

BEHIND THE SCENES OF MEDIEVAL ROOFS

An Overview of the Roofing
Systems of Italian Churches

Edited by
ANGELO PASSUELLO, MICHALIS OLYMPIOS



«L'ERMA» di BRETSCHNEIDER

Questo è un pdf di,
Behind the Scenes of Medieval Roofs An Overview of the Roofing Systems of Italian Churches,
ISBN 978-88-913-3430-5.

Il copyright su questa pubblicazione appartiene a L'ERMA di Bretschneider ®.

Come autore lei è autorizzato a fare copie stampate del pdf o di inviare il file pdf inalterato a un massimo di 50 relazioni.

Non può pubblicare questo pdf sul World Wide Web - compresi i siti web come academia.edu e Open-Access fino a tre anni dopo la pubblicazione. Per favore assicurarsi che chiunque riceva un estratto osservi anche queste regole.

Se desidera pubblicare il suo articolo immediatamente su siti ad Open-Access, si prega di contattare l'editore per quanto riguarda il pagamento della tassa di elaborazione dell'articolo.

Per domande su estratti, copyright e ripubblicazione del suo articolo, si prega di contattare l'editore tramite lerma@lerma.it

This is a pdf of,
Behind the Scenes of Medieval Roofs An Overview of the Roofing Systems of Italian Churches,
ISBN 978-88-913-3430-5.

The copyright on this publication belongs to L'ERMA di Bretschneider ®.

As author you are licensed to make printed copies of the pdf or to send the unaltered pdf file to up to 50 relations.

You may not publish this pdf on the World Wide Web – including websites such as academia.edu and open-access repositories – until three years after publication. Please ensure that anyone receiving an offprint from you observes these rules as well.

If you wish to publish your article immediately on open-access sites, please contact the publisher with regard to the payment of the article processing fee.

For queries about offprints, copyright and republication of your article, please contact the publisher via lerma@lerma.it

BIBLIOTHECA ARCHAEOLOGICA, 90

BEHIND THE SCENES OF MEDIEVAL ROOFS AN OVERVIEW OF THE ROOFING SYSTEMS OF ITALIAN CHURCHES

Edited by

ANGELO PASSUELLO -MICHALIS OLYMPIOS

«L'ERMA» di BRETSCHNEIDER
Roma-Bristol (USA)

BEHIND THE SCENES OF MEDIEVAL ROOFS AN OVERVIEW OF THE ROOFING SYSTEMS OF ITALIAN CHURCHES

edited by
ANGELO PASSUELLO and MICHALIS OLYMPIOS

© Copyright 2026 «L'ERMA» di BRETSCHNEIDER
Via Marianna Dionigi, 57 70 Enterprise Drive, Suite 2
00193 Roma – Italia Bristol, CT 06010 – USA
www.lerma.it lerma@isdistribution.com

Sistemi di garanzia della qualità
UNI EN ISO 9001:2015

Sistemi di gestione ambientale
ISO 14001:2015

This publication is part of the activities of the *Cataloguing Medieval Roofs (CaMeRoofs)* project, funded by the European Union under the Marie Skłodowska-Curie Actions (HORIZON-MSCA-2022-PF-01), grant agreement No. 101104788 (2024-2026).

The views and opinions expressed are those of the authors only and do not necessarily reflect the official position of the European Union or the granting authority, neither of which can be held responsible for them.



Funded by
the European Union

The *CaMeRoofs* project is coordinated by the University of Cyprus, with the Università degli Studi di Firenze as an associated partner.



University
of Cyprus



UNIVERSITÀ
DEGLI STUDI
FIRENZE

This publication has been subjected to a quality assessment procedure, and the contributions were accepted following a peer-review process.

Image Credits

All images included in this volume have been provided by the authors of the respective contributions. The authors confirm that they hold all necessary rights for the use and publication of the images, as required by the competent authorities. The Publisher remains available to contact any rights holders who could not be reached.

Behind the Scenes of Medieval Roofs. An Overview of the Roofing Systems of Italian Churches - (Edited by) Angelo Passuello, Michalis Olympios - «L'ERMA» di BRETSCHNEIDER, 2026. - 240 p.; ill. (Collana Bibliotheca Archaeologica, 90)

ISSN: 2240-8347

ISBN brossura: 978-88-913-3430-5

ISBN pdf: 978-88-913-3432-9

DOI: 10.48255/9788891334329

CDD 720

1. Soffitti

CONTENTS

Acknowledgements	p.	7
ANGELO PASSUELLO		
Recent Contributions to the Study of Medieval Roofing Systems in Italy. <i>Status Quaestionis</i> and New Research Perspectives	»	9
FRANCESCO SALVESTRINI		
Shielding the Vault of Heaven. Cultural and Historical Considerations Regarding the Starry Sky on the Ceilings of Italian Medieval Churches.....	»	23
ALESSANDRA PANICCO		
The Vaulting Systems of the Early Carthusian Churches in Italy (Twelfth-Fourteenth Cen- turies). Construction Techniques and European Comparisons	»	47
ANGELO GIUSEPPE LANDI, EMANUELE ZAMPERINI		
Timber Roof Structures in Medieval Churches in Cremona. The Case of the Church of San Francesco	»	63
ANGELO PASSUELLO		
The Roofing Systems of Verona Cathedral (Twelfth-Sixteenth Centuries). Construction Phases, Restorations, Dendrochronology, and Architectural Framework	»	79
LAURA JACOBUS		
Roofing and Re-roofing the Arena Chapel (Cappella degli Scrovegni) in Padua (1303-1305)...	»	101
MATTEO BIGONGIARI, STEFANO BERTOCCI		
Behind the Dome: The Hidden Roofs of Brunelleschi's Old Sacristy. A Digital Survey Approach to Medieval Construction in the Renaissance	»	123
MAURIZIO FICARI		
Romanesque Churches with Domes Enclosed by <i>Tiburios</i> in the Maremma and Sienese Areas...	»	139

ROBERTA CERONE

Mendicant Churches and Hybrid Roofs. The Case of Rieti..... » 157

ROBERTA FERRETTI, ANASTASIA COTTINI

Integrated Digital Documentation Methodologies for the Knowledge of Medieval Religious Complexes. The Porziuncola Church in Santa Maria degli Angeli, Assisi..... » 175

MICHELE COLAIANNI

Hidden Presences. The Medieval Wooden Trusses of Matera's Churches » 191

ARIANNA CARANNANTE

Domes on Axis in the Benedictine Churches of the *Terra di Bari* (Eleventh-Twelfth Centuries).. » 205

NICOLETTA USAI

Roofing Systems in Medieval Sardinia. Types, Materials, and Craft Traditions » 221

INTEGRATED DIGITAL DOCUMENTATION METHODOLOGIES FOR THE KNOWLEDGE OF MEDIEVAL RELIGIOUS COMPLEXES. THE PORZIUNCOLA CHURCH IN SANTA MARIA DEGLI ANGELI, ASSISI

ROBERTA FERRETTI*, ANASTASIA COTTINI**

DOI: 10.48255/9788891334329.10

Abstract

The Porziuncola Church remains the focal point of Saint Francis' life and his fraternity, despite the changes that it has undergone over the centuries. Built on the site of an abandoned Benedictine chapel, it transitioned from being a small church on a secondary road to hosting the first official seat of the Franciscan Order, the place of the saint's death, and a destination for obtaining the indulgence. The Porziuncola has never been fundamentally altered, remaining open to the faithful and becoming one of the most important relics of Franciscan worship. The building discovered by Saint Francis was likely a single rectangular stone hall covered by a semicircular barrel vault, traces of which are still visible on the walls. The primary interventions, according to the chronicles, were carried out by the saint in a reconstruction of the Porziuncola that seems to have focused on enlarging the openings and rebuilding the roof, which, similarly to that of the nearby church of San Damiano, is currently in the form of a pointed barrel vault. This paper aims to analyse the evolution of the Porziuncola's roof by comparing its principal pictorial representations with buildings that are similar in architectural proportions and historical context (e.g., the church of the SS. Annunziata in Cesi). The goal is to investigate the building's architectural transformations over time by correlating iconographic evidence with data acquired through integrated digital documentation technologies, which involve using close-range photogrammetric and laser-scanning techniques to obtain a thorough and detailed analysis of the structural and formal evolution of the church's roof.

Keywords: Digital survey; Franciscan observance; Religious heritage; Porziuncola; Architectural analysis

1. INTRODUCTION

This research was carried out within the framework of the European project *F-ATLAS Franciscan Landscapes – The Observance between Italy, Portugal and Spain*, coordinated by the University of Florence (UNIFI) in collaboration with the University of Barcelona (UB), the Portuguese Catholic University (UCP – CEHR), and the University of Lisbon (ISCTE – IUL). The main objective of the project was to establish an interdisciplinary network focusing on the heritage of Franciscan Observance in Europe. The Franciscan Observance was a significant reform

movement originating in Italy in the second half of the fourteenth century, aiming to return to the original ideals of Saint Francis by adhering more faithfully to the Rule, particularly its precepts of poverty, austerity, and obedience. The *F-ATLAS* project entailed interdisciplinary collaboration among the participating research groups to develop a heterogeneous and continuously updatable database, partially accessible online through a WebGIS application. The selected case studies were georeferenced, digitised, and analysed using historical and archival sources, 3D virtualisation of surviving structures, and architectural investigations.

* Roberta Ferretti, Università degli Studi di Firenze, Italy, roberta.ferretti@unifi.it, ORCID-ID: 0000-0002-8320-0408.

** Anastasia Cottini, Università degli Studi di Firenze, Italy, anastasia.cottini@unifi.it, ORCID ID: 0000-0003-4897-4405. Sections 1, 4-6 were written by Anastasia Cottini and Sections

3-4 by Roberta Ferretti. Case study data were collected during the three-year (2020-2023) European project *F-ATLAS*. We express our gratitude to the OFM and the friars of the basilica of Santa Maria degli Angeli for their support.

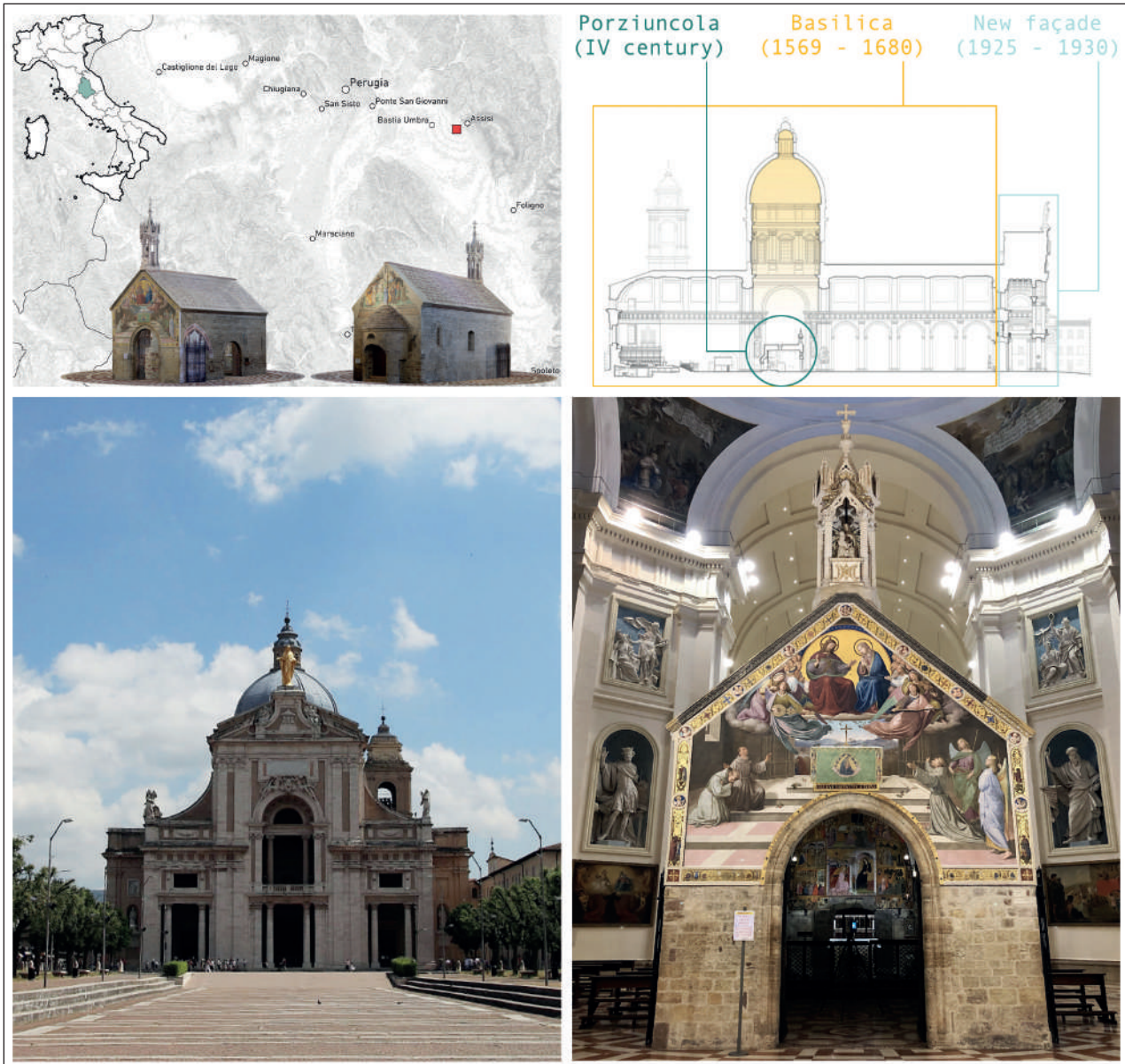


Fig. 1. *Top left*: Geographical location of the conventual complex within Umbria and point cloud models of the Porziuncola. (Elaboration by A. Cottini, C. Cerbai). *Top right*: Longitudinal section of the basilica, showing the dimensional relationships between the basilica, the Porziuncola, and the new façade. (Elaboration by G. Prosperino). *Bottom*: Photographs of the façade of the basilica and the Porziuncola. (Source: A. Cottini).

More specifically, the present research focused on interpreting the data collected concerning the church of the Porziuncola. As shown in *fig. 1*, this small ecclesiastical structure – whose origins date back to around the fourth century – is today incorporated within the Papal Basilica of Santa Maria degli Angeli, Assisi, in the province of Perugia, whose construction began around the mid-sixteenth century and was completed in the second half of the seventeenth.

2. THE PORZIUNCOLA

The Porziuncola, the Chapel of the Transitus, and the Chapel of the Roses represent the historical and spiritual core of the current basilica complex of Santa Maria degli Angeli. These spaces represent key episodes in the life of Saint Francis and embody the Franciscan message of poverty, simplicity, and devotion. Integrated digital documentation, combined with representations of these

places over time, is crucial for deepening our understanding of their origins and development. Moreover, it plays a vital role in preserving and transmitting not only the material value of these sites, but also their symbolic significance. The early Minorite settlement in the area of the Angeli, then a wooded and wild region, was established on land that had belonged since at least the eleventh century to the Benedictine monks of the abbey of San Benedetto al Subasio. This land was granted for use to Francis and his first companions around 1209-1211. At that time, the plain of Santa Maria degli Angeli had been abandoned for about a century and, according to historical accounts, the dilapidated condition of the small church prompted Francis to immediately restore it.

The Porziuncola, as known to Francis, is described as a rectangular hall covered with a stone barrel vault and culminating in a small apse at the east end. The main entrance was located on the western façade, while a smaller door opened on the southern wall. The interior was lit by a round oculus above the main portal and by three differently sized openings on the front of the triumphal arch. The presbytery was elevated by two steps and featured a central altar placed over a monolithic base¹. According to this description, the original structure would not have differed significantly from the current appearance of the Porziuncola: a single rectangular space measuring 4 by 9 metres, terminated to the east by a small semi-circular apse with an opening leading to the outside. Today, the building has a main entrance and a secondary opening on the long side, both of which are disproportionately large in relation to the overall dimensions of the space. As first suggested by Pietro di Giovanni Olivi, the enlargement of the portals is likely linked to the practice of indulgence, as it became customary to allow numerous pilgrims to enter through the main door and exit through the side door². The windows located in the apse area have been walled up, and the remaining windows are not contemporary with one another. The narrow-slit window on the

eastern side may date back to the original structure. The most significant difference concerns the roof. The small building is currently covered by a pointed barrel vault; traces of an earlier vault of the same type remain visible on the masonry of the counter-façade (fig. 2). The current vault is commonly associated with the similar pointed barrel vault of San Damiano, and some studies have linked both to the early stages of Saint Francis' conversion. According to the accounts of his earliest biographers, especially Thomas of Celano, the young Francis was involved in the restoration of at least three rural churches in the Assisi area, including the Porziuncola³.

To date the vault's reconstruction, reference is made to the studies of Angiola Maria Romanini, who attributes both interventions to «a date neither earlier nor later than the transition between the late twelfth and the early thirteenth century»⁴. As previously noted, over the centuries the settlement around the Porziuncola gradually developed and expanded in parallel with the growing number of followers. In accordance with his vow of poverty, Saint Francis provided specific instructions regarding the organisation of the space surrounding the church, advocating for the construction of simple and modest dwellings, as attested in the *Specchio di perfezione*, included in the *Fonti Francescane*⁵. During the years when Francis was still active at the Porziuncola, there are accounts of a structure built by the commune to host the friars arriving there. The construction of the *Casa del Comune* was carried out without the consent of Francis, as it did not conform to his directives for organising the settlement, both in terms of its size and its proximity to the Porziuncola. Due to the fact that it was owned by the commune, neither Saint Francis nor his successors were able to remove it, and thus it remained part of the Franciscan settlement, becoming one of the preserved and safeguarded remnants of the basilica, albeit remaining the least visible. Around 1230, the friars began the construction of a small convent which, over time, expanded progressively until it reached

¹ LUNGI 2008, p. 260.

² ID. 2019, p. 225.

³ ID. 2008, p. 260.

⁴ «Data non anteriore e non posteriore al valico fine XII-primo XIII secolo» (translated by the author) (ROMANINI 1989, p. 67).

⁵ «Questo luogo modello di tutto l'Ordine. Voglio che i frati qui sopportino le tribolazioni e i disagi per amore del Signore

Dio. E gli altri frati che vengono qua, riportino nelle loro dimore il buon esempio di povertà. Perché, se noi avessimo qua i nostri agi, anche gli altri sarebbero stimolati a fare costruzioni nei propri luoghi, scusandosi: se presso s. Maria della Porziuncola, che è il primo luogo dell'Ordine, vengono eretti gli edifici così, possiamo anche noi farli nei nostri luoghi» (*Fonti Francescane* 2004, p. 1013, n. 1563).



Fig. 2. Wireframe two-dimensional line drawings (two longitudinal sections and two cross-sections) of the Porziuncola obtained from the integrated digital survey. (Elaboration by L. Bacherini, F. Bargellini, T. Chiarugi, G. Deri).

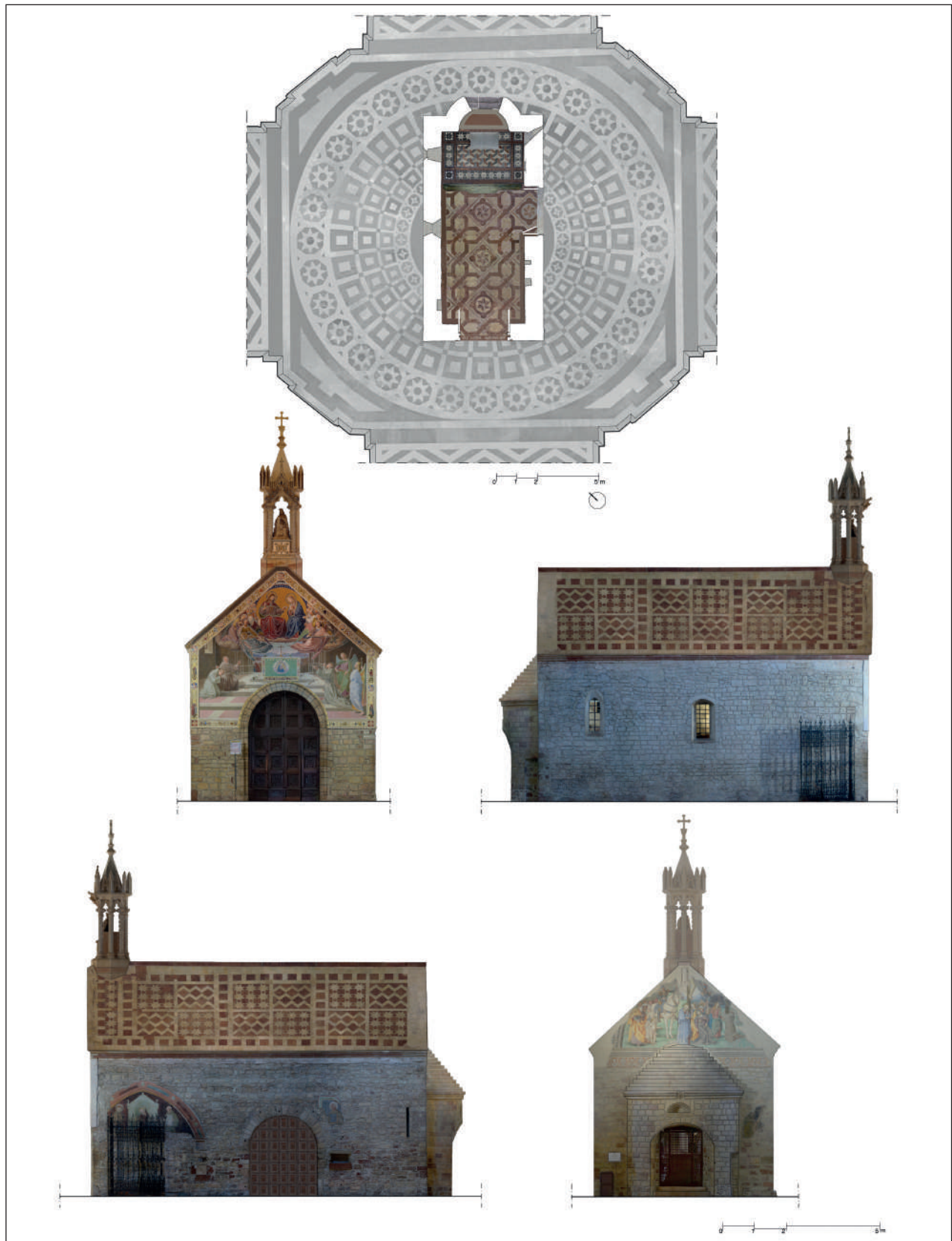


Fig. 3. Two-dimensional drawings (plan and elevations) of the Porziuncola obtained from the integrated digital survey. The wireframe drawing is overlaid with chromatic data obtained through a close-range photogrammetric survey. (Elaboration by L. Bacherini, F. Bargellini, C. Cerbai, T. Chiarugi, G. Deri).

the site of the Porziuncola⁶. At the beginning of the 1330s, the changing needs and the growth in the number of the clergy and the faithful led to the adaptation of the small building to meet the liturgical requirements of the indulgence. A series of structures, such as loggias and canopies, were also constructed adjacent to the building. The presence of these additions is attested by archaeological finds and by important iconographic sources that will be analysed later in this study. Around 1485, at the behest of Saint Bernardino of Siena, the small choir on the east side of the Porziuncola was enlarged. Subsequently, another choir, known as the 'lay choir', was built; however, its exact location remains uncertain. A.M. Romanini conjectured that it was situated to the east of Saint Bernardino's choir, but excavations conducted in 1966-1967 have not confirmed this hypothesis⁷. Another theory is presented in the *Compendio del perdono di Assisi e della chiesa detta Porziuncola*, where the author states that the choir was positioned above the church and utilised for acoustic communication «the hexagonal opening, which can still be seen in the middle of the vault»⁸.

Today, the interior of the Porziuncola exhibits the sobriety typical of Franciscan decorative tradition: the viewers' attention is immediately drawn to the altarpiece painted by Ilario da Viterbo in 1393, while the walls show mainly exposed masonry, with some fragments of frescoes surviving in the area directly adjacent to the altarpiece. The most important document pertaining to the extant remains of monumental painting is that produced by Bernardino Sperandio following the restorations of the Porziuncola, which, according to Lunghi, can be understood as an actual stratigraphic investigation of the church and its ancient plaster layers. These studies reveal that the masonry surface of the east wall was originally covered with a layer of lime plaster, identical to that applied to the walls of

the nave. On the vault, perfectly aligned with the frame of the altarpiece, there is a layer of fresh *intonachino* plaster painted with a starry sky and two peripheral bands on which vegetal motifs alternate with geometric patterns⁹. On the main façade of the Porziuncola, a fresco by Federico Overbeck, painted in 1829, is currently visible (fig. 3). This is the latest in a series of frescoes and depictions succeeding each other on the same surface, the earliest documented work being the painting by Pietro Paolo Zampa from 1638, which was later replaced due to damage caused by exposure to the elements. Before that, there existed a fresco by Nicolò Alunno¹⁰, which itself replaced an earlier decoration of which no direct evidence remains, but which is mentioned in a letter written in 1492 by the Blessed Bernardino da Feltre¹¹. On the gabled façade is positioned a Gothic-style niche containing a copy of a statue depicting the *Madonna del Latte* (the original, dating from the late fourteenth century, is now preserved in the Museo della Porziuncola). The Gothic niche is already visible in Francesco Providoni's survey drawings from 1697¹², alongside the façade fresco painted by Zampa. During the restoration of the Porziuncola following the 1997 earthquake, the rich geometric decorative scheme in white and red marble adorning the two slopes of the roof was uncovered¹³, along with large fragments of the lost fresco by Perugino depicting the *Crucifixion*¹⁴, located in the upper part of the east elevation. As part of these restoration works, the precious original floor, concealed for years beneath sixteenth-century superstructures, was also brought to light.

3. THE ICONOGRAPHY OF THE PORZIUNCOLA

Throughout its history, the Porziuncola has assumed different roles and meanings, closely linked to the growing fame of the man who chose

⁶ CANONICI 1989, p.91.

⁷ ROMANINI 1989, p. 67.

⁸ *Compendio storico* 1834, p. 67.

⁹ LUNGHY 2019, p. 203.

¹⁰ ID. 2008, p. 254.

¹¹ ID. 2019, p. 204.

¹² The drawings made by Providoni provide valuable evidence as to the appearance of the Porziuncola and the Chapel of the Transito before the exterior walls received new decoration in the nineteenth century. The drawings are held at the Archivio della Provincia Serafica in Santa Maria degli Angeli,

Carteggio amministrativo, Fabbrica, n. 14.

¹³ The roofing was carried out thanks to a bequest from the bishop of Assisi, Tebaldo Pontano, who also commissioned Giotto to execute the *Stories of Mary Magdalene* in the chapel intended for his burial in the Lower Church of Assisi (1307-1308). This may be linked to the possible presence of frescoes by the Florentine artist in the Porziuncola, as noted by Lorenzo Ghiberti, who, however, does not specify their location or subject matter (LUNGHY 2019, p. 175).

¹⁴ BELARDI, MENCHETELLI, COTANA 2024, pp. 65-75.

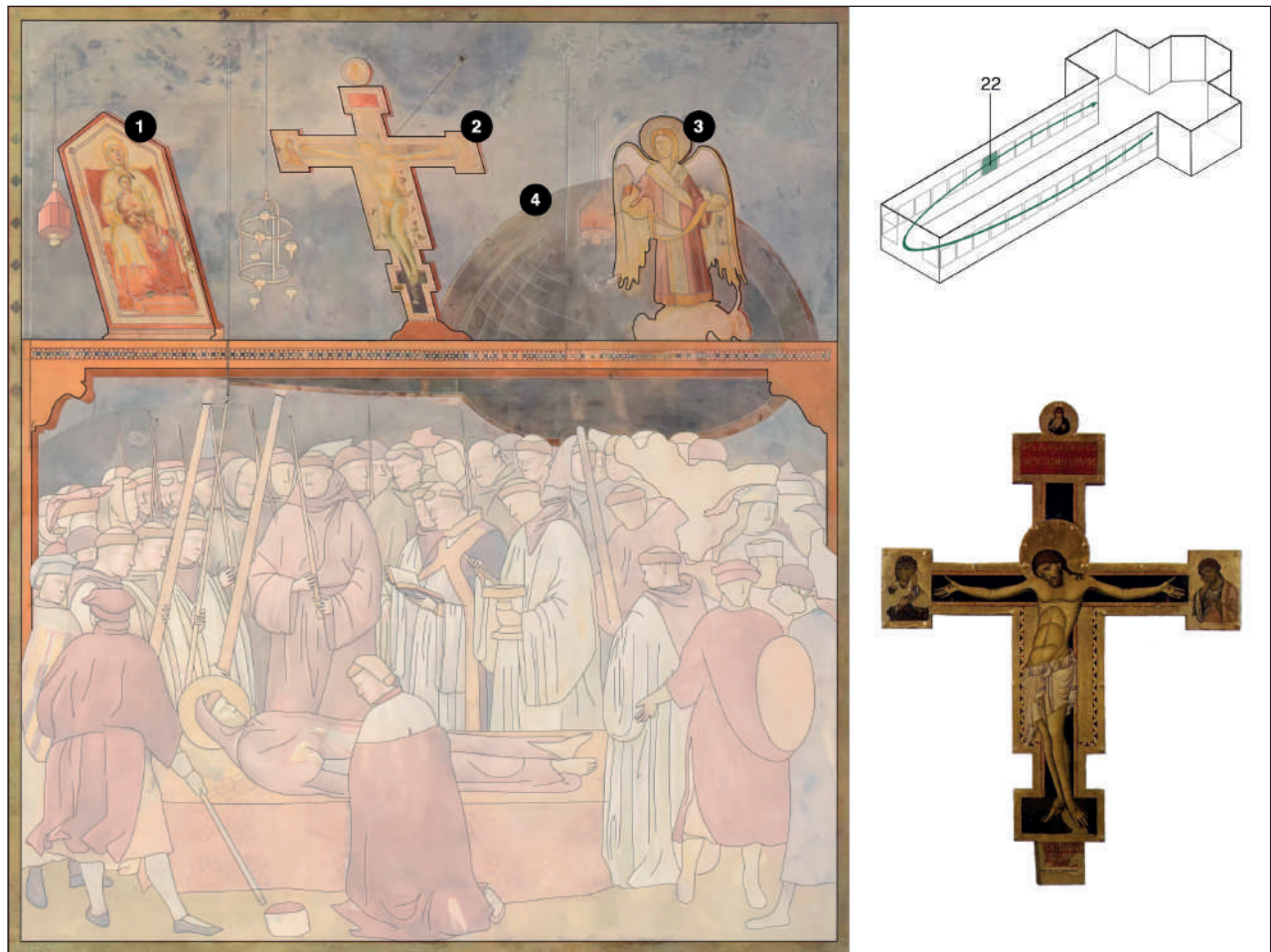


Fig. 4. *Left*: Orthomosaic obtained from SfM photogrammetry of the fresco depicting the twenty-second scene of the pictorial cycle *Stories of Saint Francis* (Upper Church, Assisi). The image shows a wireframe drawing superimposed on the orthomosaic, highlighting the architectural and decorative elements within the interior of the Porziuncola: 1. *Madonna and Child*; 2. *Crucifix*; 3. *Saint Michael*; 4. the apse. (Elaboration by the authors). *Top right*: Schematic elevation drawing of the Upper Church showing the location of the twenty-second scene. (Elaboration by the authors). *Bottom right*: Giunta Pisano's *Crucifix*. (Source: Authors).

it as his principal residence during his lifetime: from a transit church, dependent on a Benedictine abbey and situated along a secondary connecting route to the first official seat of the Order of Friars Minor; from the place of death of a man renowned in life for his sanctity to a pilgrimage route leading to the procurement of the plenary indulgence of the *Perdono*; from the central convent of the Franciscan Observance reform initiated by Paoluccio Trinci to the principal Marian sanctuary in the Umbrian Valley¹⁵.

The symbolic centrality of the Porziuncola led to its depiction in several paintings illustrating

key events in the life of Saint Francis and the origin and evolution of the Franciscan Order. These works furnish precious evidence about the site's condition at the time of their creation, offering an effective visual account of its evolution over the centuries¹⁶. The accuracy of the architectural representations in these paintings appears to reinforce the narrative's credibility through the placement of the scene within a setting more familiar to the observer¹⁷.

The only image of the ancient appearance of the Porziuncola is found in the twenty-second scene of the fresco cycle of the *Stories of Saint*

¹⁵ LUNGI 2019, p. 193.

¹⁶ BERTOCCHI 2024, p. 64.

¹⁷ *Ibid.*, pp. 61-62.

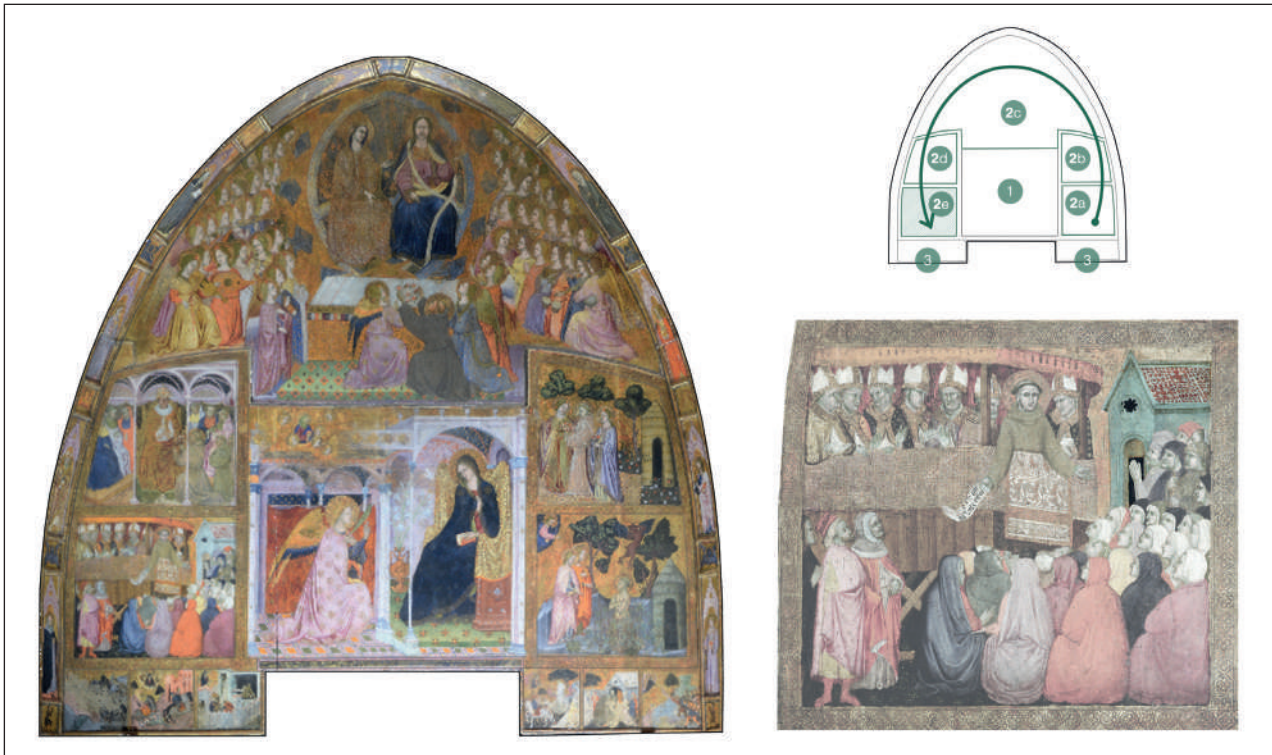


Fig. 5. *Left*: Orthomosaic obtained from SfM photogrammetry of the altarpiece by Ilario da Viterbo. (Elaboration by the authors). *Top right*: Graphic representation of the layout of the altarpiece's iconographic programme: 1. *Annunciation, Indulgence of the Porziuncola*; 2a. *Saint Francis penitent visited by the angels*; 2b. *The angels guide Saint Francis to the Porziuncola*; 2c. *Christ, through the intercession of the Virgin, appears to Saint Francis*; 2d. *Saint Francis asks Honorius III to approve the indulgence*; 2e. *Saint Francis proclaims the indulgence at the Porziuncola*; 3. Six miraculous episodes. (Elaboration by the authors). *Bottom right*: Close-up of the last episode extracted from the orthomosaic. (Elaboration by the authors).

Francis attributed to Giotto and his workshop and executed in the last decade of the thirteenth century in the Upper Church of Assisi (fig. 4). This scene depicts the verification of the stigmata on the saint's body, which, according to the chronicles and the inscription below the painting¹⁸, took place at the Porziuncola. The fresco cycle in the Upper Church represents a revolutionary moment in architectural representation, as the architectural elements contained in the painted scenes evolve from being purely conventional to reproducing at least a semblance of reality. The scene of the *Verification of the stigmata* is set inside a church equipped with a transverse beam, atop which three panels are displayed, a *Crucifix*, a *Madonna and*

Child, and a cut-out painted panel of Saint Michael the Archangel; behind this carefully curated display, an apse vault is visible, devoid of both windows and mural paintings.

The restorations carried out after the 1997 earthquake and the temporary removal of the altarpiece revealed the apse wall, which featured three windows that were likely walled up in 1485 to accommodate the choir behind¹⁹. Studies of the plaster layers previously mentioned uncovered sockets in the side walls, where a beam once rested supporting a panel painting, probably the *Crucifix* by Giunta Pisano²⁰, now housed in the Museo della Porziuncola²¹. Therefore, Giotto's painting depicting the interior of the Porziuncola appears plausible but not perfectly

¹⁸ The inscription below the painting reads «Alla Porziuncola, dove il beato Francesco giaceva morto, messer Girolamo, celebre dottore e letterato, con le sue proprie mani muoveva i chiodi e frugava le mani, i piedi e il fianco del Santo» (ZANARDI 1996, pp. 293-301).

¹⁹ LUNGH 2012, p. 140.

²⁰ SPERANDIO 2001, pp. 59-110.

²¹ Regarding the presence of these painted images within the Porziuncola, Elvio Lunghi (2008) notes that the presence of an image of the Virgin is attested by the episode of Saint Clare's



Fig. 6. *Top left*: Episode of the *Proclamation of the indulgence at the Porziuncola*, painted by Tiberio d'Assisi in the Chapel of the Roses in Montefalco. (Source: Authors). *Bottom left*: Plan of the vault of the Porziuncola obtained through integrated digital survey, showing the opening that allowed sound to reach people on the upper level. (Elaboration by the authors). *Right*: Archaeological stratigraphy around the Porziuncola (Source: Romanini 1989; Belardi, Menchetelli, Cotana 2024) compared with the buildings depicted in the fresco painted by Tiberio d'Assisi in the Chapel of the Roses at Santa Maria degli Angeli: 1. Porziuncola; 2. Choir of the lay people; 3. Choir of Saint Bernardino; 4. Wall of the convent; 5. Wall of the Sacrament Chapel; 6. Foundations of the portico. (Elaboration by the authors).

accurate to the architectural reality of the site. The artist captures and reproduces some characteristic and, in some instances, symbolic elements, sufficient to render the scene recognisable to its audience. On Ilario da Viterbo's 1393 altarpiece, located in the same space, a second significant representation of the Porziuncola may be identified (fig. 5). The altarpiece consists of two large panels joined with dovetail joints, both framed by a splayed moulding that perfectly fits the profile of the vault. The iconographic programme comprises three dis-

tinct, significant events related to Santa Maria degli Angeli: at the centre, the Annunciation; counter-clockwise around it, five key episodes of the *Perdono di Assisi*; and in the lower part, several scenes connected to the Assumption of the Virgin. The final scene of the *Perdono* episodes takes place in front of a small church visible in the background on the right, which is recognisable as the Porziuncola. Here, it is depicted as an isolated chapel built in white stone, with a portal on the main façade and a lobed oculus. What makes it identifiable is its roof,

conversion, during which Francis cut her hair at the altar of the Madonna. The presence of a crucifix is attested by Francis' own

words in his final testament.

portrayed as covered in white and red marble tiles forming geometric patterns²². Within the current complex of Santa Maria degli Angeli, the Chapel of the Roses is located apart from the other buildings adjoining the basilica. Composed of two rooms covered by lowered barrel vaults, the chapel is entirely frescoed by Tiberio d'Assisi. The scenes, completed in 1516, follow, as in the case of the previously described altarpiece, the narrative by Michele da Spello and sequentially depict five episodes leading to the miracle of the roses and the proclamation of the indulgence (*fig. 6*). The Assisi frescoes were modelled on a cycle executed a few years earlier by the same artist in the Chapel of the Roses at the convent of San Fortunato in Montefalco²³. The principal difference between the two cycles lies in the depiction of the Porziuncola. In the cycle at Santa Maria degli Angeli, the building is likely represented with greater realism based on its appearance at the time the work was painted. Although its state of preservation does not allow for a complete analysis, the Porziuncola is shown as a standalone building flanked by a grove of cypress trees, probably referencing the friars' cemetery. In these Assisi frescoes, many structures appear to have been attached to the Porziuncola; more precisely, to the right of the representation, there is a building with a white-and-pink striped façade, characteristic of convents in Assisi during the early Franciscan period, corresponding to the convent of the first friars. This façade is decorated with a large fresco, probably by Nicolò Alunno²⁴. Also of importance is the depiction of a loggia above the Porziuncola, furnished with a coffered ceiling supported by bichrome columns. The construction discernible behind the chapel could be the choir built in 1485 at the behest of Saint Bernardino of Siena. On the left, one may also see the structure that Egidio Giusto, who conducted a study of the sanctuary's ancient topography, identified as the Chapel of the Blessed Sacrament²⁵. Lastly, it is essential to highlight the presence of the frescoes painted by Francesco Providoni on the lunettes of the cloister of Santa Maria degli Angeli, i.e., a cycle depicting scenes from the life of Saint Francis unequivocally set at the Porziuncola, commissioned by the community of friars and executed in the final decades of the seventeenth century²⁶.

4. METHODOLOGY OF THE PRESENT PROJECT

During the initial phases of the project, the team undertook historical research aimed at providing an overview of the context within which the Observant movement developed. They deemed the relationship between this context and the architectural and artistic output of the movement to be crucial, not only for understanding its broader framework, but also for examining the history of the individual case studies.

The first part of the research, therefore, focused on both the collection and critical analysis of existing literature and a preliminary review of archival sources. This was intended to investigate events directly related to the buildings' construction, restoration, or demolition phases, as well as issues relating to changes in ownership, donations of property and works of art, suppressions, and confiscations of assets. The aim was to establish a research methodology for the study of the evolution of the convents under examination, their organisation through the centuries, and their relationship with the local territory and culture – an approach that would also complement and be integrated with *in situ* architectural surveys.

In the specific case of the Porziuncola, local religious archives were consulted. The next phase of the research employed integrated digital survey techniques to generate 3D point clouds and textured mesh models. These were processed to produce both two-dimensional and three-dimensional representations of the architectural structures and their surrounding landscapes at varying scales of detail. The methodologies used during the data acquisition, processing, and post-production stages are well established, both within the research group and at an international level, in the field of Cultural Heritage digitisation.

4.1 Data Gathering

The digitisation of the papal basilica complex was carried out in two data acquisition campaigns: in February 2021, the exterior and interior spaces of the basilica – including the Porziuncola

²² LUNGI 2008, p. 260.

²³ FERRETTI 2024, pp. 247-260.

²⁴ LUNGI 2019, p. 150.

²⁵ GIUSTO 1917, pp. 316-318.

²⁶ LUNGI 2019, p. 135.

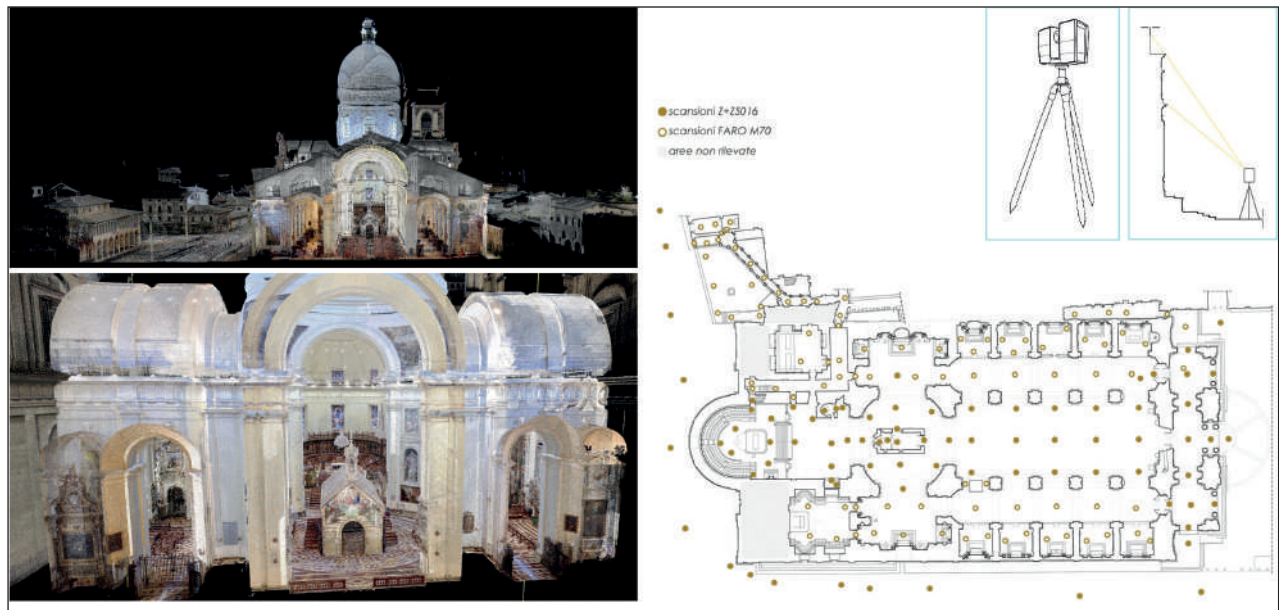


Fig. 7. *Left*: Images of the point cloud of the basilica and the Porziuncola. (Elaboration by C. Cerbai). *Right*: Schematic representation of the operation of the laser instrument and plan with laser stations. (Elaboration by C. Cerbai).

– were digitised, while, in March 2022, the roof spaces and part of the basilica’s roof covering were surveyed. For the digital surveys, both LIDAR instruments, such as laser scanners, and photographic equipment, such as drones and digital cameras, were employed, enabling the acquisition of accurate measurements and data on surface textures and colours relating to both the interior and exterior spaces of the buildings and to the surrounding context.

Through post-production and interpretation of these data, it is possible to produce technical drawings (such as plans, elevations, and sections of the buildings) at varying scales of detail, as well as navigable three-dimensional models. These outputs are essential for carrying out in-depth analyses of the architecture, its features, and its state of conservation. Furthermore, a detailed study of the architectural stratigraphy of each individual conventual complex can be cross-referenced with bibliographic and archival sources related to that particular case study, either confirming or challenging their reliability.

4.1.1 Laser scanner

The laser-scanner survey operations required careful planning of the on-site workflow to ensure

the acquisition of a non-redundant yet comprehensive dataset capable of accurately describing the architectural structures in their entirety, thereby allowing for graphic outputs at a scale of 1:50. During the processing phase, the survey was certified with a maximum section misalignment tolerance of ± 1.50 centimetres. Two laser-scanning instruments were used: the Z+F Imager 5016 was employed to survey the exterior areas of the basilica, the nave, the Porziuncola, the choir, and the roof spaces; while the Faro Focus M70 was used for the side aisles, the Baroque chapels, and the spaces extending from the sacristy to the Chapel of the Roses (fig. 7). Both instruments are phase-shift laser scanners equipped with an integrated camera for RGB data acquisition, but they differ in range.

Specifically, a total of about 300 scans were carried out to document the interior and exterior spaces of the Porziuncola.

4.1.2 Photogrammetric Survey with SfM (Structure from Motion) Technique

Alongside the laser-scanner survey, photographic acquisitions were carried out both at ground level and from elevated positions. A digital camera Canon EOS 760D was used for the former, while a DJI Mini 2 drone and a DJI Osmo Pocket

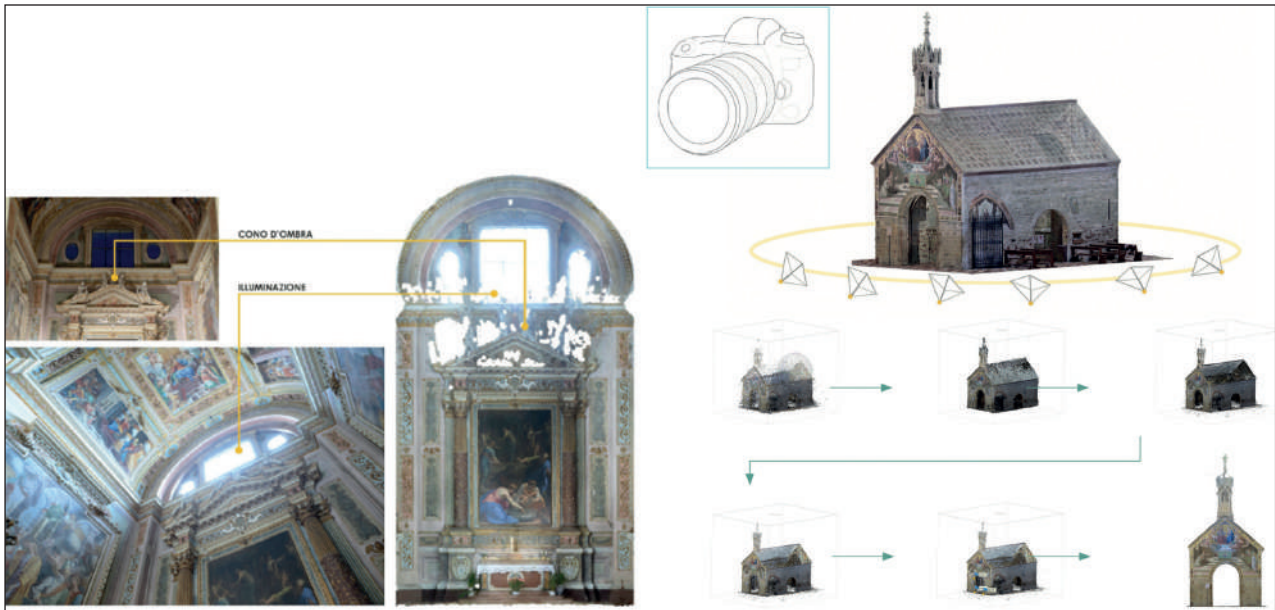


Fig. 8. *Left*: Example of a non-post-processed orthomosaic obtained from SfM photogrammetry. (Elaboration by C. Cerbai). *Top right*: Schematic representation of shooting stations. (Elaboration by C. Cerbai). *Bottom right*: Processing of photogrammetric data, from sparse point cloud to textured 3D mesh model. (Elaboration by C. Cerbai).

with an extension stick were employed for the latter. In order to achieve high-quality results, the photographs used for photogrammetry with the Structure from Motion (SfM) technique needed to be free of harsh shadows and correctly exposed, allowing the use of appropriate camera settings (low ISO, wide aperture, short exposure time). As the decision was made to use only natural light, the outdoor photographic campaigns were scheduled during times of day with the most favourable lighting conditions (fig. 8).

For the interior spaces, image acquisition was carried out exclusively using digital cameras mounted on tripods, which enabled exposure times while maintaining acceptable ISO and aperture settings.

The aim was to acquire detailed data on the colour and surface texture of the church walls, with particular attention paid to decorative elements such as the altarpiece and the façade fresco, while also ensuring sufficient photographic coverage of the roof and lantern.

4.2 Data Elaboration and Output

The acquired data were initially processed separately and, where necessary, integrated during a

second phase. The scans obtained from the laser-scanner survey were cleaned of superfluous data and registered into a single point cloud using Leica Cyclone software. The photographs were catalogued according to the environment in which they were taken and imported into Agisoft Metashape, where each set was processed to generate 3D mesh models.

These models were georeferenced based on the laser-scanner point cloud to ensure consistent scale and spatial orientation. The point cloud, providing reliable metric data, was also used to produce dimensioned two-dimensional drawings at various scales of detail, including plans, sections, elevations, and axonometric views of the Porziuncola.

From the mesh models, orthomosaics of the architectural façades were generated – namely, orthorectified images of the wall surfaces. These images were used in combination with the point cloud data to enrich the technical drawings with information on the colour and texture of the wall surfaces. This allowed for the definition, through architectural representation, of a comprehensive set of metric and morphological data for the analysis of the Porziuncola and the conventual complex in which it is situated (e.g., analysis of wall stratigraphy and construction phases).

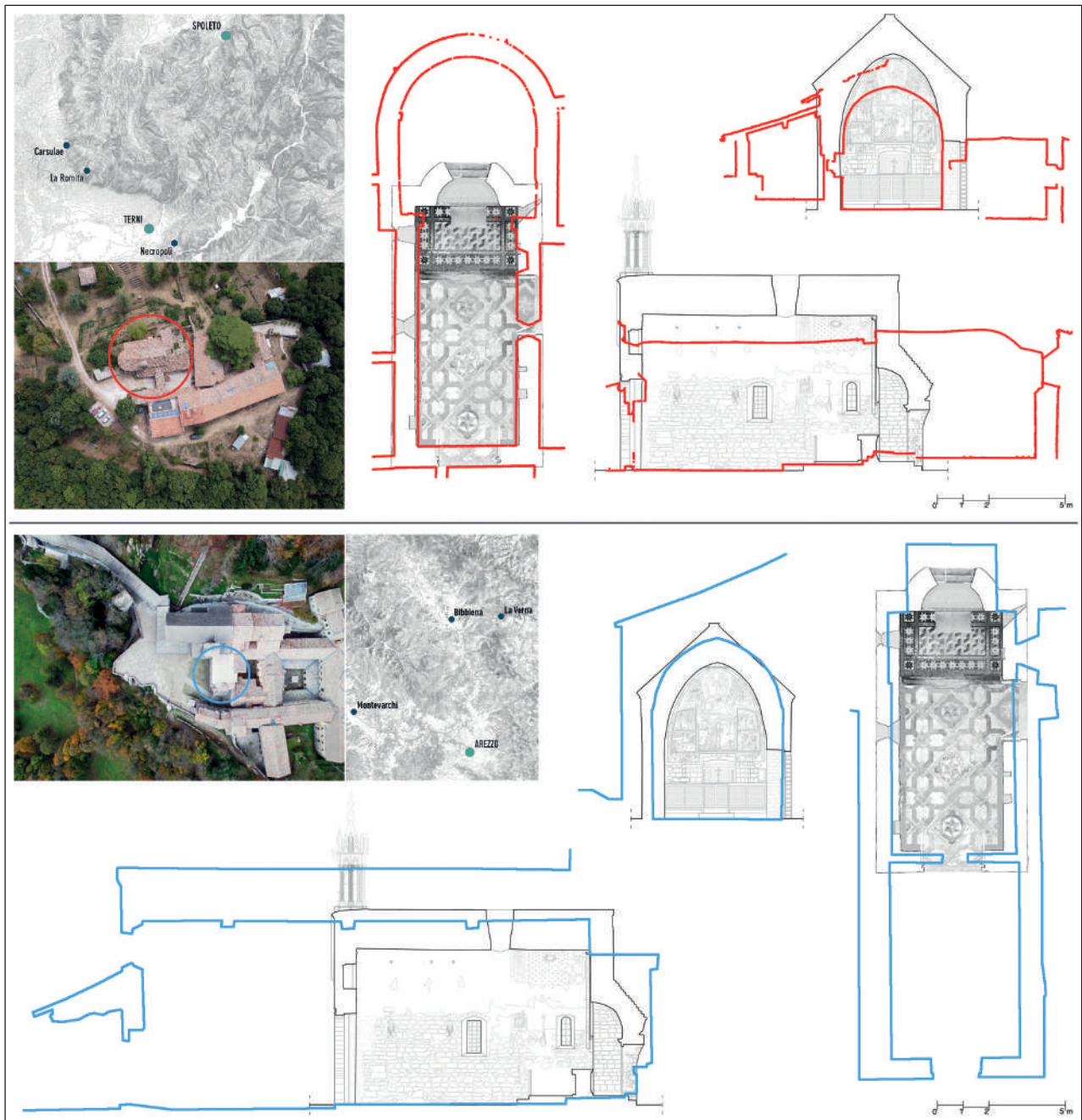


Fig. 9. *Top*: Superimposed laser-scanner surveys of the Porziuncola (in black and white) and the SS. Annunziata at La Romita (red outlines). (Elaboration by A. Cottini). *Bottom*: Superimposed laser-scanner surveys of the Porziuncola (in black and white) and the church of Santa Maria degli Angeli at La Verna (blue outlines). The scales of the buildings have been normalised to emphasise the similarity of proportions. (Elaboration by A. Cottini).

5. COMPARISONS WITH CONTEMPORARY CHURCHES

The data collected during the survey of the church of the Porziuncola were compared with those obtained from the digital survey of two Franciscan places of worship: the convent of La Romita

in Cesi (TR), Umbria, and La Verna Sanctuary in Chiusi della Verna (AR), Tuscany.

La Romita is a historically significant conventual complex, as it is one of the oratories granted to Paoluccio Trinci in 1373, later suppressed in 1866, and rediscovered in 1991 by Friar Bernardino²⁷. As

²⁷ DI GIAMPAOLO 2013, pp. 58-60.

far as the convent's origins are concerned, the archivist Rossi²⁸ reconstructed the historical events suggesting that Saint Francis stayed there on several occasions, starting in 1213. Moreover, the *poverello* is said to have built a simple shelter, using only wood and clay, next to a Benedictine hermitage founded on the site between the seventh and ninth centuries in honour of Saints Volusian and Proculus. He also requested the construction of a church dedicated to the SS. Annunziata, with the same proportions as the Porziuncola in Assisi²⁹. This church was restored through the reconstruction work carried out by Friar Bernardino from 1991 onwards³⁰.

La Verna Sanctuary originated as a site of pagan worship, and historical sources attest to the presence of Saint Francis in the woods and caves surrounding the *Sasso Spicco*, at the foot of which cells and an oratory were built around 1220³¹. In the second half of the thirteenth century, the complex developed into two main nuclei, one centred around the original church of Santa Maria degli Angeli and the other around the Chapel of the Stigmata³². Subsequent extensions and restorations were carried out over the following centuries, leading to its present configuration³³.

Fig. 9 shows the superimposition of two laser-scanner surveys: the b/w images represent the Porziuncola, the red outlines correspond to the church of the SS. Annunziata at La Romita, while the blue outlines are those of the church of Santa Maria degli Angeli (1250-1252) at La Verna (the buildings' scales are normalised). This comparison highlights the remarkable similarity in the original proportions and dimensions of the three buildings, despite the later addition of the apse to the church of the SS. Annunziata and of the frontal extension and cladding of the lateral front of the church of Santa Maria degli Angeli. Moreover, the two churches under comparison still preserve their barrel vaults, which could reasonably be interpreted as analogous to the one that originally existed in the Porziuncola³⁴.

6. CONCLUSIONS

In conclusion, it can be affirmed that the integration of digital survey techniques with the analysis

of iconographic, bibliographic, and archival sources represents a solid methodological foundation for the study of historic buildings. The literature shows that the combined use of laser scanning and SfM photogrammetry has become an established practice in the documentation of Cultural Heritage, offering accurate metric data and realistic textures. It is also important to highlight that the critical analysis of sources (photographs, drawings, documents) is an essential element in validating and enhancing the interpretation of digital models.

The resulting research database – comprising heterogeneous and continuously updatable data – is valuable for historical investigation and meets the needs of both structural and conservation diagnostics, as well as cultural enhancement and dissemination.

From an operational standpoint, the integration of metric point clouds and photogrammetric orthomosaics allows the generation of navigable two-dimensional and three-dimensional representations, which are essential tools for structural analysis, monitoring, and non-invasive restoration³⁵. For instance, organisations such as CyArk and the Zamani Project have demonstrated that precise and accessible digital documentation of cultural sites is crucial for the conservation and dissemination of heritage³⁶.

Finally, the metric reliability of the collected data is fundamental for conducting architectural analyses based on real measurements, as demonstrated by the comparisons described in Section 5. It contributes to the validation of historical sources, the dimensional, proportional, and typological comparison of buildings, and supports rigorous decision-making in relation to restoration, structural monitoring, and heritage valorisation.

BIBLIOGRAPHY

BELARDI, MENCHETELLI, COTANA 2024 = P. BELARDI, V. MENCHETELLI, F. COTANA, *Repara domum meam. The Basilica of Santa Maria degli Angeli in Assisi as an Example of Sustainability ante litteram*, in S. Bertocci, F. Cioli (eds.), *Franciscan Landscapes: Conservation, Protection and Use of Religious Cultural Heritage in the Digital Era*, I, Florence 2024, pp. 65-75.

²⁸ ROSSI 2022.

²⁹ *Ibid.*

³⁰ BERNARDINO 2020.

³¹ SALVESTRINI, VANNINI 2024, p. 28.

³² *Ibid.*, p. 34.

³³ *Ibid.*, pp. 36-38; BERTOCCHI 2024, pp. 65-73.

³⁴ COTTINI, BECHERINI 2023.

³⁵ PARRINELLO, PICCHIO 2023.

³⁶ See <https://cyark.org> and <https://www.zamaniproject.org> [last accessed 4 January 2026].

- BERNARDINO 2020 = BERNARDINO (frate), *La Romita: utopia?*, Terni 2020.
- BERTOCCI 2024 = S. BERTOCCI, *Una storia per immagini: l'iconografia dell'insediamento francescano della Verna*, in S. Bertocci, A. Guarducci (eds.), *Il convento della Verna. Storia, architettura e arte francescana*, Florence 2024, pp. 61-75.
- BORDINI, BRIZZI, FERRETTI 2021 = E. BORDINI, S. BRIZZI, R. FERRETTI, *Analisi preliminari per la documentazione del santuario del Beato Antonio Vici a Stroncone: il contributo del rilievo digitale e della termografia*, in C. Bellanca, S. Mora Alonso-Muñoyerro (eds.), *Atti del IX convegno internazionale ReUso*, Conference proceedings (Rome, 2021), Rome 2021, pp. 382-393.
- CANONICI 1989 = L. CANONICI, *Documenti e ricordi dei secoli prealesiani*, in F.F. Mancini, A. Scotti (eds.), *La basilica di Santa Maria degli Angeli presso Assisi*, I, Perugia 1989, pp. 17-34.
- Compendio storico* 1834 = *Compendio storico del Perdonò di Assisi e della chiesa detta Porziuncola*, Assisi 1834.
- COTTINI, BECHERINI 2023 = A. COTTINI, P. BECHERINI, *Integrated Investigation Methodologies for Architectural Heritage Conservation and Promotion: La Romita di Cesi (TR), Umbria, Italy*, in *VITRUVIO - International Journal of Architecture Technology and Sustainability*, VIII (Special Issue), 2023, pp. 84-93.
- DI GIAMPAOLO 2013 = F. DI GIAMPAOLO, *Pietre che parlano. Conventi chiusi e conventi aperti della Provincia Serafica di San Francesco*, Assisi 2013, pp. 58-60.
- FERRETTI 2024 = R. FERRETTI, *Integrated Digital Survey Techniques for the Documentation of the Artistic Heritage of the Franciscan Observance: The Pictorial Cycle of the Indulgence of Porziuncola by Tiberio d'Assisi*, in S. Bertocci, F. Cioli (eds.), *Franciscan Landscapes: Conservation, Protection and Use of Religious Cultural Heritage in the Digital Era*, I, Florence 2024, pp. 247-260.
- Fonti Francescane* 2004 = *Fonti Francescane. Nuova edizione*, ed. by E. Caroli, Padova 2004.
- GIUSTO 1917 = E.M. GIUSTO, *Topografia dell'antica chiesa e dell'antico convento della Porziuncola*, Assisi 1917.
- LUNGHİ 2008 = E. LUNGHİ, *I dipinti della Porziuncola come fonte storica*, in P. Messa (ed.), *San Francesco e la Porziuncola. Dalla «chiesa piccola e povera» alla basilica di Santa Maria degli Angeli*, Conference proceedings (Assisi, 2007), Perugia 2008, pp. 249-268.
- LUNGHİ 2012 = E. LUNGHİ, *Le prime immagini della Verna*, in N. Baldini (ed.), *Altro monte non ha più santo il mondo. Storia, architettura ed arte alla Verna delle origini al primo Quattrocento*, Conference proceedings (Arezzo, 2011), Florence 2012, pp. 139-142.
- LUNGHİ 2019 = E. LUNGHİ, *Immagini degli spirituali. Il significato delle immagini nelle chiese francescane di Assisi*, Foligno 2019.
- NICOLINI 1989 = U. NICOLINI, *La Porziuncola: una particella di mondo per san Francesco*, in F.F. Mancini, A. Scotti (eds.), *La basilica di Santa Maria degli Angeli presso Assisi*, I, Perugia 1989, pp. 35-52.
- PARRINELLO, PICCHIO 2023 = S. PARRINELLO, F. PICCHIO, *Digital Strategies to Enhance Cultural Heritage Routes: From Integrated Survey to Digital Twins of Different European Architectural Scenarios*, in *Drones*, VII, 9, 2023.
- ROMANINI 1989 = A.M. ROMANINI, *“Reliquiae” e documenti: i luoghi del culto francescano nella basilica di Santa Maria degli Angeli presso Assisi*, in F.F. Mancini, A. Scotti (eds.), *La basilica di Santa Maria degli Angeli presso Assisi*, I, Perugia 1989, pp. 53-88.
- ROSSI 2022 = P. ROSSI, *L'eremo di frate Francesco. L'Eremita degli Arnolfi comunemente detto Eremo di Cesi/Portaria (Terni)*, Terni 2022.
- SPERANDIO 2001 = D. SPERANDIO, *Il restauro della Santa Cappella della Porziuncola in Santa Maria degli Angeli*, in V. Garibaldi (ed.), *I lunedì della Galleria. Grandi restauri in Umbria*, Perugia 2001, pp. 59-110.
- ZANARDI 1996 = B. ZANARDI, *Il cantiere di Giotto. Le storie di San Francesco ad Assisi*, Milan 1996.