



View from the chapel of Santa Barbara of the Sant Miquel d'Escornalbou complex.

The Monastery of Sant Miquel d'Escornalbou: multidisciplinary research for the understanding of the relation between the religious complex, the territory and the European Franciscan network

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Abstract: This research is part of the European project F-ATLAS – Franciscan Landscapes the Observance between Italy, Portugal and Spain, which aim is to study the Franciscan Observance network and to find effective strategies for the conservation, protection and promotion of this important heritage. The contribution is focused on the multidisciplinary study of the Monastery of Sant Miquel d'Escornalbou (Tarragona, Spain). The historical, architectural and patrimonial research on this last and interesting centre of medieval spirituality has been developed jointly by the Italian and Spanish teams of the project. From its foundation until the last reconstruction by Eduard Toda around 1910, the complex's function and shape have changed significantly: during the centuries, several interventions have modified it to the point of making it difficult today to read its origin and evolutionary phases. The integrated laser-scanner and photogrammetric survey, together with the creation of a digital catalogue of geo-referenced convents and the results of the international workshop carried out in November 2021, represent the bases for further analysis regarding the evolutionary phases of the complex, the buildings' structure conditions and the definition of possible strategies for redevelopment.

Keywords: religious architecture; GIS; digital survey; cultural heritage; F-ATLAS Franciscan Landscapes.

1. Introduction

This work is part of the wide-ranging European project “Franciscan Landscapes. The observance between Italy, Portugal and Spain”, known as F-ATLAS (<https://www.f-atlas.eu/>). The project is coordinated by the University of Florence, with the co-participation of the University of Barcelona, the Portuguese Catholic University and the University of Lisbon (ISCTE-IUL). This partnership has made it possible to articulate a network of work around the legacy of Observant Franciscanism in Europe (Bertocci, 2020). F-ATLAS project, which started in July 2020 (end June 2023), aims to develop methodologies, protocols and tools for the management and enhancement of cultural heritage in the digital era and to define a strategy of documentation and knowledge for conservation, protection, reuse, and promotion which consider tangible, intangible, and digital heritage (Bertocci *et al.*, 2023). The Franciscan Observance is a reforming movement started in Italy during the second half of the XIV century. It advocated a return to the origins of St. Francis: a more substantial “observance” in the fulfilment of the rule in its precepts of poverty, austerity and obedience in contrast to the distention in which many of the mendicant centres had fallen. To get away from the city’s hustle, the movement promoted the construction of many monasteries in rural areas that had been abandoned for a long time and now threatened to collapse and disappear. Our project aims to significantly contribute to the promotion and study of the rich legacy of the Franciscan Observance in Europe, paying particular attention to its architectural heritage. With this purpose, the University of Barcelona team has catalogued and geo-referenced with GIS a total of 640 Observant convents documented in the territory of current Spain. This work has allowed mapping the implementation process of the Observance from the first foundations – of the end of the XIV century – until the exclaustation of the middle XIX century. The study of this large number of geo-referenced data allowed discerning the existence of several models of monastic implantation (Soler *et al.* 2021) (Fig. 1): the Observant foundation convents (among which the four proto-observant convents of the custody of Aragon stand out: San Francisco de Chelva, Nuestra Señora de los Ángeles de Manzanera, Santo Espíritu del Monte de Gilet and Santa María de los Ángeles de Segorbe), the convents linked to the “cura monialium” of the feminine communities (is the case of the “conventet” of Pedralbes in Barcelona) and the convents which origin is not related to the Observant order. Within this last model stands out, for its monumentality and rich history, the case of Sant Miquel d’Escornalbou (Baix Camp, Tarragona).

The historical, architectural and patrimonial study of this last and interesting centre of medieval spirituality

has been developed jointly by the Italian and Spanish teams of the project. This contribution is focused on the preliminary results of the shared research carried out in Sant Miquel d’Escornalbou (Baix Camp, Tarragona), which constitutes an unusual example of interdisciplinary work among historians, architects, and landscape analysts, making use of ICTs in the study and enhancement of architectural and historical heritage.

2. The monastery of Sant Miquel d’Escornalbou

The monastic complex of Sant Miquel is located within the municipality of Riudecanyes (Baix Camp, Tarragona) and on the mountain of Escornalbou, situated in the eastern spur of Sierra de l’Armentera (Fig. 2). Its construction is related to the donation made by King Alfonso el Castro to the canon Joan de Sant Boi in 1170 of the Andalusian origin castle located in this place with a fourfold mission: restore the fortress, repopulate the surrounding territory, build a church dedicated to St. Michael and establish an Augustinian canonical (Font i Rius, 1969-83).

Converted into the barony of Escornalbou, the canonical imposed its jurisdictional dominion over a vast territory, from which were collected the necessary censuses for its sustenance. Since the XIV century, the community entered a long period of turbulence, which affected both the maintenance of the buildings and the configuration of an increasingly small community, which in 1574 had just one canonic (Bolòs *et al.*, 1995). Thus, at the time of the rise of the Franciscan reform in Europe, the bishop of Tarragona gave the place to the Franciscan Recollects first (1580) and later to the Observants (1686), who knew how to establish an enduring community in this place. Subsequently, the convent also became a Franciscan school specialised in the formation of missionaries: in this way, it survived until its exclaustation in 1835. From the original monastic building, only a few structures have been well preserved: the Romanesque church of Sant Miquel and a part of the cloister, as well as the al chapter house, located in the east wing of the cloister and the sacristy, adjacent to the apse of the church (Bolòs, *et al.*, 1995). The characteristic red stoneware in all the buildings shows a constructive unity that we must date between the late XII century and the beginning of the XIII century. The monastic complex also has a set of caves and hermitages connected through the path known as the “walk of the friars”, which offered the monks both a physical and spiritual path, whose transit allowed them to develop an inner search, meditative and individual. This double spacial configuration – the main buildings and the caves or hermitages – is analogous to other Observant monasteries of medieval and modern

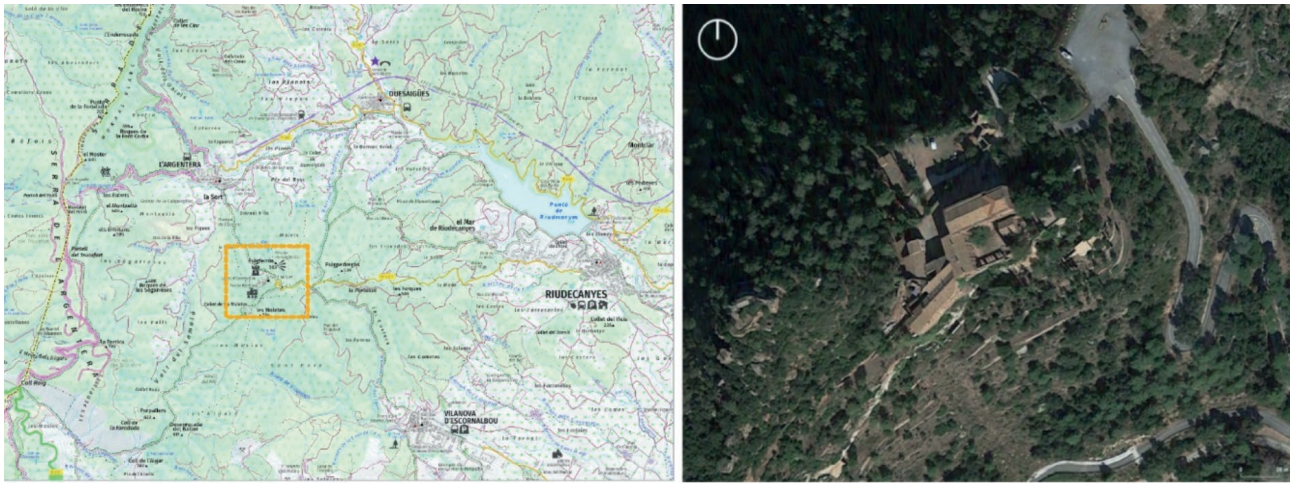


Figure 1 | Models of observant implantations in the Crown of Aragn (14th-16th centuries).

times, such as the convents of San Francesco de Chelva (Valencia, Spain) or San Vivaldo (Tuscany, Italy) (Soler *et al.*, 2022). In the case of Sant Miquel d'Escornalbou, the path leads to the chapel of Santa Barbara, located at the highest point of the mountain, although its construction dates from the XIX century. All the characteristics of this monastery, in the framework of an exceptional place which establishes a direct dialogue with nature and the forest, are an excellent ally in the Observant will of spiritual isolation.

The current appearance of the monastery of Sant Miquel d'Escornalbou is due to the diplomat and egyptologist Eduard Toda (1855-1941), who invested a part of his fortune in buying this place. The monastery was, in fact, restored and transformed into a residence, gathering inside a rich library, furniture and other collections that are still partially preserved. The traces of the long process explained up to here have marked the composition of the current buildings. Nowadays is not easy to

distinguish between medieval and modern stages and the events of the last contemporary centuries, including Toda's restoration (or, rather, reconstruction). In the development of his project, the diplomat was moved more by his romantic fascination for the exoticism of the medieval world than by the intention to recover the shapes of the original buildings, turning the place into a fantasy castle and away from its medieval architectural structure (Bolòs, *et al.*, 1995). It was at this time that the church's bell tower was destroyed, and the medieval cloister, which was in terrible condition, was dismantled piece by piece to be converted into a garden, and part of the construction was used as a spectacular overlooking to the countryside of Tarragona. Undoubtedly, this reconstructive process makes the historical and architectural analysis of the place extremely difficult. Since 1983, the complex of Escornalbou has been owned by the Diputació of Tarragona and the Generalitat de Catalunya, which manage the wealth of heritage of the place and allow the public to visit the monument.



Sant Miquel d'Escornalbou
Riudecanyes (Baix Camp, Tarragona)
UTM: 41.12736, 0.91585



Figure 2 | Location of the Monastery of Sant Miquel d'Escornalbou (Baix Camp, Tarragona).

3. Digital Survey and documentation

In November 2021, a digital survey campaign was carried out to obtain complete documentation of the monastery of Sant Miquel d'Escornalbou. The campaign included the integration of different methodologies, such as the laser-scanner survey, with the use of Lidar devices (Light Detection and Ranging) as terrestrial laser scanners, and the SfM (Structure from Motion) photogrammetric survey, which involved the use of photographic devices such as digital cameras and drones. This integrated survey methodology, previously applied to other case studies related to the F-ATLAS project (Cioli *et al.*, 2021), has allowed obtaining complete and reliable documentation regarding the metric and morphologic aspects and the component linked to the chromatic data, which is essential for carrying out analyses related to the conservation

status. Simultaneously to the survey campaign, took place an international workshop *in situ*. It was organised jointly by the University of Florence and the University of Barcelona as part of the F-ATLAS project. The eight students who attended the workshop were responsible for the photographic acquisitions, the subsequent processing phase and the development of two-dimensional drawings. The purpose of the documentation campaign was to create two-dimensional drawings (1:50) compatible with traditional representation techniques and necessary to develop the subsequent analyses and investigations provided by the project. The direct analysis of the structures, the visualisation of the planimetric developments through the graphic reconstruction of two-dimensional drawings – such as plans, elevations and sections – together with the analysis of the wall stratigraphies, allows to reconstruct the evolutionary

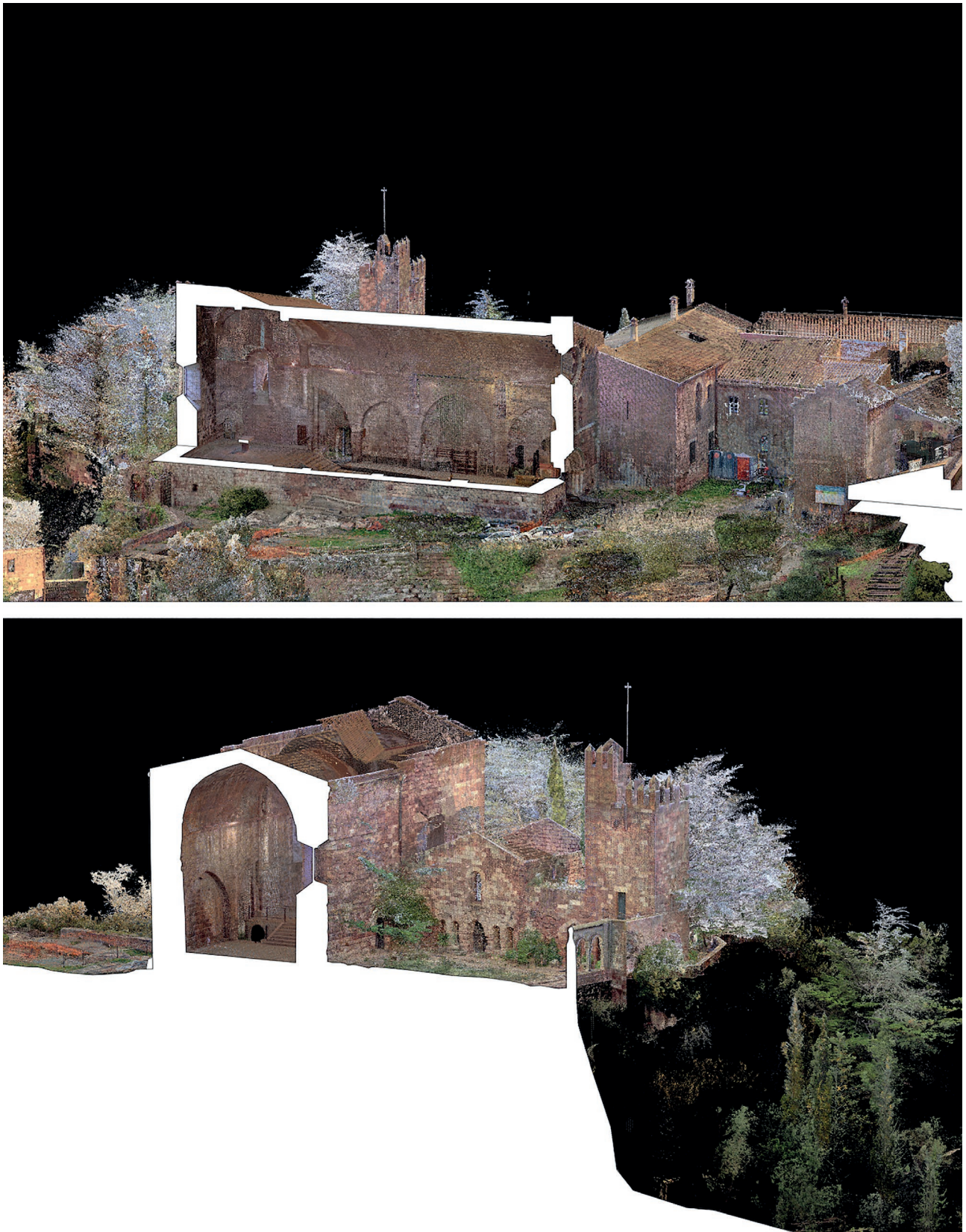


Figure 3 | Perspective views of the complex obtained by setting section planes within the 3D point cloud.



Figure 4 | Planimetric view extract from the point cloud: in red are shown the positions of the single scans made to obtain complete documentation of the monastic complex.

phases of the buildings (Amonaci, 1997) and the research the typological and architectural characteristics of the original nucleus, even if, as in this case, the building has been subject to consistent adjustments and modifications. This integrated and multidisciplinary investigation methodology allows the creation of a digital database for the knowledge of monastic complexes and their enhancement, obtaining an adequate representation of their complexity.

3.1 Laser-scanner survey

The laser scanner survey aims to obtain an overall image of the architectural building under examination with reliable metric data. For surveying operations have been used a Z+F imager 5016 laser scanner: a maximum range of 360m makes it particularly suitable for surveying architecture such as the one in question, where it was essential to acquire data related not only to the architectural component but also to the territorial context in which it is inserted. The presence of an integrated HDR camera allows the acquisition of metric and chromatic data simultaneously. The laser scanner captures photos with

different exposures and generates the final HDR image. It is also equipped with LED spotlights that allow acquiring the colour data even in particularly dark environments such as the crypt. The colour data is then superimposed on metric one to obtain a highly descriptive coloured point cloud (Fig. 3).

Due to the complexity of the monastery, it was necessary to carry out a series of successive scans carefully positioned to compensate for the not visible areas. During the survey campaign were carried out 140 scans designed to ensure the closure of a fundamental polygonal, which allows better control of the error (Fig. 4). Subsequently, the scans were joined two by two by roto-translation operations to obtain an overall point cloud. During the survey campaign, it was impossible to access all the areas of the complex because some restoration works were in progress. The documentation has mainly concerned the external facades, the church, the crypt, the sacristy and its connecting areas, the cloister and the chapter house. The integration between laser scanner survey and photogrammetric drone survey made it possible to compensate for the lack of data, particularly in the



Figure 5 | A photogrammetric model of the crypt (above) and of the church's portal (down). The acquisition schemes underline the different acquisition modes according to the object to be documented.



Figure 6 | Photogrammetric model processing steps: 1. Sparse point cloud; 2. Dense point cloud; 3. Mesh; 4. Texture (acquisition and elaboration credits: Pietro Becherini).

southeast elevation, which is not accessible with terrestrial instruments because of the dense vegetation and the considerable altitude difference between the building and the path that runs along the monastery on that front.

3.2 Photogrammetric survey

Simultaneously to the laser scanner survey campaign, a Structure from Motion (SfM) photogrammetric survey campaign has been carried out, both terrestrial and high-altitude, through the shooting of a series of specific, consecutive and suitably overlapping images. The acquisition campaign was organised in different detail scales going from general to particular. For the close-range photogrammetric acquisition, were used digital cameras, particularly a Canon 1100D with an 18-55 lens and a Nikon D610 with a 12-24mm lens. Each set of photos has been designed in relation to the characteristics and the complexity of the object to be documented, considering the light conditions at the time of the campaign, regarding which the camera parameters and the acquisition mode have been calibrated. The photos were shot in sequence, always keeping a minimum margin of overlap between contiguous frames of 50% (Pancani *et al.*, 2022).

The photographs were then processed through photo modelling software (in particular Agisoft Metashape), thus obtaining three-dimensional textured models of individual surfaces or spaces (Fig. 5). The models obtained can be subject to surface noise or gaps due to the lighting conditions, the presence of vegetation or the morphology of the building itself, which can make the acquisition phase difficult.

Survey operations on a broad scale have been carried out through a UAV (Unmanned Aerial Vehicle), particularly a DJI Mavic Mini equipped with an integrated camera. The high-altitude photogrammetric survey made possible the documentation of components that would not have been possible to acquire from the ground, such as roof covering and southeast facade. The photogrammetric acquisition from a drone requires shooting photographs at variable heights and different inclinations according to the morphological characteristics of the environment to be detected, the territorial context in which it is inserted, and the specific characteristics of the device used for the survey operations and desired level of detail. Also, in this case, capturing photos with a reasonable overlap between subsequent shots was necessary. Planning the

flights to acquire the photographs is fundamental for the survey's success. In the specific case of the high-altitude photogrammetric survey campaign carried out at the monastery of Sant Miquel d'Escornalbou, the high number of photographs acquired and processed allowed a detailed photogrammetric model.

The model obtained represents an essential basis for extracting multiple graphic elaborations helpful in analysing the architectural environment in which it is inserted (Fig. 6).

4. Architectural analysis and representation

As evidenced by the evolutionary history of the complex, the Monastery of Sant Miquel d'Escornalbou has undergone several architectural transformations over the centuries. From its foundation until 1910, when Eduard Toda began the last reconstruction, its function and shape have changed significantly. The interventions, especially those of the twentieth century, have strongly modified its image, making it difficult to read its origin and evolutionary phases. The current state of conservation shows few original elements, many of which result from the critical restoration carried out in the early twentieth century. Among these, we find the church, the cloister, and the chapter house, the main subjects of the digital survey and representation work. The digital survey activities aim to develop technical drawings, i.e., plans, sections, and elevations (Fig. 7). The drawings represent the morphological bases for further analysis of the complex's evolutionary phases and the buildings' structural conditions. The architectural representation – with adequate detail for the investigations, 1:50 – ensure the description of all the external and internal surfaces of the church, the cloister, and the adjoining rooms (Fig. 8). The reliability of the 3D point cloud model is crucial for diagnostic analysis, especially those related to the axially of masonries.

After the registration of the scans by visual alignment, the model was sectioned through horizontal and vertical planes to check that the misalignment of the section lines was less than 1 cm (Bigongiari, 2017). After verifying the model reliability, the point cloud was sectioned through orthogonal plans to export high-resolution orthographic images for redrawing in CAD by interpreting the data through a wireframe representation. The morphological survey was finally integrated with the colour data obtained from the Structure from Motion procedures through the creation of 3D mesh models calibrated on the point cloud, from which it was possible to export the textures helpful in describing the material aspects and the conservation conditions of the surfaces.

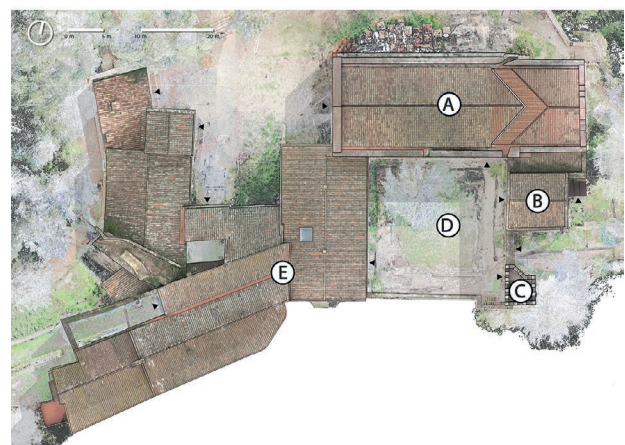


Figure 7 | Aerial images of the complex acquired by Drone DJI Mini (credits: Pietro Becherini). On the right: a general plan of the complex with the indication of the main rooms: A- church of Sant Miquel; B- Chapter room; C- South Tower; D- Cloister; E- Manor house. Below: south-east elevation with orthophoture.



Figure 8 | Images of the complex from the chapel and picture of the chapel.



Figure 9 | Images of the cloister.

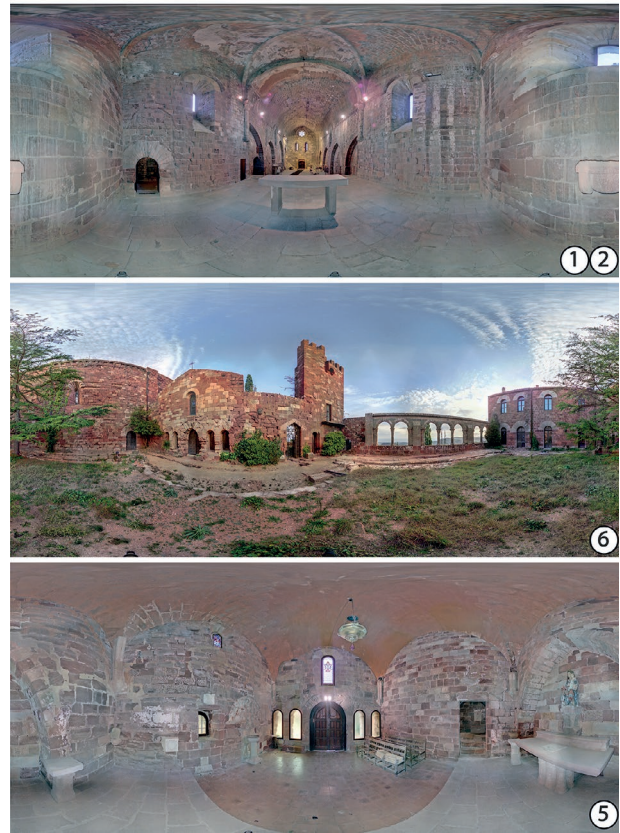
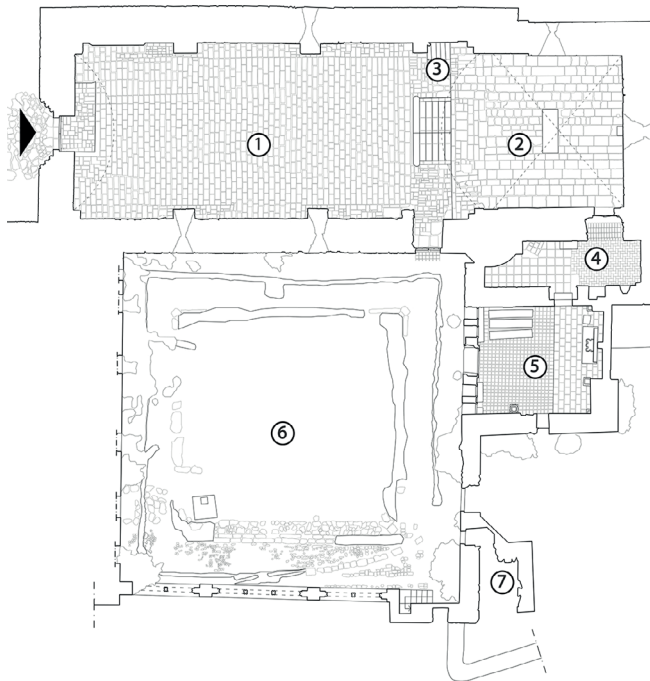


Figure 10 | Wireframe drawings of the plan of the analyzed part and spherical images of the three main rooms. 1. Nave of the Church of San Miquel; 2. Presbytery; 3. Entrance to the crypt; 4. Sacristy; 5. Chapter Hall; 6. Cloister; 7. South Tower.

4.1 Architectural and functional description

The entrance to the monastery consists of a double portal inserted in the layout of the ancient walls. A path leads to the access patio, a junction between the church and the convent. The church of Sant Miquel has a monumental Romanesque portal with a triple round arch supported by columns. The nave is marked along the longitudinal walls by a series of ogival arches of different sizes and heights that support the set of the vault. This internal structure is not clamped to the external masonry, and the last arch on both sides is cut in key, suggesting a different construction period. The presbytery has a raised floor with a central access staircase that allows the opening of two openings on the sides for the descent to the crypt. The right opening is now closed, and the dismantled staircase trace remains evident in the internal masonry of the crypt.

The crypt has three bays, the external two with barrel vaulting and the central one with a slightly ogival barrel vault, and the flooring has a slight slope with water drainage channels. A staircase connects the crypt to a

church's backyard and the south tower. The large quadrangular cloister to the church's south, which has almost completely disappeared, is evident through the signs of the arches on the original walls of the chapter house. The south side of the cloister presents a series of arches that frame the valley's panoramic view. The chapter house, with a square plan and cross vaulting, is located east of the cloister and is separated from the church by an elongated sacristy. The entrance consists of a round arch flanked by two pairs of windows, and the masonry clearly shows the effects of wind erosion. On the west side of the cloister, the imposing manor house of Toda stands where the convent rooms were initially supposed to be; some hermit cells are still visible in the path surrounding the mountain, characterized by the presence of natural caves and votive chapels.

4.2 Preliminary analyzes

The digital survey aims to understand the evolutionary phases, the state of conservation of the buildings, the interpretation of the parts to be preserved and the development of intervention guidelines (Minutoli, 2017). The

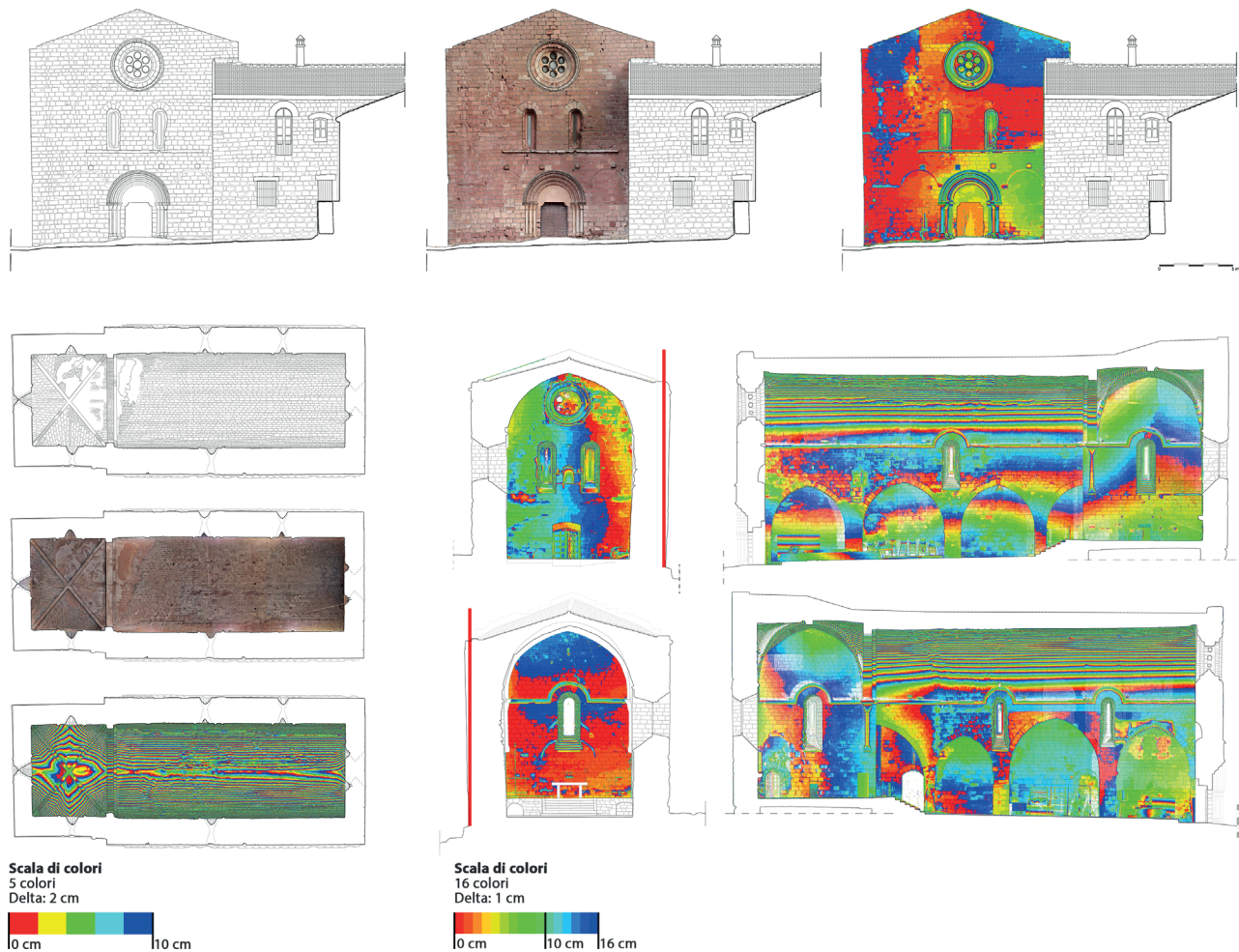


Figure 11 | Wireframe drawings, orthoimages and elevation map to analyse the axiality of the walls and vaults. The elevations and sections were analysed in 16 colours and a range of 1 cm. The vaults were analysed in five colours and a range of 2 cm.

accuracy of the drawings in describing the walls and vaulted structures is essential to check walls axiality and the presence of deformations and to interpret and understand the state of conservation of the complex (Bertocci, 2015). From the sections, significant damages are evident in the perimeter walls of the church of San Miquel, also visible in the counter-façade, strongly characterized by the presence of injuries due to the overturning of the northern wall. The detailed analysis of the deformation maps (elevation map), extracted directly from the point clouds, aims to verify the out-of-plumb and to check the geometry of the vaults and the masonries that support them (Fig. 9) (Bigongiari *et al.*, 2020). The elevation map allows us to quantify the rotation concerning the axiality of the facade of the church's north wall, apparently more affected by the deformations, which is about 30 cm out-of-plumb. The masonry has a constructive discontinuity at

the base using courses of white stone of different origins. Furthermore, from an archive photo of the early twentieth century, a full-height side chapel is visible on this side of the church. The construction involved opening one of the internal arches, also verified thanks to the thermographic survey in the field. It is not clear if this chapel was built as a buttress to reinforce subsidence already in progress or if its massive construction has somehow altered the foundation system, causing the masonry to overturn. Given the four walls' critical instability, the nave's vaults and the presbytery were also verified. It was possible to investigate whether the curvatures of the vaulted structures followed a regular geometry using the deformation maps as contour lines. This analysis did not reveal any critical irregularities, except in the ceiling parts recently restored, suggesting that the deformations in the vaults were fixed with the construction of the new roof.

5. Conclusions

The F-ATLAS project aims at developing new cultural itineraries starting from the existing routes and the data acquired during the digital survey campaign and archival research, exploiting cultural and sustainable tourism systems. These itineraries exploit the advantages of digital technologies to create a network between Italy, Spain and Portugal, which connects the places of the Franciscan Observance from a cultural, historical and landscape point of view. Based on the in-depth analysis, the Monastery of San Miguel d'Escornalbou shows three possible levels of redevelopment. First, the complete restoration of the caves and the museumisation of the route, characterised by the agricultural system, the water sources, and the surrounding boundary walls. The second intervention strategy focuses on the church of San Miquel, which, adequately consolidated, can be re-functionalized and become an auditorium or a space dedicated to exhibitions. The cloister can be rebuilt with pergolas and temporary structures that help communicate its original image without impacting the original structure. The third level is that of the manor house, heavily altered by the restorations and reconstructions during the twentieth century, which can host a museum system to rediscover the history of the settlement and its link with the territory and the surroundings. The recent recovery of the ancient "Camino de los Frailes", which connects the

monastic building with the caves and the chapel located at the highest point of the Escornalbou mountain, highlights the strong relationship of the monastery with the rural context. We are therefore faced with an exceptional landscape capable of establishing a direct dialogue with nature and the forest, great allies in the observant desire for spiritual isolation. The strong relationship of the monument with the surrounding rural environment reinforces the attraction of the place for the public interested in discovering new natural spaces with heritage interest, relatively far from the city (Tarragona, Reus) but still close enough to encourage a visit.

Acknowledgments

Paragraphs 1 and 2 were written by Maria Soler. Paragraph 3 was written by Roberta Ferretti. Paragraph 4 and 5 was written by Federico Cioli.

The project F-ATLAS is funded by JPI Cultural Heritage which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 6995237 (<https://www.f-atlas.eu>). The consortium is composed of 4 principal investigators: the University of Florence (PI Stefano Bertocci), the University Institute of Lisboa (PI Soraya Genin), the University of Barcelona (PI Maria Soler Sala), and the Portuguese Catholic University of Lisbon (PI Maria Filomena Andrade).

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