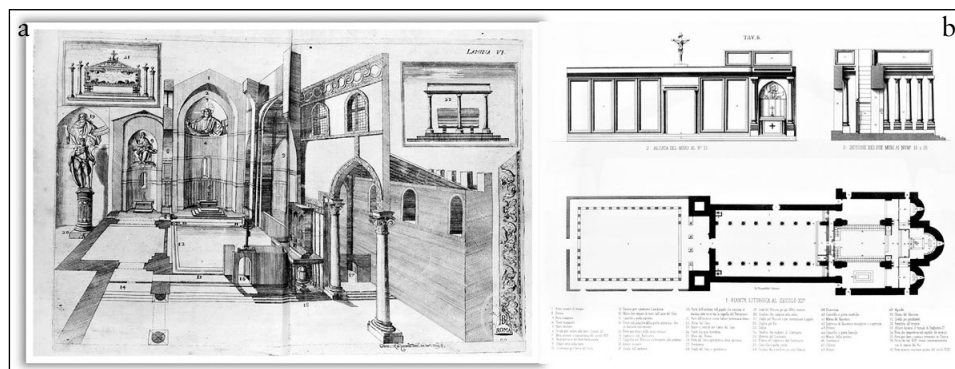


Fig. 5 – a) Gaetano Lazzara, interior view of Monreale cathedral: drawing (print on paper) with section showing the hypothetical reconstruction of the medieval furnishings (from DEL GIUDICE 1702, tav. VI); b) hypothetical reconstruction of the medieval liturgical installations of Monreale cathedral according to Domenico Gravina. Frontal and side views of the choir screen with the attached ambo, and reconstructive plan of the church (from GRAVINA 1859, II, tav. 6).

destruction of the medieval furnishings (DEL GIUDICE 1702, tav. VI). In 1859, Domenico Gravina proposed the second and very influential reconstruction (for a first critical re-evaluation, ZORIĆ 2009) based on the detailed inventory drawn up in October 1658 during the dismantling of the ambo and the choir walls (GRAVINA 1859, I, 55-58, II, tav. 6).

The 1658 inventory, published by Gravina and preserved in its original form at the Monreale Cathedral Archive¹, is an extraordinary source. It provides an ordered and detailed list with the quantity, dimensions, and location of all the architectural and structural elements that comprised the furnishings, adding notes about their constituent materials and decorations. These include the enclosures between the transept and the three naves (the two «choir walls», the «right wing wall» and the «left wing wall», as they are called in the inventory), all the architecture of the ambo (from the columns to the upper part of the platform and the access stairs), and the underlying chapel of Saint John the Baptist (floor, apse, altar, and baptismal font). Thanks to the inventory, all the parts (a few hundred) that once constituted the microarchitecture of this lost twelfth-century liturgical setup could therefore be available virtually. However, their ideal reconstruction into a reliable and verifiable model generates a series of doubts and choices that require assistance and reconciliation with other data and this is where the quantitative approach comes into play. Still, potential contradictions and ambiguities might be solved by using comparative and qualitative analysis.

¹ The Authors thank Father Nicola Gaglio for facilitating its consultation.

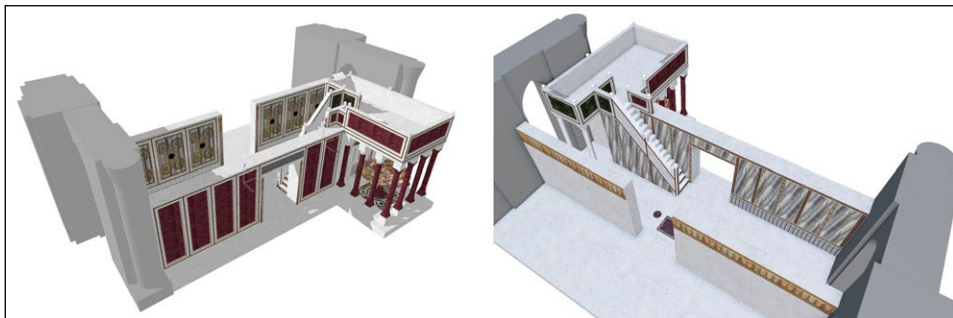


Fig. 6 – Views of the 3D model reconstructing the medieval choir screen with the attached ambo in the cathedral of Monreale: left, western (exterior) side; right, eastern (interior) side. HBIM created by R. Longo and E. Scirocco in collaboration with P. Kuroczyński and K. Argasiński (Hochschule Mainz and the Warsaw University of Technology) (funding: Bibliotheca Hertziana - Max Planck Institute for Art History, Project nr. BH-P-21-26).

Correlating the 1658 inventory with other older sources containing direct information about the liturgical setup of the Monreale choir when it was still in existence has been crucial. These sources include a map of the Monreale complex attached to the 1590 *relatio ad limina*, held in the Vatican Apostolic Archive (AAV, Congr. Concilio, Relat. Dioec., 574A, SCHIRÒ 2009), and early modern textual descriptions (DE CAUMONT 1418/1858; ALBERTI 1567; LELLO 1588, 1596). All the information extracted from the interpretation of these graphic and textual sources has been cross-referenced in a synoptic table, with simple Excel worksheets. Next, we tried to visualize the results yielded from the dialogue between the data in a reconstruction (or virtual anastylosis) by using the possibilities offered by 3D digital modeling. After making several attempts beginning in 2014, which were not fully convincing due to the difficulty interpreting certain sections, we expanded the scope of the investigation by including precise surveys of the architecture and archaeological evidence *in situ* and by studying the material and technical aspects of the surviving artifacts. This work enabled the development of a new proposal, a 3D model made in collaboration with Piotr Kuroczyński and Karol Argasiński from Hochschule Mainz and the Warsaw University of Technology using HBIM methodology (Heritage Building Information Modeling), previewed for the first time here (Fig. 6). Current studies on this site and the latest knowledge about similar cases in the surrounding geographic area support the reliability of this proposal.

Let us briefly outline the main parts of the reconstructed medieval liturgical furnishings of Monreale cathedral, made around 1180, that survived with minimal modifications until 1658. The division between the central nave and the space occupied by the monks' choir in the presbytery was made with two parallel walls. The more external one was covered with porphyry slabs

surrounded by marble bands with ornamental motifs in *opus sectile*. The other, more internal wall had cipollino marble slabs and mosaic decoration in quincunx, also surrounded by bands with *opus sectile* decoration. The ambo, which rested on the more external wall and extended into the central nave towards the west, consisted of two parts: one towards the nave, dedicated to the reading of the Gospel, and the other towards the presbytery, i.e., towards the inside of the choir, dedicated to the reading of the Epistle. The first part incorporated red porphyry, and the second part featured green porphyry. The ambo housed the chapel with the baptismal font and the aforementioned apsidiole embellished with mosaics.

Thanks to the model, we were able to deduce the following dimensions: 4.2 m in height for the first wall (in relation to the nave) and 4.4 m for the second. At its peak, the ambo reached 5.5 m, and the underlying chapel measured 3.5 m on each side. Overall, the margin of error in the model's measurements is relatively low, estimated to be between five and eight cm. This margin results from an approximation inherent in the sources, such as: 1) the imprecision of the textual information itself (e.g., «1 cane and 3 scarce palms»); 2) the conversion from the Sicilian palm measurement system to the metric decimal system; 3) the mounting systems between individual architectural elements in the overall system (for example, the inventory provides the total measurements of the dismantled porphyry slabs. However, the size of those slabs, if inlaid in frames or pilasters within the wall's structure, would be two or three centimeters smaller). In the end, after holistically reconstituting the individual components listed in the inventory, thanks to the integrated analysis of sources and material data, the resultant reconstruction differs significantly from the historical proposals of Lazzara and Gravina and is perfectly consistent with the construction and aesthetic systems in Norman-era Sicilian sacred spaces.

Our goal of creating a model that would serve as a repository for research data, organized not in tabular form (as in our Excel worksheets), but in a topographical and three-dimensional form, motivated our decision in favor of a HBIM to reconstruct a completely lost ensemble even if this technology and approach are more typically used for surveying existing buildings (ATTENNI *et al.* 2022; DEL POZZO *et al.* 2024). Appearing as annotated links to the individual architectural elements, the sources and justifications for the reconstruction can thus be queried and verified by the scientific community, just like footnotes in a written text. However, the scientific community has not yet reached unanimity, either among the different disciplines involved or within Art History itself, regarding standards for 3D models. Areas under debate, among others, include shared open-access infrastructures for publishing and annotating three-dimensional reconstruction models, the assessment of the scale of uncertainty, and standards for the publication of

three-dimensional research-based models as scientific products (APOLLONIO 2016; CAMERLENGHI *et al.* 2023; CAZZARO 2023; KUROCZYŃSKI *et al.* 2023; FOSCHI *et al.* 2024; PAPADOPOULOS 2024; IOANNIDES *et al.* 2025).

We therefore chose our first group of annotations for the HBIM model according to the needs of our case study. Currently, the model contains only a few annotations; however, the goal for the next few months is to incorporate all related metadata and paradata into the model and publish it, making it available according to FAIR principles (<https://www.go-fair.org/fair-principles/>). The metadata include function, dimensions, and constituent materials of the elements represented in the model (with reference to the controlled vocabularies of the Getty Research Institute's Art & Architecture Thesaurus®: <https://www.getty.edu/research/tools/vocabularies/aat/>). Components modeled on real extant objects specify their current location and conservation conditions. The paradata include the sources used to create the modeling, position, and texture of the individual components in the HBIM. We also indicated whether the historical existence of a given component represented in the model is hypothetical or not.

To evaluate the degree of reliability of the representation, for this specific case study, we decided to use a three-part scale of uncertainty: low, medium, and high, with a note describing the reasons for each choice made. For example, consider one of the panels with a quincunx motif mounted on the second choir wall (Fig. 7). Here, the uncertainty level is considered low because the slab with the quincunx is preserved, and its relationship to the depicted wall is definite, confirmed by all textual sources prior to 1658. The only imprecise data point is the exact position of this specific panel on the wall. In the model, we placed it in the second available slot from the left. However, there is no way to know whether this was its original position among the six possible on this wall. This missing data is ultimately negligible for the purposes of this reconstruction, since the six panels were almost identical. After we apply this criterion to all constituent parts of the model, the levels of uncertainty will be elucidated in the overall model through color coding.

In the end, we reconstructed the precise locations of the different components of the choir screens and the ambo of Monreale closely adhering to historical and archaeological data. Furthermore, the widely documented materials and decorations used in the model provide qualitative information essential to understanding the aesthetics of the furnishings. Assessing specific patterns in the ornamental *opus sectile* was not always possible, but for the 3D model we used designs resembling the original elements preserved *in situ* in the same building, i.e., the Cathedral, the Diocesan Museum, and the exhibition rooms near the Cloister Terraces.

A reconstruction model is inherently a virtual surrogate, an abstract and distilled idea of a lost original, whose real, historical qualitative features are only

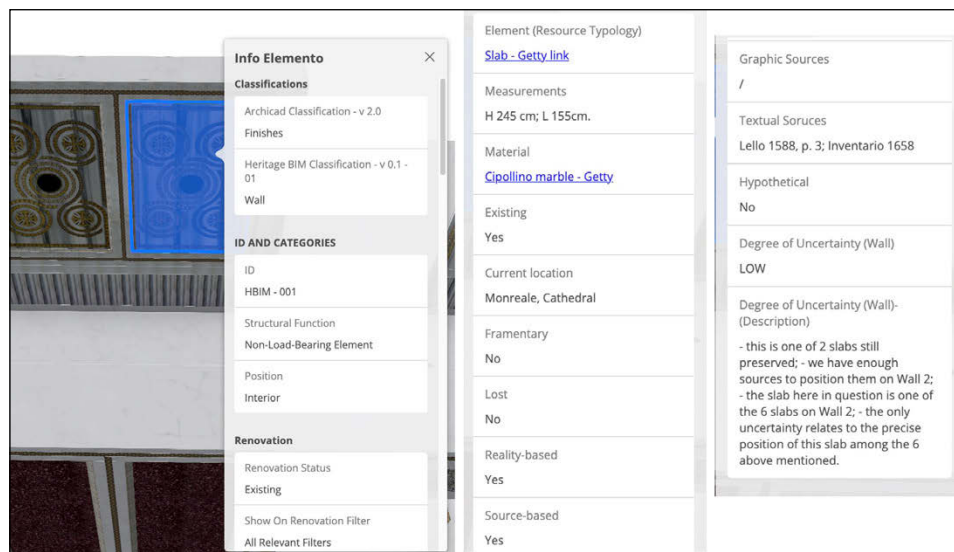


Fig. 7 – HBIM annotations with assessment of uncertainty for one of the panels with a quincunx motif mounted on the second choir wall. The annotation describes the reasons for the choice made within a three-degree scale of uncertainty (on the right).

available to us through fragmentary material evidence, and therefore destined to remain incomplete. This evidence and its degree of interpretation, however, can be integrated into the HBIM model and the metadata and paradata we applied to it (for the different aspects involved, MÜNSTER *et al.* 2024). Additionally, we would like to emphasize that the 3D modeling efforts were not undertaken solely with the intention of ‘reconstructing’ something lost. Trying to reassemble the whole also responds to the hermeneutic and epistemological need to cope with the large amount of available but fragmented information related to this exceptional case study. Modeling in 3D has proven to be an indispensable heuristic tool, which inevitably subjects hypotheses to verification and possible correction. Above all, it provides a dynamic tool that represents the current state of research while also being capable of modifications as new data and hypotheses emerge (CAMERLENGHI *et al.* 2023).

4. CONCLUSIONS: TAXONOMY AND ANALYTICAL SYNTHESIS

In conclusion, our experiences with this project as we have briefly presented them have yielded insights beyond results particular to specific research. We have deduced how Art History would benefit from quantitative and network approaches. We define ‘network’ not only as a web of relationships and

exchanges between different case studies, but also as one of interdisciplinary work. More broadly, we have underscored the need to question traditional distinctions between scientific and humanistic disciplines and to welcome holistic research approaches and practices. In so doing, we aim to usher in a new aspect of knowledge that balances mysticism and logic.

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ABSTRACT

According to a traditional distinction, quantitative and qualitative research approaches are the exclusive domain of the hard sciences, the former, and the humanities, the latter. Taking as its starting point E. Panofsky's reflections on the disciplinary status of Art History in relation

to its method of investigation (1940), this paper aims to demonstrate the anachronism of the hierarchy between disciplines based on the adoption of quantitative or qualitative methods, in favour of a more transversal scientific methodology. Looking at Art History in particular, it is undeniable that the digital revolution has enabled and strongly stimulated quantitative approaches and at the same time fostered transdisciplinary collaborations between different scientific areas. Based on these premises, the article presents the research methodologies and some results of the project Mapping Sacred Spaces: Forms, Functions, and Aesthetics in Medieval Southern Italy, in which the management of a large amount of fragmentary data is addressed. These are either fragmented artistic artefacts scattered over a wide geography, to be analysed at different topographical scales, or a single case study to which a large number of sources and research materials are linked, requiring a systematic and simultaneous management of data. In particular, a preview of the digital archive of the project will be offered, while the preliminary reconstructive 3D model (realised with HBIM technology) of the choir screens and ambo of the Cathedral of Monreale (c. 1180) will be presented for the first time.

THE CHURCH OF SAN LORENZO IN MIRANDA: POPULATING AN ECOSYSTEM

1. INTRODUCTION

The concept of cultural heritage has evolved beyond being a static entity confined to museums, archives, and libraries. Instead, it is now recognised as part of a dynamic and interconnected system, a perspective that has extended far beyond the academic community. The advent of digital technologies has revolutionised our relationship with cultural heritage, transforming it into a dynamic organism where assets and communities interact, significantly influencing its preservation, accessibility, and transmission as collective memory. In essence, we are witnessing the emergence of a true ecosystem (BIANCHINI *et al.* 2019), where technologies, platforms, tools, researchers, and citizen scientists collaborate within a shared environment that increasingly blends the physical and digital worlds into what is now termed a phygital reality. However, for this reaction to occur and be sustained, specific catalysts are required: primarily, the data available and the information that users process and reintegrate into the system. Collecting, archiving, sharing data and transforming them into information do constitute the essential fuel for the development and evolution of the cultural heritage ecosystem.

Within this framework, the layering of data and information is crucial not only for capturing the multifaceted nature of cultural heritage, but also for enhancing its accessibility by highlighting its inherently multidimensional character. This shift suggests that the challenge for both the academic community and the wider public is no longer merely the collection and digitisation of cultural assets but rather the creation of a digital environment where different levels of knowledge can be seamlessly integrated. It is important to distinguish between data and information, a distinction often overlooked in everyday language but essential within a scientific discussion. Data refer to quantitative records obtained from an object (typically through measurement) whereas information is the result of interpreting these data. This transformation process unfolds in three fundamental stages: collection, selection, and interpretation (BIANCHINI 2014).

The data collection phase has benefited enormously from the transition to digital methods. In fact, traditional approaches to architectural or archaeological survey, excavation documentation, archival research do not actually generate data but rather reflect the subjective readings of the scholars conducting these tasks. This inherent subjectivity introduces a significant

methodological bias, conflicting with the scientific definition of data. Massive-acquisition tools such as 3D capturing, digital imaging, photogrammetry and diagnostic sensors have drastically reduced this subjectivity, enabling the application of rigorous scientific standards to cultural heritage studies. This paradigm shift allows multiple researchers to work on the same, reliable dataset (e.g., a point cloud) offering diverse hypotheses and interpretations based on equally consistent and verifiable data. At this stage, however, data remains 'raw' and requires further selection and interpretation before they can be transformed into meaningful information. The selection phase involves critically assessing the collected data to identify those most relevant, while interpretation consists of a comprehensive reading that aims at enhancing our understanding of the studied object and its characteristics.

A broader challenge is now emerging: how can this vast volume of data be systematically archived, searched, and retrieved? Beyond platform-related issues where efforts are underway to establish a standard, the key lies in defining a parameter that is as independent as possible from data type that, referring to cultural heritage, can encompass images, texts, 3D models, videos, sounds and much more. In this context, georeferencing is emerging as the most promising and universal method for cataloguing any cultural heritage-related data. Georeferencing is not merely about spatial localisation; it serves as the foundational infrastructure for interlinking diverse elements, including historical documentation, digital models, stratigraphic data, landscape constraints, restoration interventions and so on. This approach facilitates the construction of an integrated knowledge network where each heritage element is positioned within a unique spatial context, providing a common denominator for its different components.

The reliability of this infrastructure depends significantly on the tools employed. While open-source technologies can have margins of error up to 20 m, more precise techniques such as GNSS, laser scanning, and photogrammetry offer accuracies within just a few centimetres. The integration of these technologies enhances both localisation precision and the interoperability of data formats (e.g., GIS, BIM), promoting a more dynamic and effective management of cultural heritage. Furthermore, georeferencing enables not only the cataloguing of tangible elements, but also the diachronic documentation of their transformations, benefiting both scientific research and conservation efforts. This approach offers a viable path towards overcoming traditional divisions between archives, museums, and territorial information systems, fostering the development of a sustainable and inclusive phygital ecosystem where knowledge is continuously enriched and updated. To ensure the full effectiveness of this model, investment is needed in shared infrastructures, format standardisation, and open-access policies, as only through conscious integration can these processes be sustained.

Quite apart from these broader considerations, the digitisation of built artefacts has undergone an even more profound transformation, especially in the processes of data collection, selection, and interpretation. In this field, in fact, 3D capturing technologies have not only minimised methodological biases in data acquisition, but have also, for the first time, allowed the artefact itself to be regarded as a primary source of information for its own study. At first glance, the idea that a heritage artefact should be considered a source of information for its own analysis may seem self-evident. However, this perspective has only become truly viable due to the combined effects of two digital-age advancements. The first is the availability of scientifically reliable data, as previously discussed. The second, more procedural and design-related, concerns the comprehensiveness of acquired data relative to the physical extent of the artefact, a high-resolution model composed of billions of geometric points, maintaining consistent metric and geometric reliability.

This emergent property, combined with the prospect of widespread data sharing among scholars (as is already common practice in the hard sciences but still rare in heritage studies), means that hypotheses previously based on limited, inaccurate, and non-shared datasets can now be tested directly against the artefact itself. Producing such datasets naturally requires additional effort and cost at the acquisition stage. However, when viewed from the perspective of cultural heritage as an ecosystem, this investment becomes negligible compared to the long-term benefits in advancing knowledge, enriching data repositories, and ultimately preserving the collective memory upon which every society is built.

C.B.

2. THE APPLICATION OF THE METHODOLOGY FOR THE COMPLEX OF SAN LORENZO IN MIRANDA

As part of the PNRR PE05 CHANGES-Spoke 8 project, the aforementioned challenges were tackled by testing various methodological and procedural solutions using the church of San Lorenzo in Miranda (Rome) as a case study. In this context, the traditional approach to the church's historical and architectural study was enriched with new inputs, driven by the need to build an ecosystem that ensures interoperability and interdisciplinarity in data collection and organization. With the ultimate goal of transforming data into meaningful information through a process of 'knowledge stratification', the first step involved establishing a shared coordinate system for data georeferencing, defining a standardized structure for data and metadata organization, and identifying an information system capable of storing and displaying the data.



Fig. 1 – On the left, the church of San Lorenzo in Miranda's 3D laser scanner point cloud vertical section; on the right, aerial views in the archaeological area of the Roman Forum (images acquired during the SAPR survey campaign in 2022).

Regarding data georeferencing, a two-phase 3D integrated survey was conducted in 2022 and 2024 to capture and document the monument's physical characteristics. These campaigns combined 3D laser scanning, photogrammetry, and a topographic survey to georeference the point cloud by linking it to the archaeological Park of the Colosseum's network (Fig. 1). The reference geographic system adopted was the RDN which materializes the 2000's realization of the European Terrestrial Reference System (ETRS) (BARONI *et al.* 2009). Consequently, the georeferenced 3D point cloud became a fundamental resource for analysing the church and providing precise 3D absolute coordinates for all its elements. While the georeferencing procedures were being carried out, another key aspect involved structuring the data and metadata organization. As in all fields of research concerning tangible cultural heritage (TCH), the domain of architectural documentation and analysis required identifying all potential data sources – such as cartography, existing survey drawings, historical images, point clouds, and 3D models – and classifying the relevant metadata within a standardized framework.

For the church of S. Lorenzo in Miranda, this shared database structure was adapted from the one developed within the LazioAntico project (<https://lazioantico.datascape.dev/app.html>), a GIS-based atlas documenting the archaeological remains of ancient Rome (CARAFA 2017, 44-55). The database is

designed to associate each archaeological unit of the ancient landscape with all available data, structured according to a specific taxonomy and semantic relationships. Its hierarchical framework is based on the concept of the Topographic Unit (TU), defined as ‘the smallest trace that can be identified of human settlement or activity’ (IPPOLITI 2023, 3). Following this ‘functional’ distinction, the database is structured to host several phases and periods for each TU. Phases are meant as a timeframe from the starting to the end of a meaningful constructive transformation. Although the classification methods were largely compatible, the original structure – developed for archaeological data – required further adaptation to accommodate architectural documentation. In this context, the level of detail of information retrievable from written and graphic sources can be very high, varying significantly depending on the period of construction. For instance, in the case of the church of San Lorenzo in Miranda, bibliographic and archival sources make it possible to reconstruct the worksite stages, from the initial design to completion. This extensive documentation enabled us to trace the entire evolution of this initial phase, providing valuable insights into the building’s historical and structural development.

Given this, while the original database structure’s first TU phase would have identified a single period spanning from the beginning of construction in 1602 to the first modifications prompted by archaeological excavations in 1810, an additional criterion was introduced to distinguish the construction phase as a separate one going from 1602 until the completion of the church in 1720. Additionally, when dealing with architecture rather than archaeological remains, information related to the material consistency, the distribution of movable objects or furniture as well as the state of conservation documentation are crucial to describe in a more complete way an architectural object. To address this need, the database structure was enriched with additional TU parameters to provide more detailed descriptions.

As a result, the dataset classification of the church aimed to reproduce the constructive features of the building through a virtual dismantling. This virtual dismantling, allowed by the semantic structure, is the base for a digital reconstruction through 3D informative systems. In this direction Building Information Modelling (BIM) solutions can play a key role in stratifying the knowledge and interacting with multidisciplinary and heterogeneous data. In this perspective, the database structure was tested also to ensure a full compatibility with BIM parameters structure for future developments.

The following paragraphs will deal with the detailed description of the data collection and cataloguing phase for the case study and with the ultimate task of transforming data into information, unveiling through a combined study of point clouds, bibliographic sources and historical graphic documentation.

M.G.

3. THE CASE STUDY OF SAN LORENZO IN MIRANDA, FROM KNOWLEDGE TO DATA CATALOGUING BY TOPOGRAPHIC UNITS

Having regard to the directives given by the Spoke 8, the study method is divided into two main stages. The first one consists of the collection of all available sources, both in analogue and digital form. The first stage starts from the selection of websites and databases related to the architectural heritage, not only able to provide digitised and freely accessible records, but also able to identify the location of analogue sources: archival documents, graphic and bibliographic sources. The second step is the digitisation of analogue materials, inventoried on the basis of scientific criteria. This operation is preparatory for their indexing, namely for association with historical, functional, typological and material information. All new documents – such as drawings, photographic documentation, test reports – are produced in digital form. This is also a precursor to a possible georeferencing of the data: in essence, the data are suitable to be inserted in a digital environment, possibly with more spatial references: not only the location of the architectural object, but also the place of the source itself (archives, libraries or other cultural institutes). Against this background, to better explain the study method, it is appropriate to provide brief descriptive notes on the monument under study, referring to the rich bibliography for more exhaustive details.

The church of San Lorenzo in Miranda, located in the Roman Forum, was built at the beginning of the 17th century on the ruins of the temple of

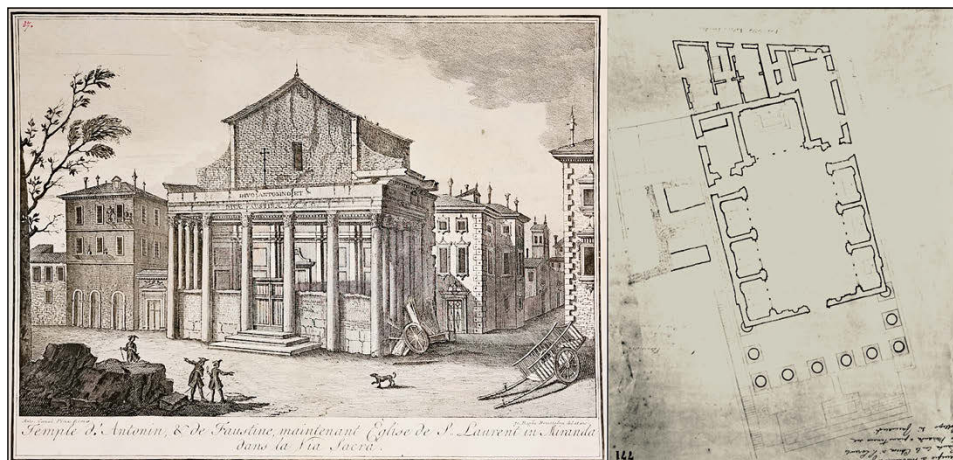


Fig. 2 – Left: J.B. Brustoloni, *Temple of Antoninus and Faustina, currently church of San Lorenzo in Miranda on the Via Sacra*, engraving, early 18th century (BIASA, Roma XI.3.VI.37); right: A. Migliorati, *Plan of the church and ground floor of the Nobile Collegio Chimico-Farmaceutico*, survey, 1903-1905 (A.S.A.R.M., Archivio Disegni, Cart. Tempio di Antonino e Faustina).

Antoninus and Faustina 2nd century AD): the base, the side walls of the naos and the colonnade of the *pronaos* are closely connected to the early Baroque church, whose design is perfectly integrated with the ancient ruins. The building, therefore, is not simply rich in historical stratifications, but can be more appropriately defined as a binomial of two monuments, one within the other. Each of them retains its precise identity, but is now inseparable from the other. It is therefore a perfect subject for a study based on scientific data cataloguing criteria, as well as for the creation of an interactive product.

The ancient Roman temple – which according to reconstructions was of prostyle type, preceded by a hexastyle U-shaped *pronaos*, and raised on a high base in tuff blocks preceded by a staircase (PENSABENE 1996) – was transformed into a church already in 630, when pope Honorius II founded the collegiate of San Lorenzo the martyr in its ruins. This church was suppressed in 1429 by pope Martin V, who entrusted the complex to the *Universitas Aromatariorum Urbis*. Following this event, the *Speziali* (apothecaries) demolished the medieval building to make room for a small hospital and a chapel dedicated to St. Lawrence. These buildings were demolished in 1536 in the context of the redevelopment of the Roman Forum, ordered by pope Paul III on the occasion of the visit of emperor Charles V. Later, a phase of spoliation of the temple preparatory to the construction of the current church begun.

The construction of the current church, commissioned by the Nobile Collegio degli Speziali, began in 1602 under the direction of the architect Orazio Torriani (Bracciano 1578-Rome 1657, DAL MAS 2023) and ended in 1616, except for the facade, whose higher part was made only between 1721 and 1722, by the architect Matteo Sassi (PALMISANO 2009). The religious building belongs to the most common type of church in the Counter-Reformation Age, consisting of a rectangular hall roofed with barrel vault, flanked by six chapels (three on each side) and concluded by a quadrangular presbytery (Fig. 2) (BENEDETTI 2011). The façade, in brick curtain and decorative elements in travertine, is structured with two overlapping orders of pilasters, with a curvilinear broken pediment. The sacred building was joined, on the back, by a four-storey building, designed by Torriani as a seat for the Speziali. This building was demolished in 1932, as part of the opening of Via dei Fori Imperiali. After the demolition it was necessary to redefine the rear façade of the church and rearrange the few remaining spaces as headquarter of the Order of Pharmacists, following a design provided by architect Virgilio Marchi (DAL MAS 1998).

The study of the building started from an analysis of the rich available bibliography primarily DAL MAS 1998 – which constitutes the main reference – but also subsequent articles by the same author (DAL MAS 2002, 2014, 2022, 2023) and other scholars (PENSABENE 1996; PALMISANO 2009), which provided a solid and reliable basis, thanks to their rich documentary

appendices. Nevertheless, further research has been conducted, unfortunately unsuccessfully, at the State Archives of Rome and the Capitoline Historical Archive. On the contrary, the collection of iconographic sources – mainly carried out at the Library of the Institute of Archaeology and Art History of Rome – was satisfactory. This research has provided a great number of images (engravings, drawings, surveys, old photographs) which show the changes of the building over time and allow to reconstruct the history of the building, integrating information from documentary sources. In total, the data collected can be grouped into three categories: 1) reliable data, documented from archival sources; 2) hypothetical data, due to the assumptions and critical reasoning of the authors who have previously studied the monumental complex, now accepted by the scientific community; 3) graphic sources, such as ancient drawings, engravings, paintings, photographs and depictions of the building.

The study of the sources has allowed reconstruction of a very rich chronology and a rather precise dating for most of the building elements. Another important step was an accurate metrological analysis on plans and elevations, obtained by a laser scanner survey. This analysis has allowed to identify the 'module' used by Orazio Torriani in the design of the 17th century church inside the ruins of the temple, highlighting also the great skill of the masons, who erected a rather regular building within an ancient pre-existence and taking into account also the many structural instabilities that have occurred over time on the wall structure, largely as a result of the 19th century's excavations.

M.P

4. THE DATABASE STRUCTURE

All data collected (historical information, sources and images) were stored in a GIS database, ensuring that the entire process was conducted according to established archaeological methods. Considering the history of the building, six topographic units were identified in the architectural organism. Precisely, the temple of Antoninus Pius and Faustina (unit 137), the medieval church (unit 499), the hospital of the Speziali (unit 500), the current baroque church (unit 501), the arrangement of the archaeological area (unit 502), the seat of the Speziali (unit 503). Each topographical unit has been circumscribed by accurate descriptions of architectural and artistic character. It should be noted that not all topographic units identify still existing parts of the building; in fact, the medieval church and the first hospital have been demolished and replaced by the current building, but in order to create a BIM model that would follow the complete historical evolution of the monument, it is necessary to take into account also the lost phases.

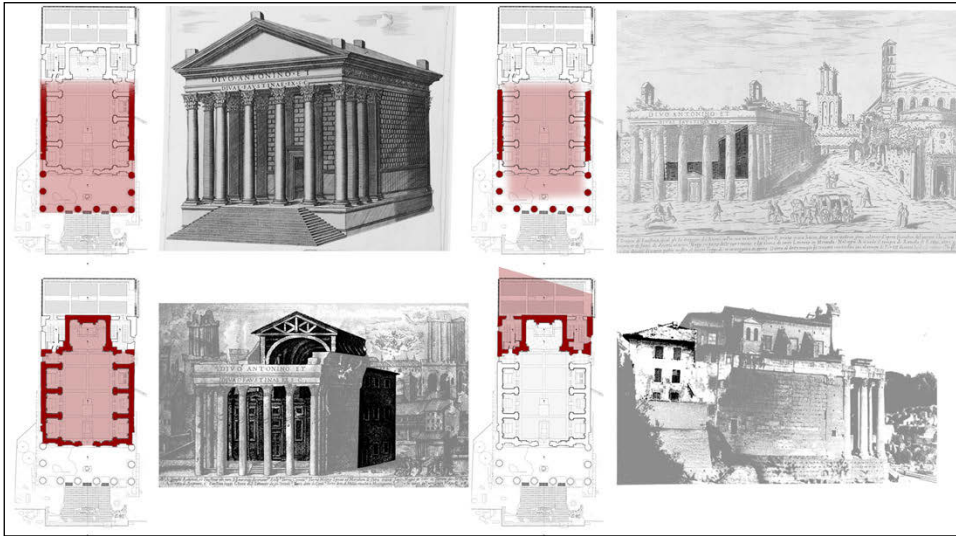


Fig. 3 – The topographic units and the corresponding graphic sources identifying them.

Moreover, the architectural history of each topographic unit has been synthesized into phases, of which chronological references and brief descriptions have been provided (Fig. 3). For topographic unit 137 (temple) a single phase has been identified: 1) stage 1 (141-present day): construction, after the death of Antoninus the temple was also dedicated to him, and the corresponding inscription was added. For topographic unit 499 (medieval church), considering the lack of information, a single phase has been identified: 1) stage 1 (630-1428): from the foundation of the church to its demolition. For topographic unit 500 (hospital of the Speziali), two phases have been identified: 1) stage 1 (1429-1535): construction and use of the hospital; 2) stage 2 (1536-1601): demolition of the hospital and partial spoliation of the temple ruins.

For topographic unit 501 (current baroque church of San Lorenzo in Miranda), five phases have been identified: 1) stage 1 (1602-1720): from the beginning of the construction of the current church, to the completion of the facade; 2) stage 2 (1721-1809): the church is regularly officiated, without significant architectural interventions; 3) stage 3 (1810-1834): first archaeological excavations in the portico of the temple, which prevented access to the church from its main door; 4) stage 4 (1835-1874): presence of a masonry bridge that connected the door of the church to the floor of the Campo Vaccino, bypassing the excavated *pronaos*; 5) stage 5 (1875-present day): demolition of the bridge and progressive continuation of excavations around the building.

For topographic unit 502 (arrangement of the archaeological area), three phases have been identified: 1) stage 1 (1810-1874): first stages of excavation. Initially only the bases of the columns and the floor of the *pronaos* were exposed, while the floor of the Roman Forum remained unaffected. The church door is accessible by a small masonry bridge built in 1835; 2) stage 2 (1875-1928): the site of the Roman Forum is progressively excavated to expose the entire base of the temple, while the bridge is demolished; 3) stage 3 (1929-present day): in 1929 the current brick staircase was built. Since that time there have been no further significant changes.

For topographic unit 503 (seat of the *Speziali*), three phases have been identified: 1) stage 1 (1613-1931): from the construction of the building up to the entire period in which the building exists; 2) stage 2 (1932-1957): from the demolition of the building and the arrangement of the rear façade of the church by Virgilio Marchi, until the period in which no major changes are recorded; 3) stage 3 (1958-present day): construction of the underground hall, behind the church choir, under the floor of the current courtyard.

The six topographic units and their phases are also referred to in the cataloguing of the graphic sources, which have been collected in a special database. Each source, in addition to parameters such as title, author, inventory number, type of representation and execution technique, has been placed in one or more historical periods of the topographic unit depicted, depending on the date of the source itself or the subject depicted. The same approach was followed for cataloguing bibliographic sources. In this way, all the materials useful for the study of the building are collected in a robust and flexible data structure, ready to support future research and analysis.

R.B.

5. RECONSTRUCTING THE TEMPLE'S PLAN: INSIGHTS FROM SURVEY DATA

The comparison between data obtained through laser scanner surveys and previously proposed reconstructions of the temple's original floor plan has revealed an important and unprecedented discovery. Current knowledge suggests a rectangular cella with a wall flush with the two external pilasters that turn onto the front, forming an L-shaped pillar (for the Roman phases of the temple: BARTOLI 1914; CASSATELLA 1993; PENSABENE 1996; DAL MAS 1998, 11-60; the modern reconstructions of the temple are based on those published in BARTOLI 1914, tav. 1-2-3). For an effective graphic representation of the current state of knowledge regarding the temple's original appearance, refer to (CARANDINI 2012, tav. 103). However, the survey conducted during this study allowed for the precise localization of the remains of two pilaster capitals, now visible within the rooms of the current college (Fig. 4). These elements are positioned exactly in correspondence with the remains of the

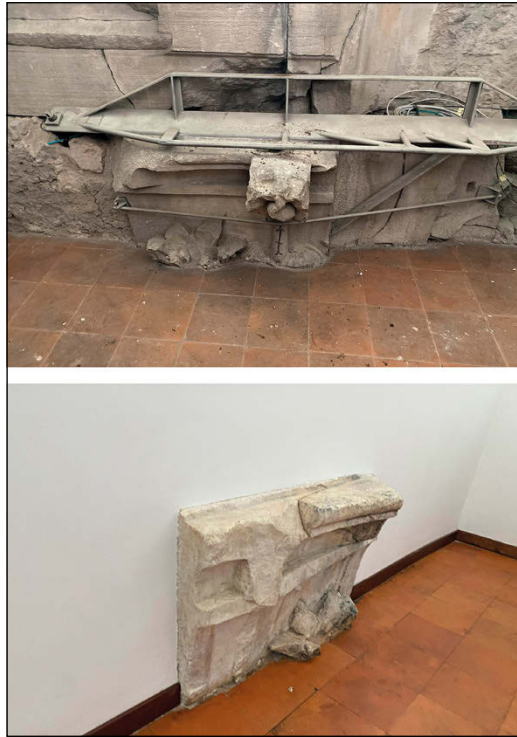


Fig. 4 – Rome, temple of Antoninus and Faustina. Upper image: capital from the interior of the left wall of the cella; lower image: capital from the interior of the right wall of the cella. Today, both capitals are in the rooms of the College of Apothecaries.

external pilasters of the temple's cella wall, long known, thus creating a pillar free on three sides and anchored to the wall of the cella on the fourth side. The capital within the N-W wall logically continues into the peperino blocks corresponding to its base, which protrude from the wall line, despite erosion, indicating the presence of the pilaster itself. On the opposite side, later interventions have not preserved further traces.

These observations suggest that the temple's cella could not have had the floor plan currently attributed to it, where the naos wall is flush with the external pilaster. In this configuration, the wall would conflict with the presence of the internal pilaster. Consequently, this wall must be shifted inward by an indeterminate measure. The examination of historical representations of the temple helps to better understand this issue, which seemed to be recognized at least until the 18th century. A reconstruction of the temple's plan with the

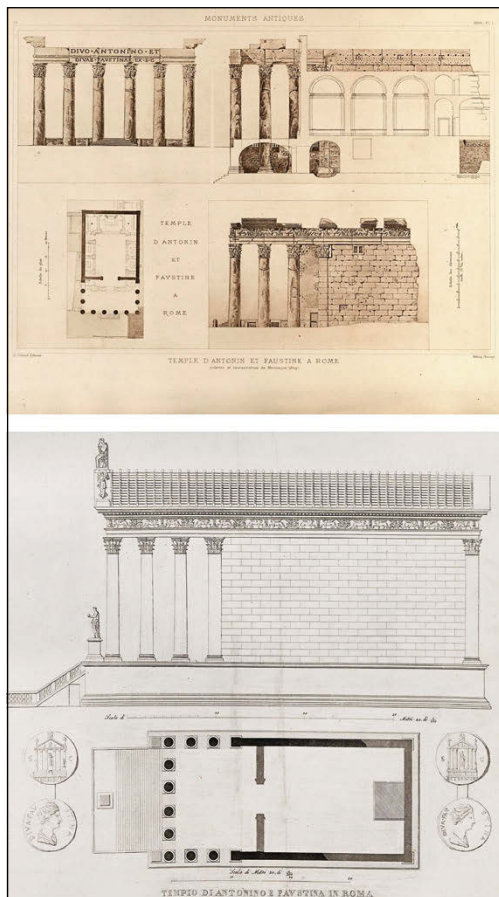


Fig. 5 – Upper image: sections and plan of the remains of the temple of Antoninus and Faustina (from D'ESPLOY 1905, II, 96, pl. 1); lower image: graphic reconstructions of the temple of Antoninus and Faustina (from CANINA 1848, II, tav. XXIV).

cella wall flush with its front limit was already proposed by PALLADIO (1570, lib. IV, cap. IX, 33) and hinted at, with slight variations, in the drawings of Baldassarre Peruzzi (BARTOLI 1914-1922, IV, fig. 506, tav. CCCVII) and Giovan Battista da Sangallo (BARTOLI 1914-1922, IV, fig. 506, tav. CCCVII). The drawings by Giovanni Antonio Dosio (BARTOLI 1914-1922, V, fig. 838, 839, tav. CDLVI) and Antonio da Sangallo the Elder (BARTOLI 1914-1922, I, fig. 101, tav. LXVI), however, left the cella open, unable to identify the wall in question. Antonio da Sangallo the Younger presented an incomplete drawing

suggesting the presence of the wall without fully depicting it (BARTOLI 1914-1922, III, fig. 477, tav. CCXC). Renaissance graphic documentation thus reveals that even then, there was uncertainty about the cella wall's location. Architects hypothesized its alignment with the external pilasters, without significant protrusions of the longitudinal cella walls.

In the 18th century, studies on the temple led to new reconstructions of its appearance and floor plan. Investigations promoted by the French Academy identified the capitals within the cella wall, corresponding to the external pilasters. Their presence suggested that the cella wall was set back from the longitudinal walls' ends by the width of the pilaster itself (D'ESPOUY 1905, II, 96, pl. 1) (Fig. 5). Luigi Canina also recognized the issue posed by the internal capitals and hypothesized the wall was recessed by an intercolumniation (CANINA 1848, II, tav. XXIV) (Fig. 5). Historical reconstructions thus formulated two hypotheses, those of Canina and Mesnager, both plausible given the surviving remains. However, Canina's hypothesis appears more credible, as there is no trace of the cella wall adhering to the internal pilaster, implying a more inward placement. A third possibility exists for the arrangement of the temple of Antoninus and Faustina's cella wall, proposing the absence of a wall and the presence of a colonnade composed of four columns between the antae. This solution would explain why the wall has not been traced since the Renaissance and could find a partial parallel in the *Templum Pacis* in the Forum of Vespasian, where the cella wall was replaced by a colonnade. However, the extreme rarity of such an arrangement makes this hypothesis unlikely. It is more probable that the cella wall was dismantled earlier than other structures, as it did not support the roof, which rested on the lateral walls. This hypothesis also explains the complete absence of traces of the temple's rear wall, likely dismantled before the Renaissance, possibly alongside the front wall.

The structure, consisting of a pillar free on three sides at the ends of the cella's longitudinal walls, finds precedents in temples where the cella's side walls extend towards the front columns, as seen in the later phases of the *Aedes Iani* and *Aedes Iunoni Sospitae* at the current church of San Nicola in Carcere. Additional comparison comes from the temple of Juno Regina at the Portico of Octavia (VISCOGLIOSI 1996), which features a similar floor plan, particularly regarding the cella wall and the arrangement of front columns extending along the side for three intercolumniations. The layout under examination also finds a strong parallel in the *Hadrianeum* (PRESICCE, BALDI 2024), whose cella presented a similar solution with pillars at the ends of the longitudinal walls. Notably, while the *Hadrianeum* was a peripteral temple, the core structure of the cella and its pronaos resemble that of the temple of Antoninus and Faustina, a significant detail considering the same patronage and their use as temples commemorating relatives of Antoninus Pius.

R.D.A.

6. CONCLUSION

In conclusion, the presented work highlights how the integration of digital technologies in the field of cultural heritage studies is radically transforming research, documentation, and conservation methods. The use of advanced tools such as GIS and BIM allows for a deeper and more accurate understanding of artefacts, overcoming the limitations of traditional practices. The ability to archive and share data in digital format also fosters the creation of a collaborative and shared working environment among researchers, professionals, and citizens, paving the way for a phygital ecosystem in which cultural heritage becomes a dynamic and constantly evolving resource. Digitization is not limited to mere data preservation but rather opens up new opportunities for the interpretation and enjoyment of heritage. Emerging technologies allow for overcoming the divisions between archives, museums, and territorial information systems, integrating different types of data into a single knowledge network. This multidisciplinary and interoperable approach enables a more comprehensive analysis of artefact characteristics, improving the quality and accuracy of the available information.

The case study of the Church of S. Lorenzo in Miranda demonstrates how the combination of historical analysis, digital data, and comparisons with similar examples allows for rethinking and reinterpreting the monument's structure in a more informed and scientifically grounded way. The differences in the diachronic stratification of the elements that make up the artefact and the details examined (such as the capital) highlight the need for a revision of traditional hypotheses, based on a more careful and precise reading of the available data. The aim is to build an active memory that crystallizes a diverse range of perspectives focused on the same cultural asset, defining the cross-cutting role of digitization as central to the study and conservation of Cultural Heritage.

In summary, advancements in digital technologies offer new fundamental tools for the conservation and enhancement of cultural heritage, transforming our ability to understand, manage, and preserve the material witnesses of our past civilizations. However, for these tools to be effective in the long term, continuous investment in shared infrastructures, the standardization of formats, and the adoption of open-access policies are necessary, ensuring that cultural heritage becomes an open and globally accessible resource.

F.P.

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ABSTRACT

This paper explores the impact of digital technologies on the study, conservation, and enhancement of cultural heritage, highlighting how tools such as integrated large-scale surveys, georeferencing, GIS, and BIM are transforming the research and management landscape of cultural assets, particularly in the integration of heterogeneous data. The paper emphasizes how the collection, selection, and interpretation of such data can be integrated into an interoperable system that connects various types of sources (historical, architectural, graphic) within a shared and phygital environment. The case study of the Church of San Lorenzo in Miranda (Rome) is presented to demonstrate how the collected data enable a more accurate understanding of ancient structures and their transformations. The proposed approach allows overcoming the limitations of traditional methods, offering new opportunities for documentation, research, and conservation. The paper concludes by highlighting the need to invest in shared digital infrastructures and open-access policies to ensure that cultural heritage becomes a global and sustainable resource for future generations.

REMOTE REFLECTANCE SPECTROSCOPY ON THE PAINTING ‘SAINTS PETER AND STEPHEN’ CONSERVED AT THE FONDAZIONE GIORGIO CINI

1. INTRODUCTION

The preservation of Venice’s cultural legacy, as emphasized by the Cini Foundation’s motto, is not the worship of ashes but the stewardship of fire. This stewardship aims to pass down traditions, expertise, and the beauty of Venetian culture to future generations. The growing awareness of cultural heritage and technological advancements have driven the development of Heritage Science, a multidisciplinary field dedicated to improving «the understanding, care, sustainable use, and management of tangible and intangible heritage to enrich people’s lives today and in the future» (ICCRUM). Applied globally, Heritage Science highlights that effective conservation and preservation rely on understanding the material, historical, and artistic characteristics of artworks, along with their condition and degradation processes (SOLDOVIERI *et al.* 2024). These factors are crucial for characterizing heritage items – be they objects, buildings, or sites – offering insights into historical contexts and craftsmanship while enabling precise restoration and long-term documentation.

Material characterization focuses on identifying materials, assessing their conservation state, and understanding degradation processes to guide restoration efforts. Several scientific disciplines can contribute to this goal: particularly physics (MOSCA CONTE *et al.* 2014) and, more specifically, the Science of Complexity, which has the appropriate scientific method to face the challenges of real complex objects such as ancient artworks (MARCHANT 2025). Among diagnostic techniques, non-destructive and non-invasive methods are preferred. These approaches, based on the interaction of electromagnetic radiation with matter, include imaging and portable spectroscopic systems. Techniques are classified by the specific electromagnetic spectral regions used or generated during measurement.

Multispectral and hyperspectral imaging capture objects across defined wavelength ranges beyond human vision (VASCO *et al.* 2024). Optical spectroscopy explores electromagnetic interactions with matter in the UV (200-380 nm), visible (Vis) (380-750 nm), NIR (750-1100 nm), and SWIR (1100-2500 nm) regions, typically in transmittance or reflectance modes. Photoluminescence, in turn, measures visible radiation emitted by materials under UV stimulation. These methods provide qualitative and quantitative data and are widely used in cultural heritage for pigment and dye analysis and for monitoring artwork cleaning processes (PICOLLO *et al.* 2019). The advent

of Fiber Optic Reflectance Spectroscopy (FORS) introduced a non-invasive technique, further refined with portable instruments capable of spanning UV to SWIR wavelengths. However, FORS is traditionally limited to cases where the probe can be placed in contact or near-contact with the artwork (MISSORI *et al.* 2019; TITUBANTE *et al.* 2022). This study addresses that limitation by introducing a novel approach for remote FORS measurements.

Inspired by astronomical techniques, earlier attempts to achieve remote diagnostic reflectance measurements include the PRISMS system, which imaged wall and ceiling paintings from ground-level distances of tens of meters (LIANG *et al.* 2007). More recently, advanced stand-off systems, including Raman spectroscopy, LIBS, hyperspectral imaging, and others, have expanded spectral range and resolution for remote sensing at distances of approximately 10 meters (LI *et al.* 2024). Additionally, Fourier-transform infrared spectroscopy has been adapted for remote applications, exemplified by the TWINS FT-HSI portable hyperspectral camera, which enables rapid investigation of paintings with enhanced spectral capabilities (PERRI *et al.* 2019).

In this article, we present a method for remote FORS and apply it to the study of the colorants in the painting on a wooden panel, *Saints Peter and Stephen*, tentatively attributed to Antonio del Massaro da Viterbo (circa 1450-1516) and dated to the late 15th-early 16th century. The painting is conserved at the Fondazione Giorgio Cini on the island of San Giorgio in Venice, Italy. To demonstrate the validity of the remote method, the analyses were conducted both in contact using a standard FORS setup and at an 8-meter distance from the painting using a specifically designed optical setup.

2. THE PAINTING OF *SAINTS PETER AND STEPHEN*: ATTRIBUTION, HISTORICAL CONTEXT, AND RESTORATION INTERVENTIONS

The painting depicting *Saints Peter and Stephen* (Fig. 1), an artwork of debated attribution – with proposed names including the Faenza-born painter Giovanni Battista Bertucci the Elder (ca. 1465/1470-1516), Cola dell’Amatrice (ca. 1480/1489-1547/1559), and, more recently and still tentatively, the Viterbo artist Antonio del Massaro, known as Pastura (ca. 1450–before 1516) – can be linked to the figurative culture of early Renaissance Central Italy (late 15th/early 16th century), characterized by a lexicon rooted in the Perugian style. The painting, a precious tempera on panel (dimensions: 152.5×66 cm², with frame: 178×94×8.5 cm²), was part of the collection of the Marquess of Lothian (Newbattle Abbey, Dalkeith, Scotland) and entered the Cini collections in 1958 as part of a group of ancient works intended to decorate the Castle of Monselice. It was housed in the Sala del Castelletto, as evidenced by documentation preserved in the Giorgio Cini Foundation (a letter from Bruno Visentin to Adolfo Cattin, custodian of the Castle of Monselice, dated May 9, 1980).



Fig. 1 – The painting depicting saints Peter and Stephen (late 15th/early 16th century) recently and tentatively attributed to Antonio del Massaro, known as Pastura (ca. 1450-before 1516). In the image, the measurement points are indicated.

The «large panel with a sculpted and gilded frame» was undoubtedly part of an altarpiece polyptych and portrays the two saints, Peter on the left and Stephen on the right, standing with their respective, prominently displayed iconographic attributes: a pair of large keys for the former, signifying his preeminence within the ecclesiastical hierarchy, along with the book he holds and his intense gaze; stones – the instruments of martyrdom – for the latter, conspicuously displayed on his halo, with his upward gaze situating him in a superior, contemplative dimension achieved through Christian sacrifice. Additional stones are scattered on the ground beneath their bare feet, resting on a stony terrain dotted with sparse tufts of grass. Behind the saints unfolds a hint of landscape against an intensely blue sky, signalling the master's adoption of

the harmonious manner of the Central Italian tradition. The artwork, currently housed in the Council Room of the Giorgio Cini Foundation, underwent restoration in 2011 due to several losses of colour on the lower part of the painted surface and a general dullness caused by dust deposits and altered past treatments, which impeded its full readability. The conservation and aesthetic intervention allowed the painting to recover clarity and legibility.

3. THE FONDAZIONE GIORGIO CINI

The Fondazione Giorgio Cini, established in 1951 by Vittorio Cini in memory of his son Giorgio, is dedicated to promoting dialogue between cultures, fostering humanistic and scientific research, and advancing knowledge. Its primary goal was to restore the dilapidated San Giorgio Maggiore Island in Venice, transforming it into an international centre for cultural, research, and scholarly activities. Over the decades, the Fondazione has hosted numerous events, seminars, and conferences on contemporary challenges in technology, ethics, philosophy, and global issues, attracting top researchers and experts worldwide. It has also played a significant role as a meeting place for East and West during the Cold War and has collaborated with major organizations such as UNESCO and the G7. The Fondazione houses seven institutes and three research centres focused on theatre, music, spirituality, art, and cultural heritage preservation through digital technologies. Notably, the Vittore Branca Center provides residential scholarships for scholars from around the world.

San Giorgio Maggiore island, the Fondazione's home, boasts a rich history, evolving from a medieval monastic centre to a Renaissance landmark. Architects like Andrea Palladio and Baldassare Longhena shaped its iconic structures, while thanks to restoration efforts led by Vittorio Cini after the Second World War, the complex was returned to its ancient splendour. In addition to preserving historical architecture, the Foundation has repurposed spaces like the Manica Lunga as a modern art history library and created new landmarks such as the Teatro Verde amphitheatre and Le Stanze del Vetro for glass art exhibitions. The Foundation continues to be a hub for cultural preservation, artistic innovation, and scholarly exchange.

4. REMOTE SET-UP DESCRIPTION

Reflectance spectra in the visible (Vis) and near-infrared (NIR) regions of the spots of interest in the painting *Saints Peter and Stephen* were measured in contact using a standard Fiber Optic Reflectance Spectroscopy (FORS) set-up, and at a remote distance using the innovative method described below. The contact reflectance of the colourants of the painting were measured by a standard FORS set-up from Avantes (The Netherlands), composed of an AvaLight-DH-S-BAL ultraviolet (UV), Vis and NIR radiation source, connected through an

800 μm diameter solarized optical fibre (model FC-UV800-2-SR) to a 50 mm diameter AvaSphere-50-REFL integrating sphere with sample-port of 10 mm in diameter. A gloss trap, coated with black absorbing material, was used in the sphere to avoid measuring specular reflection from the surface of the painting. The integrating sphere was connected to a 600 μm diameter optical fibre (model FC-UV600-2) that transferred the radiation to the AvaSpec-2048 $\times$ 14-USB2 spectrometer. This spectrometer used a diffraction grating enabling applications in the 248-1050-nm range and a fixed 100-micron slit to achieve a spectral resolution of 4.3 nm. Contact FORS measurements were calibrated using a Spectralon® (Labsphere, USA) reflectance standard (model SRS-99-010) with a nominal reflectance of 0.99 over the UV-VIS-NIR spectrum.

The remote reflectance spectra in the Vis and NIR regions were measured by a setup formed by an achromatic refractor telescope from Celestron, model AC 70/400 TravelScope AZ, with 70 mm aperture and 400 mm focal length, with a 45° diagonal erecting prism (Fig. 1). The telescope was mounted by using a suitable connector support on a photographic tripod equipped with a head that can be rotated in three directions to allow aiming towards the region of interest of the painting. The painting was about 8 m from the telescope: at such distance, the collected region is a spot about 2 cm in diameter, therefore it has double the diameter of the sample port of the integrating sphere. The collected region in the painting was illuminated by a light projector using an 18 W GE1649 incandescent lamp focalized by a convergent lens with a diameter of 8 cm and f-number 1. The lens can be moved relative to the lamp to allow the image of the filament to be focused on the painting. Inserted in the 45° diagonal erecting prism was a connector for the 800- μm -diameter optical fibre enabling the transmission of the radiation to the AvaSpec-2048 $\times$ 14-USB2 spectrometer used for the contact set-up. A personal computer was used for spectrometer control and data recording. Remote reflectance calibration was achieved by measuring the reflectance of a white cardboard placed at the same distance as the painting. The contact reflectance of the white cardboard was measured separately by the standard FORS set-up allowing the calibration of the remote reflectance measurements.

The telescope was positioned perpendicular to the painted surface, while the radiation from the light projector had an incidence angle of approximately 20 degrees with respect to it. In this configuration, most of the specular reflection is excluded, as in the contact measurements. Additionally, assuming that the painted surface is a Lambertian surface that reflects light uniformly in all directions, according to Lambert's law of diffuse reflection the intensity I of the radiation collected by the telescope varies as:

$$I \propto \frac{I_0 \cos \alpha}{d^2}$$

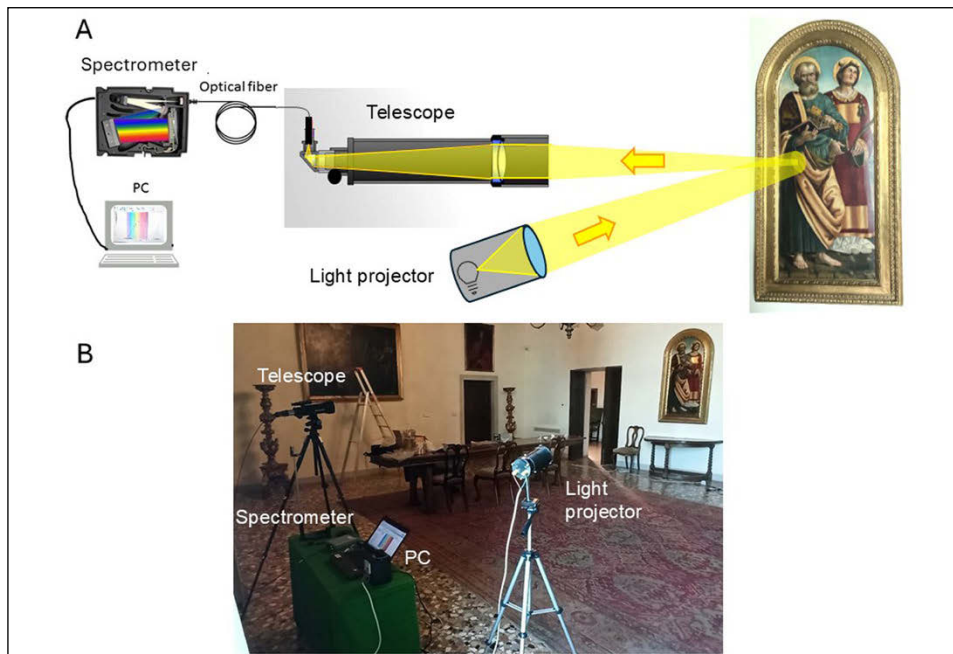


Fig. 2 – A) Schematic of remote reflectance spectroscopy; B) image of the setup during the measurement session of the painting of saints Peter and Stephen.

where I_0 is the intensity of the incident illumination within the area of the fiber projected onto the painting, α is the angle of observation relative to the normal, and d is the distance between the painting surface and the telescope (KORTUM 1969). For all measured points on the painting and the calibration white cardboard, α and d were carefully maintained within a range that ensured that the intensity of the radiation collected by the telescope varied less than $\pm 1.5\%$. Contact and remote measurements were carried out on 6 points shown in Fig. 2, in correspondence with specific coloured features of the painting: Saint Stephen's white robe (a), Saint Peter's yellow robe (b), Saint Stephen's red robe (c), Saint Peter's green/blue robe (d), Saint Stephen's yellow robe (e), and cyan sky (f).

5. RESULTS AND DISCUSSION

The reflectance spectra collected at contact and remote distances are shown in Figs. 3-5. The spectra for point a, acquired at the location of Saint Stephen's white robe, are shown in the left panel of Fig. 3. The spectra in the two acquisition modes show very similar trends, with higher reflectance values of about

0.5-0.6 in the NIR region and a decrease in reflectance values for wavelengths below approximately 600 nm, reaching about 0.2 at 400 nm. The reflectance spectrum acquired in the contact mode overall shows lower reflectance values, with differences ranging from 5% to 10% less than those acquired in the remote mode, depending on the wavelength. This trend can be interpreted as being due to chromatic inhomogeneities in the paint layer at point a of the painting. These chromatic inhomogeneities are visible in this point in Fig. 2 and are caused by the use of a dark pigment for depicting the drapery of Saint Stephen's white robe. Therefore, while the overall spectral behaviour of reflectance in the two modes is qualitatively similar, the lower overall values in the contact mode are likely due to slight differences in the measurement point between the two techniques in an area of the painting that exhibits inhomogeneities in the brightness of the white colour. In fact, in Renaissance paintings, white was often combined with dark pigments (e.g., umber, charcoal black) to create chiaroscuro effects and detailed drapery (MARTIN KEMP 1992).

Concerning the identification of the kind of colorant used for the white robe, the lack of evident spectral features makes these materials difficult to identify using reflectance spectroscopy. Pure white corresponds to almost total reflection of visible radiation, so reflectance spectra of typical white pigments, such as lead white, bone white, and gypsum, are very similar in the visible range, showing an unshaped and relatively flat spectral curve line at high reflectance values. However, the decrease in reflectance below approximately 600 nm, specifically in the violet, blue, and green spectral regions, and the relatively higher reflectance values above 600 nm, specifically in the yellow and red spectral regions, suggest that the white pigment could be white lead, which is subject to yellowing with aging (PASTORELLI *et al.* 2024). The reflectance spectra for point b, acquired at the location of Saint Peter's yellow robe, are shown in the right panel of Fig. 3.

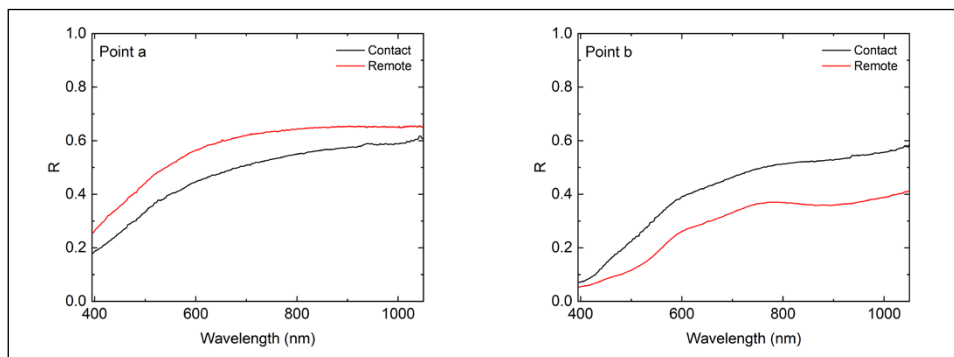


Fig. 3 – The contact and remote reflectance spectra in the Vis and NIR of points a (left) and b (right).

The spectra in the two acquisition modes show similar trends and spectral features even if the remote reflectance appears more structured. Even in this case, a general difference in the intensity of the reflectance spectra is noticeable, with the spectrum acquired in contact mode showing values up to 17% higher than those acquired in remote mode. However, the same considerations made previously for point a can also be applied to this spectrum for point b: the difference can be interpreted as being due to chromatic inhomogeneities in the paint layer at point b. These chromatic inhomogeneities are visible in this point in Fig. 2 and are caused by the use of a dark pigment for depicting the drapery of Saint Peter's yellow robe, as in Renaissance paintings, yellow was often combined with dark pigments (e.g., umber, charcoal black) to create chiaroscuro effects and detailed drapery (MARTIN KEMP 1992). Therefore, while the overall spectral behaviour of reflectance in the two modes is qualitatively similar, the lower overall values in the contact mode are likely due to slight differences in the measurement point between the two techniques in an area of the painting that exhibits inhomogeneities in the brightness of the yellow colour.

In the spectra, starting from the lower wavelength, are evident an increasing of the reflectance, a flex (more evident for the contact mode spectrum) at about 550 nm, two shoulders at about 600 and 770 nm with a central reflectance minimum (which correspond to absorption maxima of the material) at about 640-650 nm, and another absorption at about 900 nm. These features can be easily identified in the different yellow iron-based pigments, such as yellow ochre, goethite, natural sienna and natural umber earths (ACETO *et al.* 2014). Based on the results of the contact or remote reflectance, it is not possible to discriminate among the different yellow iron-based pigments mentioned.

The reflectance spectra for point c, acquired at the location of Saint Stephen's red robe, are shown in the left panel of Fig. 4. The spectra in the two acquisition modes are superimposed in a large part of the spectral range and show reflectance intensity differences as small as 5%, particularly above 900 nm. This very good coincidence may also be due to the homogeneity of the paint application for point c, as observed in Fig. 1. The two acquisition modes give spectra consisting of a non-zero reflectance at 400 nm, small features in the blue-green region followed by a steady increase in reflectance before 600 nm, an inflection point at about 600 nm, and a smaller increase in the NIR region. Overall, this spectrum is compatible with that of a red lake. Since many of the absorption features of red lakes vary depending on their preparation method, the identification of red organic compounds is difficult by using reflectance spectroscopy (FONSECA *et al.* 2019). However, considering the period of the painting, it can be suggested that the red lacquer used was likely derived from natural dyes, common in the Italian Renaissance, such as:

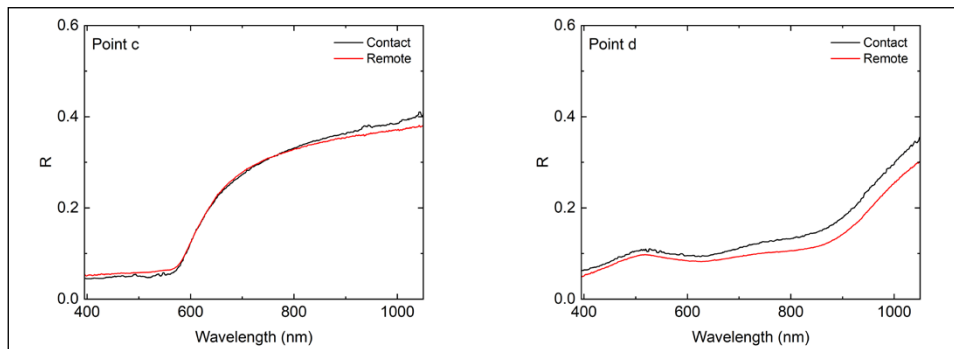


Fig. 4 – The contact and remote reflectance spectra in the Vis and NIR of points c (left) and d (right).

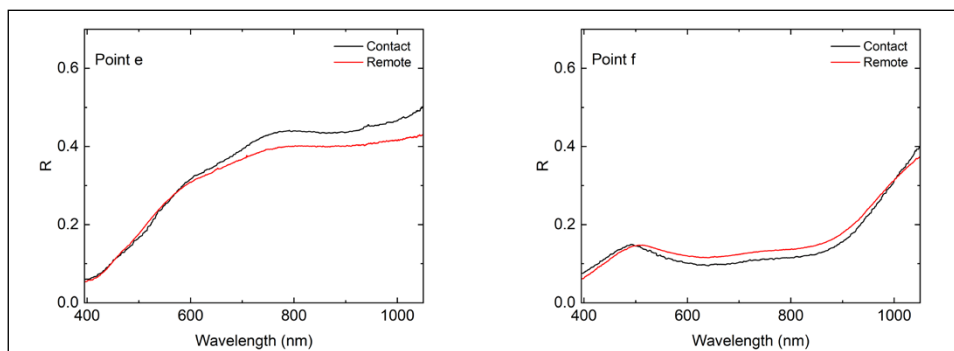


Fig. 5 – The contact and remote reflectance spectra in the Vis and NIR of points e (left) and f (right).

i) madder lacquer (*Rubia tinctorum*), a widely used pigment that produced various red tones, from deep red to pink, with alizarin as the main component extracted from the root; ii) carmine, derived from insects like cochineal.

The reflectance spectra for point d, acquired at the location of Saint Peter's green/blue robe, are shown in the right panel of Fig. 4. The spectra acquired in the two modes show low values of the reflectance up to about 800 nm. They show the same spectral features, namely a first reflectance peak at around 520 nm, a minimum (absorption) at approximately 630 nm, a maximum at around 760 nm, and another absorption at approximately 850 nm. At longer wavelengths, a consistent increase in reflectance is observed, reaching values above 0.5 at 1050 nm. These spectral features suggest the combination of two pigments to achieve the green/blue colour observed with the naked eye. They are consistent with the presence of malachite (a green pigment also made from copper carbonate) mixed with azurite (a

blue pigment made from copper carbonate), which exhibit absorptions at approximately 640 nm and around 800-850 nm, respectively. During the Italian Renaissance, artists sometimes mixed azurite and malachite to create green-blue shades. This combination allowed for customized tones, ranging from green to blue, ideal for depicting natural elements like skies, clothing, and vegetation, offering more realistic and harmonious nuances. The choice to mix these pigments stemmed from their chemical compatibility (both are copper carbonates) and availability as natural materials, though their use often depended on the desired colour effect, artistic technique, and the artist's financial resources, as both pigments were quite expensive.

The reflectance spectra for point e, acquired at the location of Saint Stephen's yellow robe, are shown in the left panel of Fig. 5. The spectra in the two acquisition modes show similar trends and spectral features. Up to about 600 nm, the spectra acquired in the two modes overlap and then separate at longer wavelengths, where the contact spectrum shows a higher reflectance, up to 10%. The spectra exhibit spectral features similar to those of point b (Fig. 3 right), with an inflection at about 520-530 nm, two shoulders at about 600 and 770 nm, with an absorption at about 660-670 nm at their centre, and another absorption at about 900 nm. Therefore, it can be stated that these features can again be identified in different yellow iron-based pigments, such as yellow ochre, goethite, natural sienna, and natural umber earths (ACETO *et al.* 2014). Again, it is not possible to distinguish between these materials using reflectance spectroscopy. Finally, the reflectance spectra for point f, acquired at the location of cyan sky, are shown in the right panel of Fig. 5. These two spectra are very close to each other showing a reflectance intensity difference that can reach a maximum of 0.02. The spectral features are remarkably like those of point d, with absorptions at approximately 630 nm and 840 nm. Therefore, it can also be stated that the artist used the same malachite and azurite mixture to achieve the green/blue colour of the sky filling.

6. CONCLUSION

We present a novel approach for remote FORS measurements using a telescope connected by optical fibres to a multichannel Vis-NIR spectrometer. This setup was employed to study the colourants in the painting Saints Peter and Stephen, conserved at the Fondazione Giorgio Cini and tentatively attributed to Antonio del Massaro da Viterbo (circa 1450-1516). To assess the accuracy of the remote FORS measurements, a comparison was made with standard FORS measurements carried out with a contact integrating sphere. The reflectance spectra collected at contact and remote distances show excellent agreement and enable the identification of the colorants used by the artist. For point a, corresponding to Saint Stephen's white robe, the spectra exhibit

similar features, suggesting the use of white lead. For point b, corresponding to Saint Peter's yellow robe, the spectral features align with yellow iron-based pigments such as yellow ochre or goethite. For these two points, the different overall reflectance intensities are attributed to chromatic inhomogeneities in the paint, likely caused by the use of dark pigments for chiaroscuro effects in the robes. At point c, the spectra for Saint Stephen's red robe are well-matched between the two modes, with minimal reflectance intensity differences, suggesting homogeneity in the paint. The spectral features are consistent with red lake pigments, such as madder lacquer or carmine. For point d, depicting Saint Peter's green/blue robe, the spectral data indicate a mixture of malachite and azurite, which were commonly combined during the Renaissance to create varied green-blue hues. For points e and f, corresponding to Saint Stephen's yellow robes and the cyan sky, the spectra are similar to those of points b and d, indicating the use of yellow iron-based pigments and the same malachite-azurite mixture, respectively. These findings provide insights into the materials and techniques used by the Renaissance artist to achieve specific colours.

We intend to further develop the remote FORS setup by improving the optical set-up to optimize the overlap between the points measured in contact mode and those measured remotely. Additional information regarding the coloured materials of Saints Peter and Stephen could be obtained through other non-destructive investigative methods, such as X-ray fluorescence spectroscopy and infrared and Raman vibrational spectroscopies.

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ABSTRACT

This study presents a novel approach for remote Fiber Optic Reflectance Spectroscopy (FORS) applied to the Renaissance painting Saints Peter and Stephen, tentatively attributed to Antonio del Massaro da Viterbo. The painting, housed at the Fondazione Giorgio Cini in Venice, was analyzed using both contact and remote FORS, with the latter performed at an 8 meter distance using a custom optical setup inspired by astronomical techniques. The reflectance spectra obtained in both configurations showed strong agreement, enabling the identification of pigments such as iron-based yellows, red lake, malachite, and azurite. The findings offer new insights into the artist's material choices and techniques, while also demonstrating the feasibility of remote FORS as a non-invasive diagnostic tool for cultural heritage. Future developments will focus on refining the optical setup to further improve measurement accuracy and expand the applicability of remote FORS in heritage science.

A REVIEW OF TWO RECENT VOLUMES ON ARCHAEOLOGICAL NETWORK RESEARCH

The study of network science in archaeology has emerged as a promising and dynamic field, offering innovative tools and methodologies to analyze the past in its diverse components. The recent publication of *Network Science in Archaeology* (edited by Tom Brughmans and Matthew A. Peeples) and *The Oxford Handbook of Archaeological Network Research* (edited by Brughmans, Barbara J. Mills, Jessica Munson, and Peeples) marks a significant milestone in the development of this interdisciplinary area of research. These two volumes provide complementary insights, and they were likely intended to be published in the same year, 2023. Notably, the *Handbook* is listed in the bibliography of *Network Science in Archaeology* with a 2023 publication date, even though it was officially published in 2024.

Archaeological network research holds considerable promise, as it enables scholars to structure and investigate large-scale relational phenomena that have historically been difficult to analyze using traditional methods. The ability to map and explore connections – whether social, economic, or ecological – provides a new framework for addressing both longstanding and emerging questions in archaeology. By emphasizing relationships between elements, this approach allows researchers to move beyond isolated artifacts or sites and instead focus on the broader patterns and systems that shaped past human behavior. Indeed, one of the most compelling aspects of network science in archaeology can be considered as its versatility. The methodologies introduced in these volumes can be applied to a wide range of periods and regions, from prehistoric societies to more recent historical periods. The flexibility of network analysis allows archaeologists to investigate relationships and interconnections across diverse datasets, whether these involve material culture, social interactions, trade routes, or spatial arrangements. Furthermore, by examining the intricate web of connections that characterize these systems, network research offers a unique lens through which to understand how change occurred over time and how it was influenced by the flow of information, resources, and people.

Network Science in Archaeology offers a comprehensive and accessible guide to the application of network science within the field of archaeology. This work is particularly focused on helping archaeologists navigate the often complex process of turning archaeological questions into actionable network data, performing analyses, and generating meaningful results. While network science offers a set of powerful tools for exploring relational phenomena, the

editors stress the importance of aligning these tools with relevant theoretical frameworks. Network science in archaeology, as presented in the book, is not just a set of methods, but a theoretical perspective that offers new ways of thinking about relationships between entities, such as social connections, trade routes, or communication networks.

One of the key strengths of this volume is its practical focus also. The editors and contributors emphasize the hands-on application of network science tools, offering step-by-step guidance on how to collect, manage, and analyze archaeological network data. Through a variety of methods, including exploratory network analysis, network visualization, and spatial network analysis, the volume teaches how to explore and represent complex data sets, even though the mathematical and statistical content is kept to a minimum and relegated to appendices, making the volume more user-friendly for those less familiar with complex quantitative techniques. Furthermore, the Online Companion to the volume further enhances its usability. Accessible through a dedicated website (<https://book.archnetworks.net/>), the companion includes downloadable datasets and R code that demonstrate the application of the network science methods discussed in the book. This feature allows readers to replicate examples, explore datasets, and experiment with the methods on their own, providing a hands-on learning experience that reinforces the concepts presented in the text.

Chapters 1 through 3 lay the groundwork for the entire volume. Chapter 1 (pp. 1-25) introduces the theoretical underpinnings of network science, explaining how it fits into archaeological research. The focus here is on demonstrating how network science can be both a methodology and a theoretical framework for understanding past relational phenomena. Chapter 2 (pp. 26-63) reviews the primary applications of network science in archaeology, such as the study of social networks, transport systems, and exchanges. Chapter 3 (pp. 64-102) defines network data, providing the foundational knowledge required to handle and manipulate them in the context of archaeological research. The subsequent chapters – 4 through 7 – serve as more technical guides. They focus on practical applications and methodologies in network analysis, including exploratory analysis, uncertainty quantification, visualization techniques, and spatial networks. These chapters provide clear guidance for archaeologists looking to incorporate network methods into their research, offering both conceptual explanations and practical advice for implementation.

For example, Chapter 6 (pp. 196-236) on network visualization discusses how to graphically represent complex networks to better understand relationships between elements in archaeological contexts. Chapter 8 (pp. 263-280) returns to a critical theme introduced earlier in the volume: the relationship between method and theory. The authors argue that network

science in archaeology should not be applied in isolation from the theoretical perspectives that drive its use to ensure that the insights generated are meaningful and contribute to broader understandings of the past.

Complementary to the manual in many respects, *The Oxford Handbook of Archaeological Network Research* is the first comprehensive and authoritative reference work that explores the application of network science in archaeology. The introductory chapter, authored by Matthew A. Peeples, Jessica Munson, Barbara J. Mills, and Tom Brughmans, provides an overview of the role of network research in archaeology. It discusses the evolution of the field, the increasing adoption of network approaches, and the potential of network science to address archaeological questions (pp. 1-11). The chapter also outlines the structure of the volume, which is composed of ten thematic parts, each containing several chapters that address different aspects of archaeological network research.

The section on *Archaeological Networks in Practice* (Part I, pp. 15-83) lays the methodological and theoretical groundwork for network research in archaeology. Clara Filet and Fabrice Rossi present the diversity of the methods most frequently applied in archaeology and to introduce the basic properties of graph theory mobilized by these approaches (pp. 15-33), while Matthew A. Peeples, John M. Roberts Jr., and Yi Yin discuss challenges specific to archaeological network research, such as data limitations and interpretative uncertainties (pp. 33-49). Benjamin Bach and Mereke van Garderen explore advancements in network visualization, emphasizing the need for effective representation of archaeological networks (pp. 50-66). Per Östborn and Henrik Gerding address some challenges related to the definition and exploration of spatial single mode networks inferred from archaeological data, with the aim to introduce a mode of thinking about archaeological network analysis (pp. 67-83).

The section on *Material Culture Networks* (Part II, pp. 88-161) investigates how networks can help analyze material culture and culture change. Jennifer Birch presents concepts and cases focusing on temporal and material dimensions of culture change as investigated through social network analysis (pp. 87-102), while Elliot H. Blair discusses a selection of case studies and a series of issues, related to the process of abstraction and representation that are required to generate meaning from archaeological material culture similarity networks (pp. 101-116). Daniel Sosna examines networks within mortuary archaeology (pp. 117-131), and Mark Golitko introduces the definition of 'geochemical' network as «any archaeological approach that combines geochemical information on artifacts with methods drawn from network science/analysis to examine the structure or dynamics of ancient exchange and interaction» (pp. 132-148, p. 132). Sarah M. Griffin and Florian Klimm discuss the application of network methods to museum collections, focusing

on the Met's collection illustrating how digital and physical archives can be interlinked (pp. 149-161).

The section on *Geographical Networks* (Part III, pp. 165-263) starts with Diego Jiménez-Badillo's discussion on several models for network retrieval with specific characteristics, focusing especially on the concept of relative neighborhood (pp. 165-185), while Ray Rivers, Tim Evans, and Eleftheria Paliou discuss gravity models, debating the approach of MaxEnt (maximum entropy) that lends itself naturally to networking (pp. 186-199). Irmela Herzog examines transportation networks and least-cost path (LCP) models (pp. 200-216). Mu-Chun Wu applies space syntax and pedestrian modeling techniques to facilitate studies of social-spatial phenomena from a spatial network perspective (pp. 217-229), whereas Zoran Čucković focuses on visibility networks, defined as models of explicit visual relationships between one or more observers and their visual targets (pp. 230-247). In conclusion, Eduardo Apolinaire and Laura Bastourre analyze hydrographic networks to investigate «key phenomena in archaeological research, such as large-scale population movements, the spread of ideas and material culture, exchange systems, and control over the landscape» (pp. 248-262, p. 248).

The section on *Network Simulation* (Part IV, pp. 265-307) start with Iza Romanowska's discussion on the intersection of complexity science concepts and methods and archaeology (pp. 265-279), while Wendy H. Cegielski examines the integration of agent-based modeling (ABM) with social network research (SNA) for the advancement of archaeological research (pp. 280-293). In conclusion, Viviana Amati introduces random graph models, explaining that their use in investigating archaeological data requires further investigation (pp. 293-307).

The section entitled *Biological Networks* (Part V, pp. 311-344) provide valuable perspectives on human evolution and ecological interactions. Kent M. Johnson explores the use of network analysis techniques to investigate patterns of phenotypic variation in human skeletal remains within biological distance research (pp. 331-330), while Stefani A. Crabtree and Jennifer A. Dunne examine food webs «as a type of ecological network that represents the topic interactions, or consumption links, within a community» (pp. 331-344, p. 333). The section *Text-Based Networks* (Part VI, pp. 347-426) examines the study of textual and inscriptional data through network analysis. Claire Lemerrier discusses the integration of historical and archaeological network data (pp. 347-362), while Diane Harris Cline and Jessica Munson explore epigraphic networks by considering the dual nature of epigraphic evidence as artifacts and historical sources (pp. 363-377). Valeria Vitale and Rainer Simon introduce Linked Open Data (LOD) and discuss differences, commonalities and touch points of this method for publishing structured data on the web and network analysis (pp. 378-391). Allison Mickel, Anthony

Sinclair, and Tom Brughmans examine knowledge networks and the role of bibliometrics in academia (pp. 392-412), while Vojtěch Kaše, Tomáš Glomb, and Jan Fousek investigate the potential of formal network analysis for the study of religious transformations in past societies (pp. 412-426).

The section *Cultural Transmission and Human Evolution* (Part VII, pp. 429-473) starts with Valéria Romano and Sergi Lozano's analysis of primate social networks to infer patterns of human behavioral evolution (pp. 429-442); Claudine Gravel-Miguel and Fiona Coward discuss why formal network methods are difficult to apply to the Palaeolithic and suggest combining them with other approaches, especially the agent-based models (ABM) (pp. 442-458) while, in conclusion, Briggs Buchanan and Marcus J. Hamilton examine human networks and cultural transmission in hunter-gatherer societies (pp. 459-473). The section *Movement, Exchange, and Flows through Networks* (Part VIII, pp. 477-541) starts with Justin Leidwanger's discussion of maritime space approached through network thinking and analysis applied to the material culture of interaction (pp. 477-491). Barbara J. Mills and Matthew A. Peeples focus on how the study of past migrations can be conducted through network-based approaches (pp. 492-511), while Marek Vlach explore epidemiological modelling and methods of implementing it (pp. 512-527). Shawn Graham and Damien Huffer explore how digital networks, particularly social media, have transformed the antiquities trade, shedding light on illicit activities and their implications for heritage preservation (pp. 528-541).

The section *Assessing the Structural Characteristics of Networks* (Part IX, pp. 545-621) focuses on how archaeologists study the structural characteristics of networks. Matthew Pailes discusses inequality and social network analysis (pp. 545-560), while Erik Gjesfeld examines how networks respond to catastrophes (pp. 561-572). Jelena Grujić and Miljana Radivojević debate the concept of 'archaeological culture' and explore specific community detection methods (pp. 573-592). Scott G. Ortman applies settlement scaling analysis as a form of social network analysis (pp. 593-607), and Jacob Holland-Lulewicz investigates the methodological principles and conceptual frameworks of archaeological network analysis that can help to characterize and evaluate organizational structures connecting members of different societies (pp. 608-621).

Looking Ahead and Beyond (Part X) reflects on the future of archaeological network research. Ulrik Brandes discusses the broader implications of archaeological network science, marking the importance of a data-centric approach that should be aligned with domain-specific theories to be usefully applied in empirical research (pp. 625-633, p. 626), while John Edward Terrell explores relational thinking and contingency analysis in network thinking in archaeology (pp. 634-648). Carl Knappett and Angus Mol

discuss how archaeological network studies form a point of connection for relational theories and practices (pp. 649-663), and the concluding chapter by Jessica Munson, Barbara J. Mills, Tom Brughmans, and Matthew A. Peeples summarizes the volume's most significant insights and anticipates future developments in the field, highlighting emerging methodologies and research directions (pp. 664-674).

As demonstrated in the concise review of the two volumes, network analysis can significantly enhance quantitative approaches in archaeology, and these works can be regarded as foundational milestones for future research in the field. However, to effectively integrate network analysis into archaeological research as a practical and applied method, it is crucial to stress the importance of proper methodological application and the development of a robust theoretical framework guiding its use. Only by adopting an appropriate approach can archaeological data be properly collected, organized, and analyzed to reveal meaningful results. As an emerging and promising field, network archaeology holds significant potential to transform the discipline. However, it should be introduced only after a thorough understanding of the foundational principles of archaeological research has been established. In this regard, a professional master's program could provide an optimal framework for advanced study and training, enabling students to first develop proficiency in traditional archaeological methods before engaging with more complex and innovative approaches such as network analysis.

In Italy, one of the main challenges to integrating network archaeological research lies in the fact that applied digital methods predominantly consist of relevant tools like GIS, BIM, and 3D modeling. These tools are essential – particularly GIS and BIM – for managing data that supports the conservation and promotion of the country's cultural heritage by both public and private organizations. As a result, the time and resources allocated for testing innovative archaeological network research methodologies within Italian academia are limited. However, the extensive availability of datasets on the country's heritage represents a valuable resource for researchers worldwide seeking to apply network-based approaches to archaeological research, offering innovative perspectives on relational data. Indeed, as a rapidly evolving field, network archaeology holds significant potential for future discoveries and insights. Nevertheless, its long-term success, I argue, depends on a thoughtful and comprehensive educational framework that equips future researchers with the methodological and theoretical skills necessary to apply these approaches effectively.

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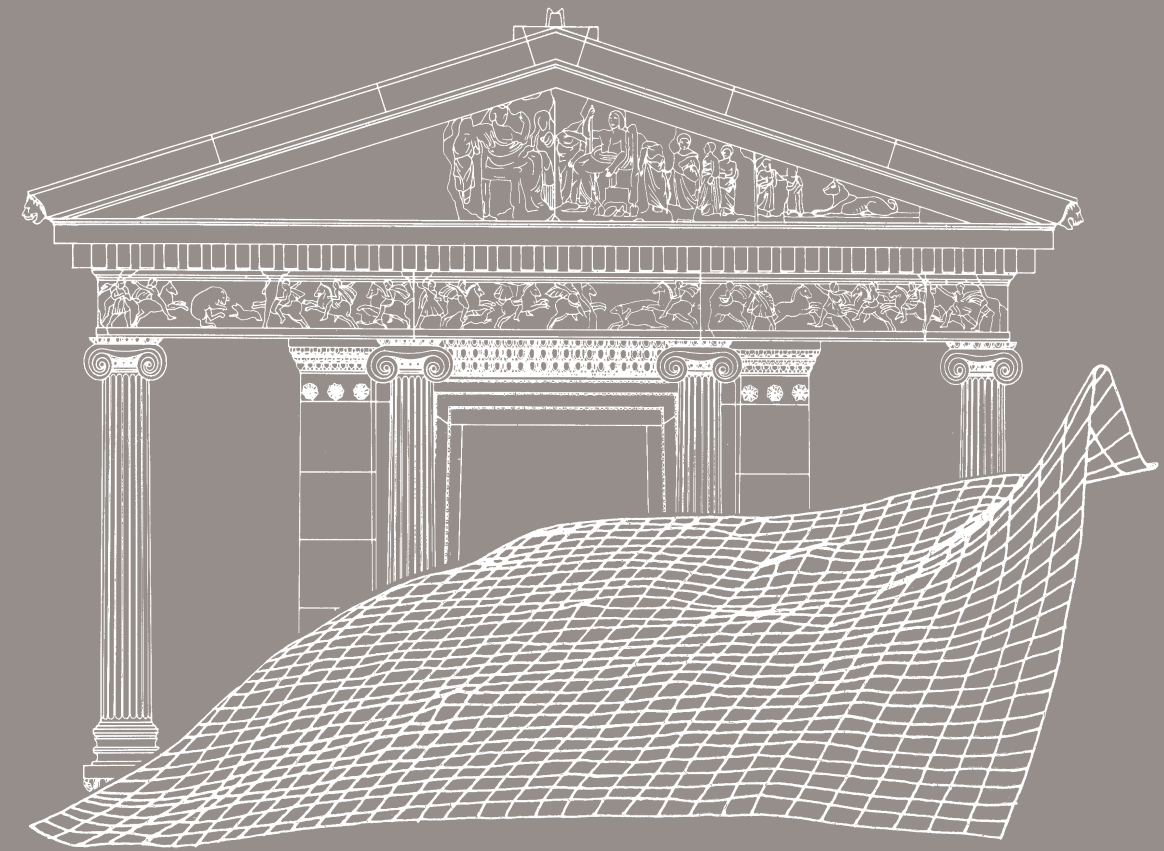
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ABSTRACT

This paper discusses two recent volumes that significantly contribute to the field of archaeological network research: *Network Science in Archaeology* (2023), edited by Tom Brughmans and Matthew A. Peebles, and *The Oxford Handbook of Archaeological Network Research* (2024), edited by Tom Brughmans, Barbara J. Mills, Jessica Munson, and Matthew A. Peebles. Together, these works provide a comprehensive overview of current methodologies and applications of network science in archaeology, offering valuable theoretical frameworks and case studies.

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