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SfM Photogrammetric Techniques Applied in the Building Archaeology Works of the Old Cloister of the Monastery of San Francisco from the 16th Century (Cazalla de la Sierra, Seville)

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Abstract: The cloister from the old monastery of San Francisco (Cazalla de la Sierra, Seville) has been suffering a series of remodeling transformations from its original construction in the 16th century to the current day. Thus, a study of building archaeology needed to be accomplished by using photogrammetric techniques by SfM (Structure from Motion) and laser scanning or TLS (Terrestrial Laser Scanning), which ensure the geometric exactitude and high resolution of the facings surveying. For that, over 500 images were taken for the 4 existing facings (about 78 lineal meters) from which a photogrammetric model was obtained of over 50 million polygons, as well as a cloud of over 40 million points from the laser scanning. It can be concluded that by using the techniques of SfM, the task of documenting, analyzing and studying the facings of the historical building in order to establish its evolutional process gains not only precision and exactitude but also opens the possibility to go further by obtaining products that are capable of helping us conserve, restore and protect the historical heritage, as well as generate the 3D virtualizations planned for the diffusion.

Keywords: building archaeology; photogrammetry; SfM; heritage; restoration

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1. Introduction

The current Municipal Food Market of Cazalla de la Sierra (Seville) (Figure 1) is located in a building whose history began at least as early as 1588, when the order of San Francisco, settled in Cazalla from 1493 in the old Monastery of San Jerónimo (current Hermitage of Carmen), decided to be relocated inside the walls of the city and build their new monastery in the block in which the monastery was located [1–3]. Although neither the exact date is clear nor the rhythm of edification of the new monastery, it would not be ludicrous to think that at least the main buildings would have already been built, especially the dependencies where the daily life would be developed and the cloister in which the aforesaid activity will revolve around.

The exact space that the Municipal Food Market reuses from this monastery of San Francisco is its cloister (Figure 1), in which, during the 10th century, modifications and reforms of the original building were realized, so as to adapt it to its new use. However, this cloister displays the footprint of other reforms and adaptations that it had had for previous uses that have taken place throughout its almost 450 years of history.

With this background and as part of the work of retrieving the cloister's original remains, an archaeological intervention took place to eliminate the current use as a market and all the elements added to the original building. For this task, the Ministry of Culture of Junta de Andalucía urged that a building archaeology study had to be carried out by the photogrammetric surveying of the different panels that the inside perimeter of the

Municipal Food Market was compounded by, so as to elucidate what was preserved in the old cloister of the Monastery of San Francisco and in what state these possible remains were.

Figure 1. Location of the Municipal Food Market of Cazalla de la Sierra and indoor sight, where the cloister of the monastery of San Francisco is located.

The works were carried out by combining the photogrammetry techniques SfM (Structure for Motion) [4,5] and the laser-scanning TLS (Terrestrial Laser Scanning) [6] with the purpose of generating a three-dimensional model (3D) of high resolution and geometric precision, from which it was possible to obtain scaled and georeferenced surveying from the four facings that the cloister was compounded by [7]. With these surveys, the wall face analysis and the study of its components [8] would be carried out, as well as the cartographic and planimetric outputs needed for documenting and justifying the explanatory proposal and the subsequent labors of restoration, conservation and elimination of the outside additions of the original building.

Broadly speaking, seven different phases can be determined, an aspect that will be more fully developed when we move into the description and explanation of the facings it is composed by, each of which has left its respective footprints, with some more visible than others, and some of them especially damaging in terms of what they have meant in terms of alteration concerning their initial appearance and irretrievable loss of those parts.

The phases referred to are the following:

1. Original building—construction of the original cloister: circa 1588;
2. First reform of the cloister—first remodeling encouraged by the construction of San Diego's Church attached to its flank W: from 1623 to 1716 (ending year);
3. Final reform of the cloister—second remodeling because of the addition of a porticoed gallery with arcades: during the 17th century (in this phase, a subphase can be identified, probably from the 18th century with light reforms);
4. Reforms during the Spanish confiscation period—third remodeling due to the fact of the Spanish confiscations and the implementation of a schnapps factory in its environment: from 1835 and during the rest of the 19th century.
5. First transformation for the Municipal Food Market's adequacy—reforms for the implantation of the municipal market: circa 1940;
6. Second transformation for the Municipal Food Market's adequacy—reforms for a new adequacy for the usage as a market: approximately in the last decade of the 20th century;

7. Current work—works on improving that were being carried out in the facings as of the date of the fieldwork for this study, July 2019.

2. Materials and Methods

2.1. Materials

The current Municipal Food Market is located in a building whose history begins at least as early as 1588, when the order of San Francisco, settled in Cazalla in 1493 in the old Monastery of San Jerónimo (the current Hermitage of Carmen), decided to be relocated inside the walls of the city and build a new monastery in the block in which the monastery was located [1–3].

We say at least from 1588 since that is the date in which the relocation from the old monastery of San Jerónimo to the new one of San Francisco took place; thus, it would be logical to think that at least the main buildings were already built, especially the dependencies where the daily life would be developed and the cloister around which the aforesaid activity would revolve.

The relocation to the town center was due to the ruin situation and the distancing from the parishioners that asked for the approximation of the monastery, as it was quite far from the population nucleus.

The new monastery was located beside some wineries in which tithes were recollected, and from that moment, it began a slow, but intense, urban transformation of the buildings on which the monastery was settled, as well as its immediate surrounding, reaching to occupy 15% of the total population area at that time.

The cloister, with a clear quadrangular layout, is currently formed by three facings of between 24 and 26.5 meters and a fourth, of which about 3 meters remains on each flank, where a double arcade was built to make this wall completely diaphanous, and where columns and capitals that were reused from earlier periods can be seen.

The concrete space of the market from this monastery of San Francisco is the cloister, which presents some modifications and reforms, so as to adapt it to its new usage, although it displays the footprint of previous reforms and adaptations for other usages that have taken place during its 405 years of history.

2.2. Methods

2.2.1. Coordinate System Implantation

Two pieces of GNSS equipment (GS18 and GS16) were used in order to place in the outdoor area of the market square a series of georeferenced coordinate points, in the UTM projection, in zone 30 and ETRS89 datum [9], established by the IGN (National Geographic Institute) and official for the Iberian Peninsula. These points have been marked with nails that will remain in place for future interventions (Figure 2); thus, those in the future will be able to work in the same coordinate system.

These absolute coordinate points will be useful so as to be able to georeference every point that will be taken inside the site.

Using a Leica's total station TCR705 [10], a free stationing was carried out, taking as reference the previously measured points with the GNSS, in particular those two which were visible from the inside of the site, located at the pavement from which the entrance to the market square is accessible (Figure 2). These points and the rest of the measured points in the work were taken by employing a mini prism (Leica's GMP111-0), except those points that were located on the surface of the walls to be measured that, because of being on top of a vertical plane, were signposted by adhesive paper targets; in this case, the TCR1705 was used in "red laser" measurement mode, modifying the measurement parameters in the equipment (Figure 2).

Figure 2. GNSS stationing, placing and measurement of permanent points inside and outside the cloister.

The geodetic topographic work would be completed by obtaining the following data:

- Points measured to generate the GNSS positioning network: 5 points, all outdoors;
- Points measured with the TCR705 inside the enclosure on the ground: 11 in total measured on mini prism;
- Points measured with the TCR705 on targets placed on the wall: 19 points, which would be used for adjustment in photogrammetry [11].
- Points measured with the TCR705 on scanner targets, GZT21 on a tripod pole: 7 points taken. [12].

It is necessary to adjust the point coordinates that were obtained during the measurement by the GNSS. For that, supporting data from the Andalusian Positioning Network (its abbreviation in Spanish of RAP) that belong to the Statistic and Cartography Institute of Andalusia (from its abbreviation in Spanish of IECA) we used, obtaining a sub-centimetric precision [13].

These data were loaded together with the GNSS data into the Leica Geo Office program to calculate the coordinates of the base point where the GS16 was placed and to obtain these coordinates with great precision.

With all of these points, different ASCII files were generated that were necessary so as to make adjustments to both the photogrammetric process and the process generated by TLS. A drawing file in DWG format was obtained with Civil 3D to check that all the obtained points were correctly located and to continue with the following processes.

2.2.2. Laser Scanner Method

With the laser scanner, 13 positions were performed in order to cover up the whole site. In one of them, the scanner registered three GZT21 targets [14] that were measured previously by using the total station in the coordinate system established for the whole surveying. Seven positions of targets were carried out to encompass the three walls that the work was composed of. Due to the high precision of the scanner (a Leica's P20), only two targets were needed to be measured from each scanner position, but in order to obtain better results, three targets were measured [15].

The total number of obtained points in the whole process was 40,461,333 points, generating with all of them a dense cloud of points in 3D with RGB colors [16] (Figure 3).

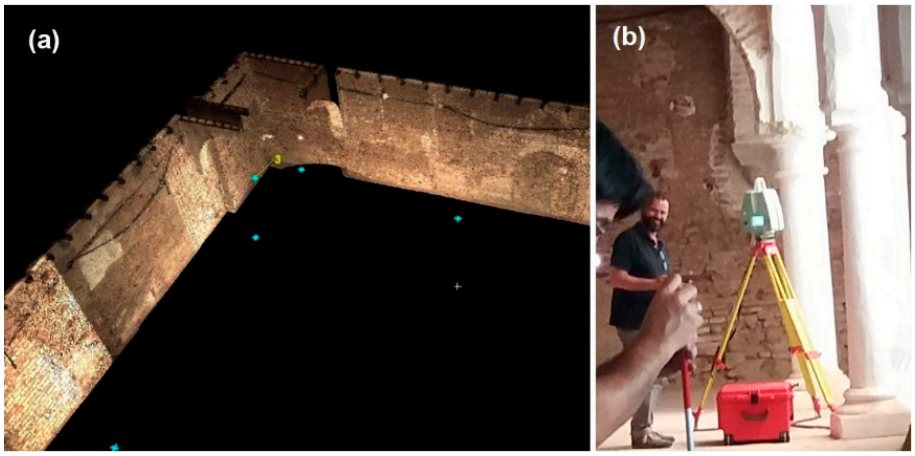

Figure 3. Dense cloud of points in 3D with RGB colors (**a**) and Scanner P20—Leica (**b**).

2.2.3. Photogrammetric Method

This method was carried out in two phases: images' acquisition and a subsequent processing of them [17].

In order to cover the first phase, and due to the location conditions—indoor areas with low natural light—it was necessary (to guarantee the luminosity conditions in the pictures acquisition) to use artificial light equipment consisting of four neutral light luminaires that were distributed and moved as the interior atrium progressed. The images were taken every 2–3 m (depending on the detail requirements of the area), with a coverage of 5–6 images at three heights.

Once the images' acquisition was over, the second phase consisted of the processing of the images, employing the Metashape program so as to generate a three-dimensional model (Figure 4) and, subsequently, obtaining a set of four orthophotos. These orthophotos are the ones that were taken as a base for the realization of the wall face study from the archaeological point of view.

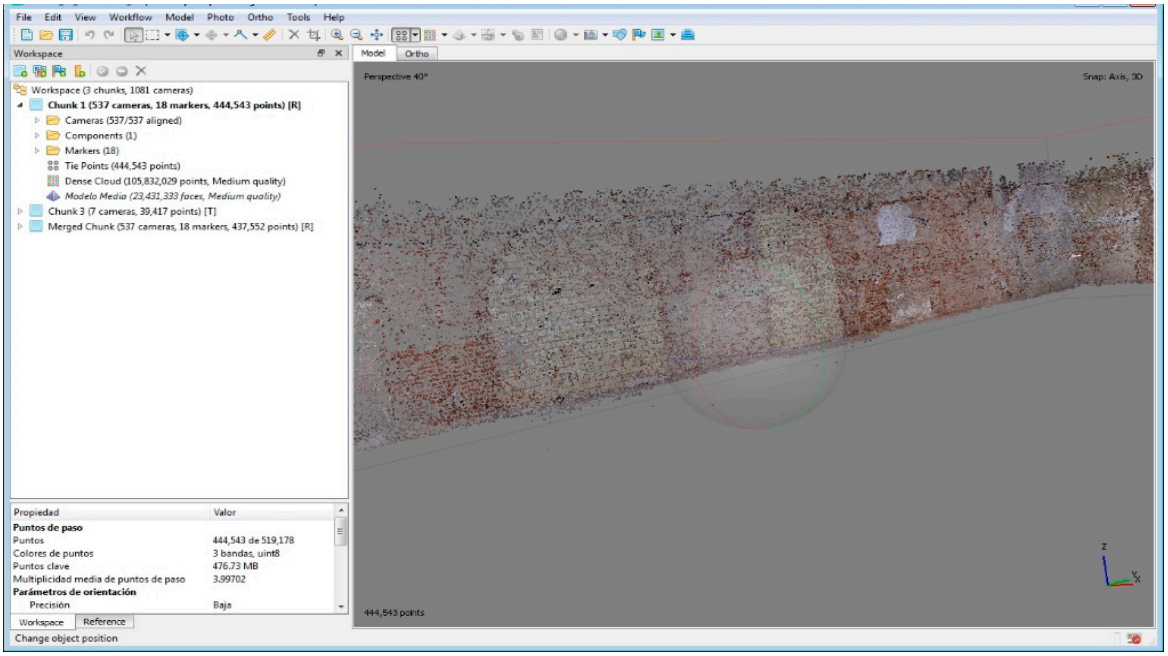

Figure 4. Processing of pictures in Metashape.

For the correct execution and dimensioning of the model, the same targets that were established in the walls were used, as measured both by scanning and by total station; however, they were ultimately removed so that each area could be photographed to obtain the real texture of these parts of the walls without the appearance of elements that are foreign to the object of study.

In the first phase, 537 pictures were acquired.

During the second phase, different tests were performed, obtaining the optimum result with a "dense cloud of points" of 108 million points [18] (Figure 5a).

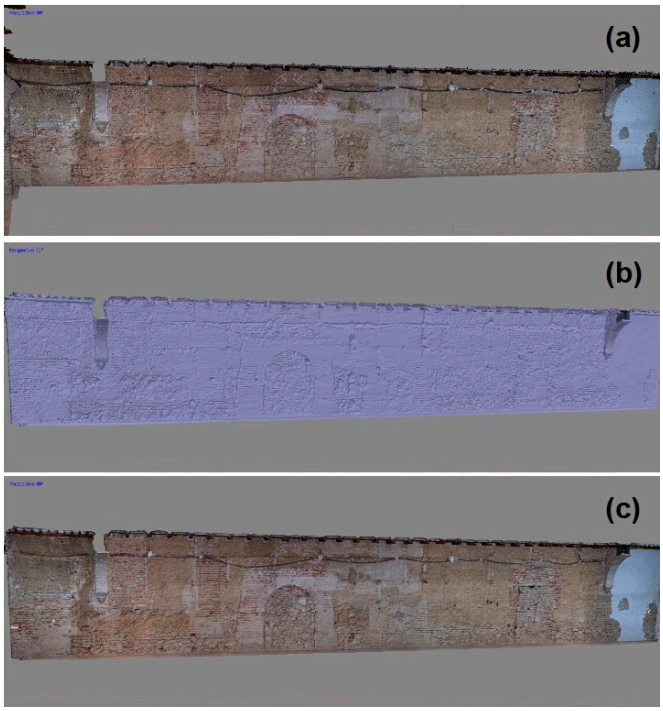

Figure 5. Wall 2 (cloister's N panel): (**a**) dense cloud of points, (**b**) solid mesh and (**c**) texturized mesh.

2.2.4. TLS Results and Photogrammetry

Conducting a comparison of the obtained results with the different methods [19,20], the following can be observed:

- With the TLS technique, more than 40,000,000 points were obtained. All of them are part of a dense cloud of points in 3D and with RGB (Red–Green–Blue) (Figure 3a). The cloud of points is the result of the union of several scanning taken from different positions and that are integrated into a single geometry thanks to the field measurement of the HDS targets that were previously surveyed with the total station. After making the register process, employing Leica's CYCLONE program and integrating the partial clouds of points, a joint cloud was obtained, scaled and precisely georeferenced.
- With the photogrammetry technique, a dense cloud of points of more than 108,000,000 points was obtained, as well as a 3D mesh of more than 21,000,000 polygons (Figure 5b,c).

With this methodology, we can consider a low-cost technique; thus, the results obtained are excellent for obtaining 3D heritage modeling. [21,22]

2.3. Wall Face Analysis

In the archaeological analysis and comprehension of the buildings, the principles of stratigraphy, as defined by E.C. Harris [23], later improved and completed by A. Carandini [24] regarding the buildings' studies, are a key when establishing topologic relations of the facings and its parts, as well as the establishment of a method of a systematized data collection.

Based on approaches by Harris and Carandini, from the 1990s onwards, a whole series of works and methodological proposals emerged, headed by the *Archeologia dell'architettura*, a term that was coined by T. Mannoni [25], describing the accumulated experience in Italy during the previous decade [26–30], and which was followed by many others developed all over Europe: the *Archéologie du bâtio* or *Archéologie des élévations* in France [31–33], the *Bauforschung* in Germany [34,35], or the *Ar-chaeology of Buildings* or *Building Archaeology* in Great Britain [36–38].

Spain currently has one of the best exponents of archaeology of the architecture in the System of Archaeological Analysis of Historical Buildings developed by M.A. Tabales [39–42] and launched in several real estates of Seville, among them, the Reales Alcázares [43], to which we can add the work of L. Caballero Zoreda, one of the precursors of building rehabilitation studies [44,45], or that of the Conservation Service of the Barcelona's Deputation [46–50].

The analysis carried out on the facings of the cloister of San Francisco attempted to combine three fundamental principles for this type of work on emerging archaeological structures:

- The concept of transformation of the structure, i.e., of the changes, added and modifications that, at an archaeological level, had occurred, which model variations in the uses;
- The concept of archaeological sequence occurred over itself, understanding this as the evolution that the structure displays through the documented stratigraphic sequence, defined by each of the identifiable elements in the building structure and its spatiotemporal arrangement, from its construction until the present time or until its definitive amortization.;
- The concept of a historical process—that goes further from its physical nature and that requires its environment—refers to both the level of the edification and the historical moment in which each structure or its parts are framed.

A systematic strategy was carried out by the application of a series of consecutive and interrelated procedures, because the development and the partial result of one help in the execution of the following one, which is described below:

2.3.1. Building Components Definition

This process was about the observation of the surveying generated in the photogrammetric procedure so as to identify and map all and each of the components that had a function or that represented similar characteristics, e.g., facings, hollows and their consecutive closures, pathed by reforms, etc.

The contours of the principal components were accurately mapped, and the secondary components were simplified. Moreover, the interior of the units (masonry, fills and walling) was limited to a more schematic mapping, which was only carried out in detail when they presented particular characteristics of interest.

2.3.2. Assignation of Materials to the Components

Once all the components were delimited, these elements were classified into a typology of masonry materials, e.g., masonry, rammed earth, stone, brick, etc. This classification helped in the determination of different moments for components that, at first glance, appeared to be similar.

2.3.3. Establishment of Usage and Components' Function

Based on the acquired experience up until this point, regarding the delimitation of components and material of their composition, we proceeded to establish the different uses and functions that each of them had to have in their historical moment to which they were ascribed, taking into account the whole building and its general articulation, as well.

2.3.4. Ascription to the Phases of the Archaeological Sequence Observed

Depending on the topological relationships of the different components; on the similarity or equality; and, in some cases, on the factory materials and its physical and formal characteristics, we established the archaeological sequence that would allow order them in a temporal and sequential logic. For this, we relied on the Harris matrix generated for each facing in particular and all of them in general.

2.3.5. Determination of Phases and Historical Contexts

In a process of accumulated knowledge throughout the different phases of the procedure that were developed before and having as a result of the temporal logic of the archaeological sequence established in the previous step, the correct adscription of each component with a phase and historical context was derived.

Some gaps have remained in this part of the study that cannot be resolved with just a wall face analysis of the building; it will be necessary to deepen its study with a series of archaeological soundings in the sub-floor.

For the determination of the historical contexts, it was necessary to go beyond the limit of the concrete space of the cloister, so as to attempt to understand the totality of the monastery and to be able to accurately match the final proposals of the evolution of the building in general and the cloister in particular.

3. Results

The analyzed facings (Figure 6) were numbered for their correct identification, moving clockwise, starting from the most W point.

Figure 6. Localization and numeration of the studied walls panels: 1 west wall, 2 north wall, 3 east wall, 4 south wall.

The results that we display are given according to each phase that was documented after the wall face analysis, without going into describing and commenting on each individual facing separately. So as to have more information and details about the results of each particular facing, we refer the reader to the supplementary documentation that joins this article in which the results are developed in detail.

The photogrammetric method allowed us to obtain four orthophotos generated from an X–Z or Y–Z view, both the front view and back view, as appropriate for the spatial

location of each facing (Figure 7). Thus, the final photogrammetric product that we used to perform our analysis was the surveys of the four facings studied.

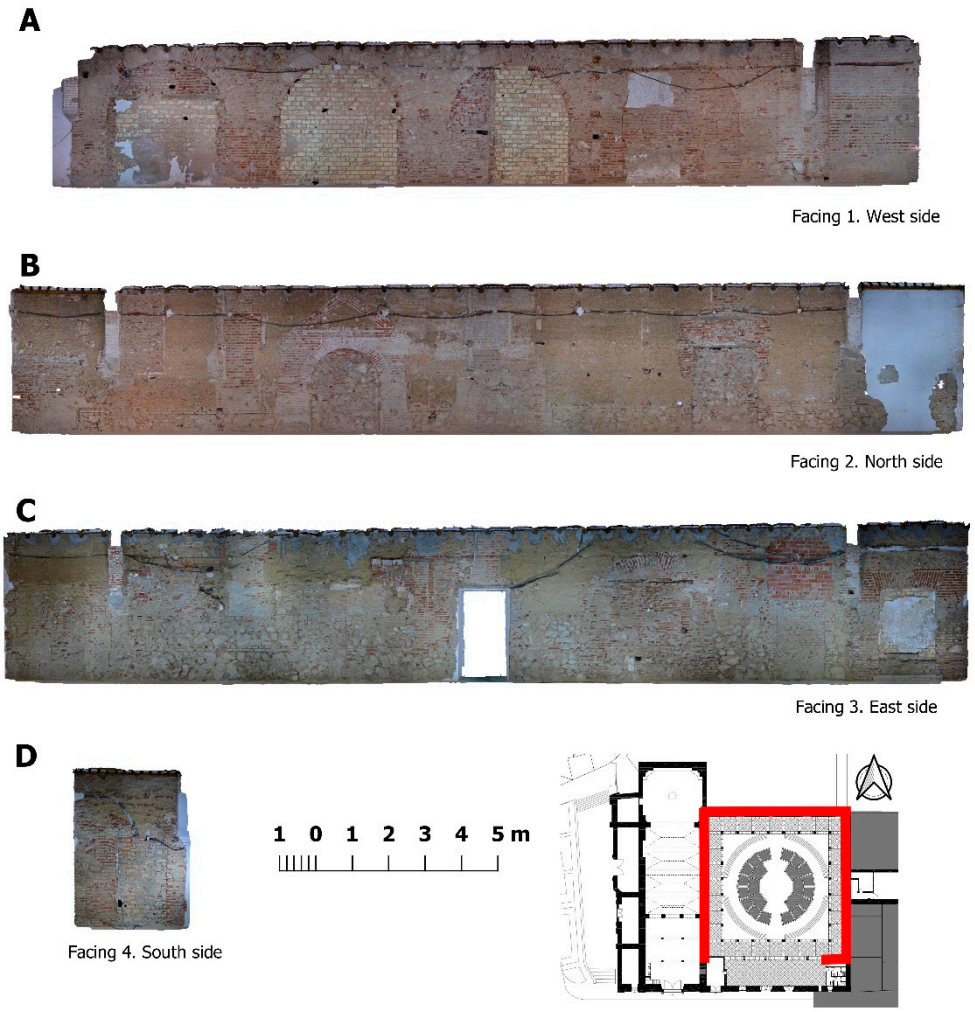

Figure 7. Facing's orthophotos: (**A**) west wall, (**B**) north wall, (**C**) east wall, (**D**) south wall.

The obtained surveys by photogrammetry have paved the way for the delimitation of the building components, making it possible to map them with high precision since the surveys resolved 1 mm (Figure 8).

With that high resolution, the assignation of materials and the establishment of the usage and components fiction (Figure 9) were relatively easy; they were carried out by the combination of the orthophoto visualizations, visual inspection in situ and the field data taken during the process of chipping the faces of the facings.

Finally, the determination of the chronological phases, embodied by a color system over the orthophotos, allows us to observe the chrono-stratigraphic evolution of the facings (Figure 10).

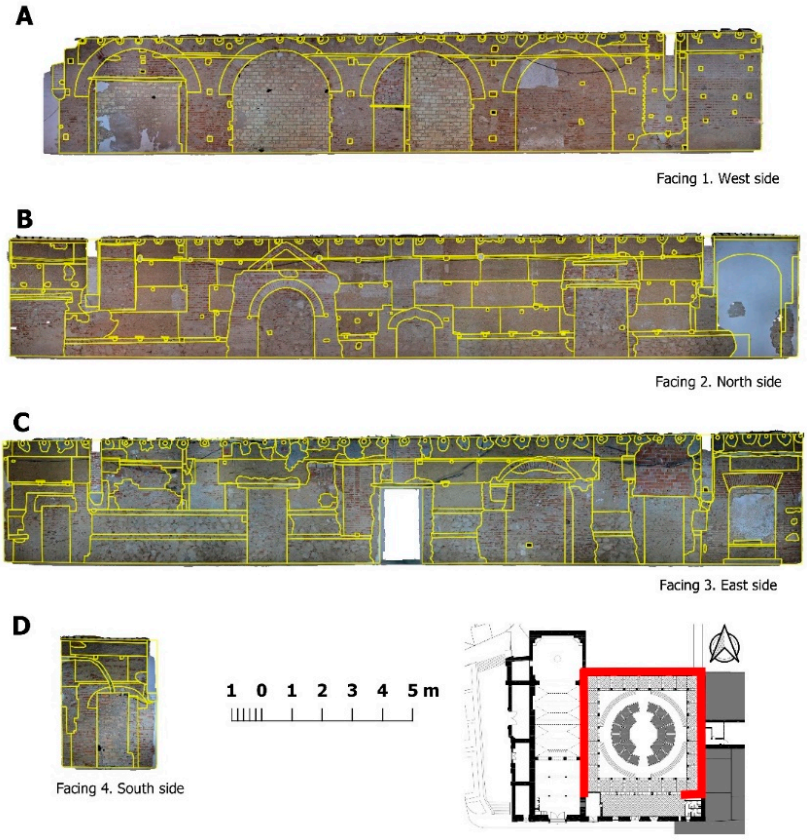

Figure 8. Documented building components: (**A**) west wall, (**B**) north wall, (**C**) east wall, (**D**) south wall.

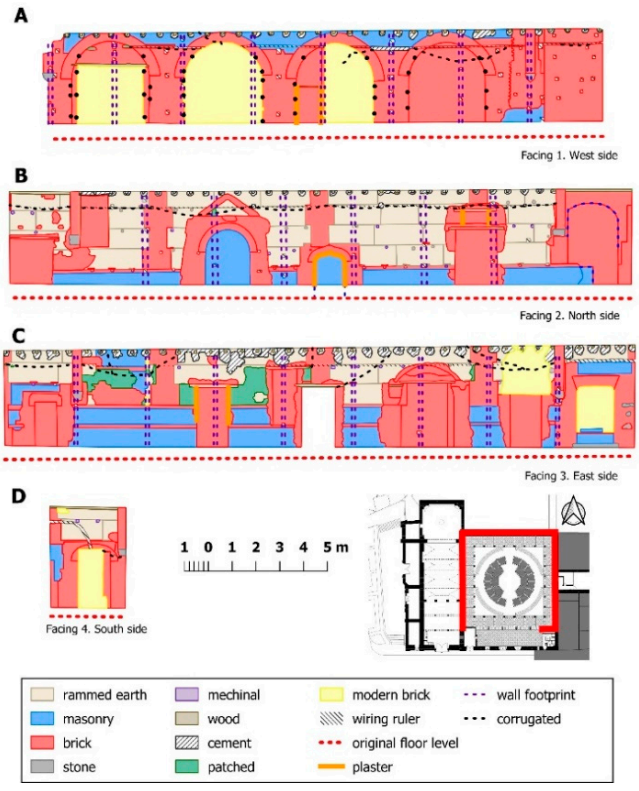

Figure 9. Construction materials and elements: (**A**) west wall, (**B**) north wall, (**C**) east wall, (**D**) south wall.

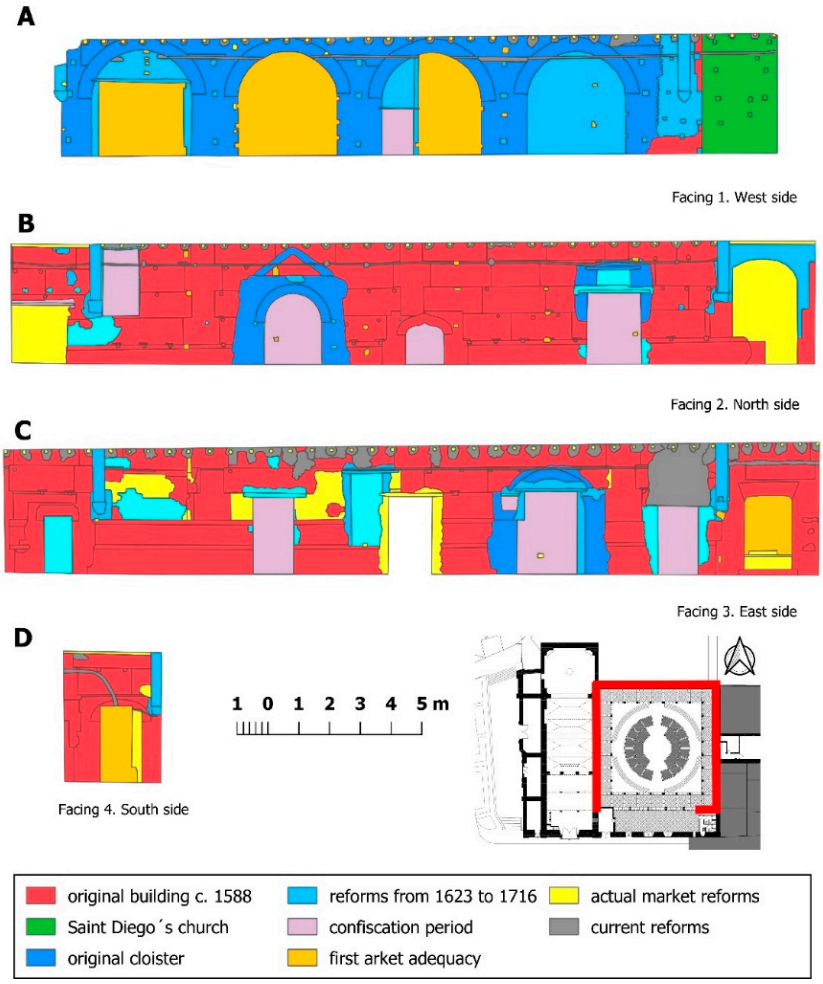

Figure 10. Chrono-stratigraphic phases: (**A**) west wall, (**B**) north wall, (**C**) east wall, (**D**) south wall.

3.1. Original Building—Construction of the Original Cloister: Circa 1588

The original cloister presented quite a different physiognomy from what can be observed nowadays, which also differs from the one that took shape after the huge reforms carried out in the 17th century and some other minor reforms in the 18th century.

In general terms, its aspect was soberer and more austere, which is in perfect consonance with the philosophy of the Franciscan Order for those moments.

The patio must not have had a porticoed gallery, as no evidence of such a presence has been preserved in the original preserved part of its facings. The scarcity of doors and gates would further emphasize the sobriety to which we are referring.

The production of the walls of the original cloister are made of two different parts: a plinth of masonry of stones of a medium size well edged on the visible faces of the facings; and a remaining wall of improved rammed earth, separated from the lower plinth by a double brick wall, with well-differentiated boxes with fine lines of lime, and with brick chains at certain distances [51] (Figure 11).

The Facings 2 and 3 preserve a huge amount of this original factory, and in them, the characteristics of it can be easily observed, and the specificity can be observed in Facing 3, in which the plinth presents a higher height, and even reaches the ceiling of the wall in some parts. This variant obeys facts of structural nature of the panel of the wall.

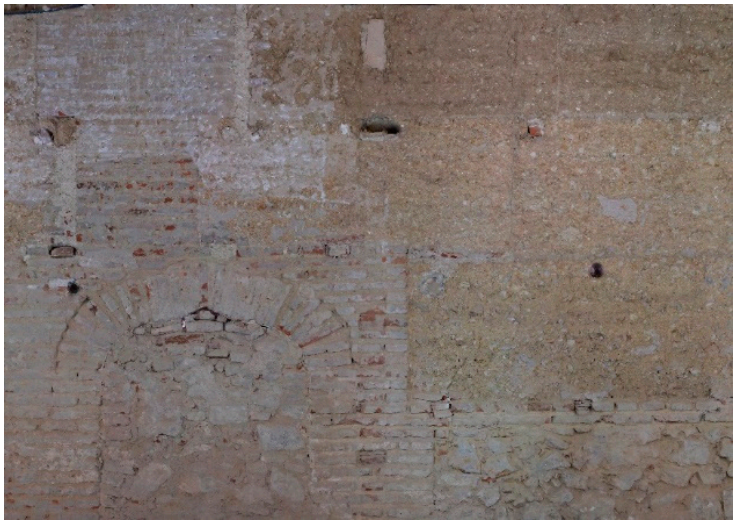

Figure 11. Original factory on Facing 2.

No windows have been documented to allow light into the rooms that must have been arranged on the other side of the facings, and the doors were scarce and of a size more in keeping with the human scale than with any other module designed to show exuberance.

The layout of these doors seems to display a well-designed scheme to go unnoticed. Doors have been preserved at the distal ends of Facings 3 and 4, and we believe that there must have been another one located at the N extreme of Facing 1, currently hidden under a wall panel belonging to the later church of San Diego. In this way, Facings 1, 3 and 4 located to the E, W and S, respectively, would have had a door at each of their distal ends, making the rest of the wall continuous and conveying the sensation of austerity that was sought for the whole complex.

This austerity was broken in Facing 2, located at the N of the cloister. In it, just a door is documented, located in the exact center of the wall, and it has an ogee arch on the top. Despite this stylistic license, the door presents a similar size to the rest of the documented doors (Figure 12). The fact of locating just a door in this facing, centered concerning it and with a slight stylistic and formal difference concerning the others, leads us to believe that it would have been the point of access to the noblest area of the monastery at that time, perhaps a chapel or some other room of rank and importance in the life of the monastery.

Figure 12. Main door of the original cloister with an ogee arch on the top.

Finally, we should point out that the floor level that is currently conserved would make it impossible for what we have indicated as a door in Facing 2 to be a door as such since its passage would be too low to allow passage through it adequately and comfortably. Later we will explain that the current level of the cloister floor is not the original one, and we will see how the one corresponding to this initial moment would be sufficiently lower to allow passage through the door without major inconvenience.

3.2. First Reform of the Cloister—First Remodeling Encouraged by the Construction of San Diego's Church: Early 17th Century

Between 1623 and 1716, the edification of San Diego's Church took place, which is completely attached to the W flank of the cloister, causing the almost total transformation of this. We say "almost total" because only a small residual sample of the original masonry can be seen at the N end of Facing 1, which we already mentioned in the previous section (Figure 13).

Figure 13. Detailed image of the facing of the church, the original wall and the reforms of the cloister.

The austerity of the philosophy of the Franciscan Rules was complemented in this case with the idea of communication and opening to the people that pretended to be evangelized, and due to this fact, the physiognomy of Facing 1 will reflects this aspect.

The newly built church openly communicated with the cloister through a series of semi-circular arches, i.e., up to four, whose middle pillars connected with church's arches that supported the vault.

Facings 2 and 3, which represented an austere aspect, mainly because of the absence of windows and doors, except the ones located in the extremes, were transformed with the openings of some hollows added to the previous ones. This is the most significant fact regarding the changes made in this phase.

The most noticeable change was the one produced on Facing 2, where another new door was opened immediately beside the one existing in the previous phase. This new door was bigger than the previous one, presenting a triangular front at the top, of which only the traces of its fitting into the original masonry of the cloister wall remain (Figure 14).

Figure 14. Detail of the front and the semicircular arch of the new open portal on Facing 2.

This fact only redounds to the idea we expressed earlier, that behind this facing must have been the noblest rooms of the monastery, so it makes sense to monumentalize the access to these rooms in some way.

In Facing 3, in addition to the smaller windows and doors mentioned above, there is also a door of larger dimensions, similar in size to the monumentalized one in Facing 2, but simpler in its execution and ornamentation.

3.3. Final Reform of the Cloister—Second Remodeling during the 17th Century and the First Third of the 18th Century

The reforms that took place in this phase had a higher expression in the configuration of the cloister patio, which acquires its final aspect and transcended to the current days.

In general terms, the porticoed gallery was built, and the corner of the arches must have been fitted into the original walls. In some cases, this fitting is very evident and has left significant traces (Figure 15), while in others, it is softer and even hardly noticeable.

In some cases, the facing of the original building had to be almost completely replaced by a new facing of solid bricks in order to have the right consistency to fit the arch and its corresponding bracket.

Figure 15. Corbel in the shape of a human head from an arch in the porticoed gallery on Facing 2.

Another significant aspect of his facing is the elevation of the pavement coordinate of the cloister, elevating it up to reach the usage level that is observed in the current days. Thanks to georeferenced photographs of Facing 2 and superimposing on it the mapping of the main components of the wall obtained from the orthophoto generated by photogrammetric methods for this work, it can be established that the original pavement is approximately 0.60 m below the current one (Figure 16).

Figure 16. North Facing 2, with the elements of the south face, georeferenced and indicating the original floor level of the cloister.

The rest of transformations of this phase correspond to the closure of almost all the hollows of the previous phase, as well as the openings of some new and the partial reform of several of the previous ones that were not closed.

To conclude, the visual connection that was established with the connected church by a series of four big arches closed with grids disappeared completely when three of them were closed and the fourth one was reduced in size.

3.4. Reforms during the Spanish Confiscation Period: From 1835 and during the Rest of the 19th Century

The Spanish Confiscation of the cloister would mean a radical transformation, both in regard to visual aspects and the uses it would have from that moment on.

The cloister and probably some other dependencies of the cloister, including San Diego's Church, became places destined for the production of Miura's anisette that was installed in 1870 in what used to be the monastery's vegetable garden.

This new adaptation of the cloister to the new use resulted in the closing of all the doors and openings in the walls, except for the one that existed at the NE extreme of Facing 2, which must have served to connect with the rooms of the factory, built in that sector.

The industrial use of the monastery must also have entailed the demolition of the northernmost wing of the cloister, preserving only the facing separating the two areas.

3.5. Transformations for the Market's Adequacy: Circa 1940 and the Last Decade of the 20th Century

In order to make the cloister adequate for the Municipal Food Market, two different changes were made: one circa 1940, when it was installed there; and the other in the last decade of the 20th century, when the physiognomy changes were made to the current one.

In the first reform, all the hollows that could have been left open were closed and a new door was opened for a connection of the center of Facing 3 with the dependences of the W wing.

What is more, a series of brick quoins, loosely embedded in the original walls, are placed along the whole length of the cloister gallery, so that they share the cloister (Figure 17), defining different quadrangular spaces used as stalls for the sale of goods traded in the market.

Figure 17. Imprint of the market walls, drawn on the wall of the cloister.

The second reform supposed the elimination of stalls attached to the original walls of the cloister, which shared the porticoed gallery, leaving it diaphanous and placing the stalls in the center of the patio.

Regarding the facings, they obtained a new plaster that homogenizes their appearance and which is the one that has survived to the present day.

4. Discussion

The results of the analysis of the facings described in the previous section (identification and mapping of the wall components, assignment of materials, classification of the typology of use and establishment of the chronostratigraphic sequence) allow us to establish and locate the documented phases and the different elements and transformations that took place in the cloister within its chrono-spatial context, that is, concerning the rest of the known buildings of the monastery and taking into account the historical process that justifies it.

The block in which the monastery is located currently is completely built, except for some little empty spaces in its insides.

Looking at an orthophoto of previous years (although we have available orthophotos from 1945, we opted for a 1977 one [52] due to the resolution quality that it offers), we can more clearly identify the different parts of the monastery that transcended up to its definitive destruction of the last room of the 20th century, as well as the ones that are still preserved (Figure 18)

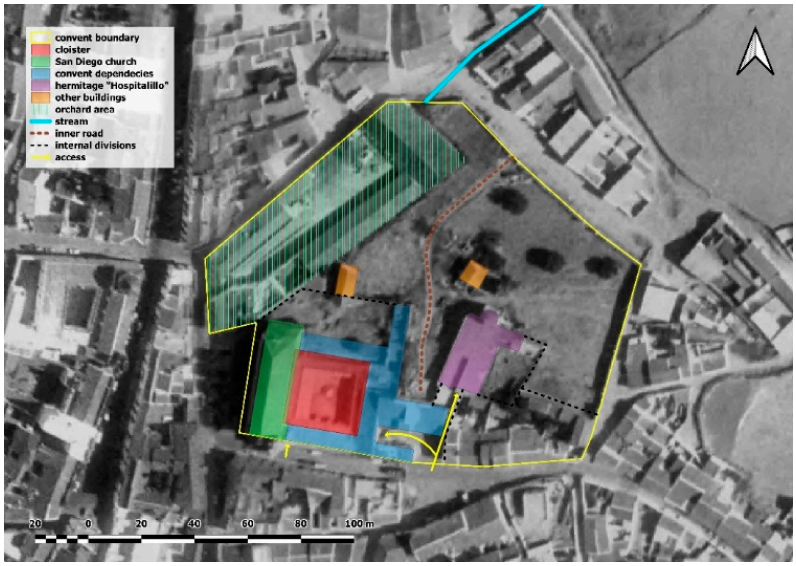

Figure 18. Identifiable elements of the San Francisco Monastery on the 1977 orthophoto.

The church, the cloister and part of the dependencies of the monastery, as well as the hermitage known as the "Hospitalillo" (diminutive name for Hospital) can be identified. All of these elements still exist today. It is only to be regretted the destruction of the N part of the monastery dependencies and the transformation of the rest of them, including the church, for other uses.

The accesses to the complex would be mainly on the S flank of the plot: the one located further to the W to access the noble part of the convent; and the one located in the center of this flank to access the Hospitalillo and possibly the convent's dependencies for supplying or similar tasks.

The Miura schnapps factory is currently located on the N flank, where the monastery's vegetable gardens were once located. Another unidentifiable element is a group of dependences to the S of the Hospitalillo; we are not in a position to say whether all or any of them could belong to the monastery. It is most likely the result of the process of urbanization of the block, as already visible in the orthophoto of 1945.

The rest of the monastery space is free of buildings, except for a couple of small buildings in the center of the plot, none of which exist today, and a series of internal partitions with fences, as well as a path. All of these elements can also be considered fossilized remains of the monastery, which, at the date of this orthophoto, would have had other functions, and which no longer exist today.

Evolution of the Cloister in the Cloister's Context

The original cloister (Figure 19a), as already described in the wall face analysis, developed the four sides of the square that formed it. The W and S flanks are hypothetical in most of their layout, as only a small part of them currently exists at their respective extremes. It is logical to suppose that their continuity is a viable proposal, bearing in mind that these parts exist, as can already be seen in Facing 1, cut to build a new wall, that of the arcades of connection with the future San Diego's Church.

When San Diego's Church was being built, attached to the W flank of the cloister, an important transformation took place (Figure 19b). On this side, a new facing was built between both spaces that consisted of four big arches that paved the way for the intervisibility between them, but which are closed by grids to prevent direct communication

There are also two new doors, one on the N and the other on the E flank, of large dimensions that must have given the cloister a more monumental appearance. There is also a small window on the N side of the cloister.

Another big reform was the demolition of most of the S wall to create five large arcades supported by pairs of columns, which should have further enhanced the monumental aspect mentioned above.

It was in the mid-17th century that the big reforms mentioned above must have taken place, affecting not only the cloister but the monastery in general. It was at this time that the "Hospitalillo" was built, which is how the hermitage built to the E of the main convent buildings was known. This building had its access from outside the monastery, isolated from the monastery, through which the users of this facility could reach it without interfering with the monastic life.

Regarding the cloister, there were two types of reforms and transformations that gave it its current appearance (Figure 19c).

On the one hand, several hollows of the previous phases were closed, and some new ones were opened, as well. Moreover, all the arcades that visually communicated with the church were also closed, except for two of them: the first from the S, whose width was reduced and which was fitted with a new grid; and the third from the S, which reduced its space to a small door that facilitated physical communication.

The great transformation took place inside the cloister. A porticoed gallery was built with seven semi-circular arches on each side. The fountain that existed until recently in the center of the cloister patio must also have been built at this time.

During the remaining life of the cloister, the reforms are reduced to the opening or closure of some hollows (Figure 19d).

With the arrival of the Spanish Confiscation, the cloister would suffer some changes that especially affected aspects of its facings: almost all the hollows were closed, including all the arches that connected with the church; and a new hollow was opened on the N wall (Figure 19e).

The greatest changes of the 19th century were produced in the rest of the dependencies and cloister's space. In 1870, the factory of Miura schnapps was installed where the vegetable gardens were before, in the N zone of the plot of the monastery. This implantation led not only to this transformation of the N space, but it also supposed the demolition of all the attached buildings of the cloister on its N flank, leaving its facing exempt.

Likely, the existent dependencies of the E flank were segregated to the cloister, and from that, the closure of all the hollows of this sector took place, which would open new accesses from indoors.

The last great reform of the cloister was produced so as to make it adequate to serve as the Municipal Food Market circa 1940 (Figure 19f).

All the remaining hollows were closed completely and just one new hollow was opened in the middle of the E facing, so as to give access to the dependencies of the new market located on the other side. As commented above, the stands are arranged under the porticoed gallery, building brick quoins from each column of the gallery to the corresponding wall of the cloister at its perpendicular. This way, 23 stands are available.

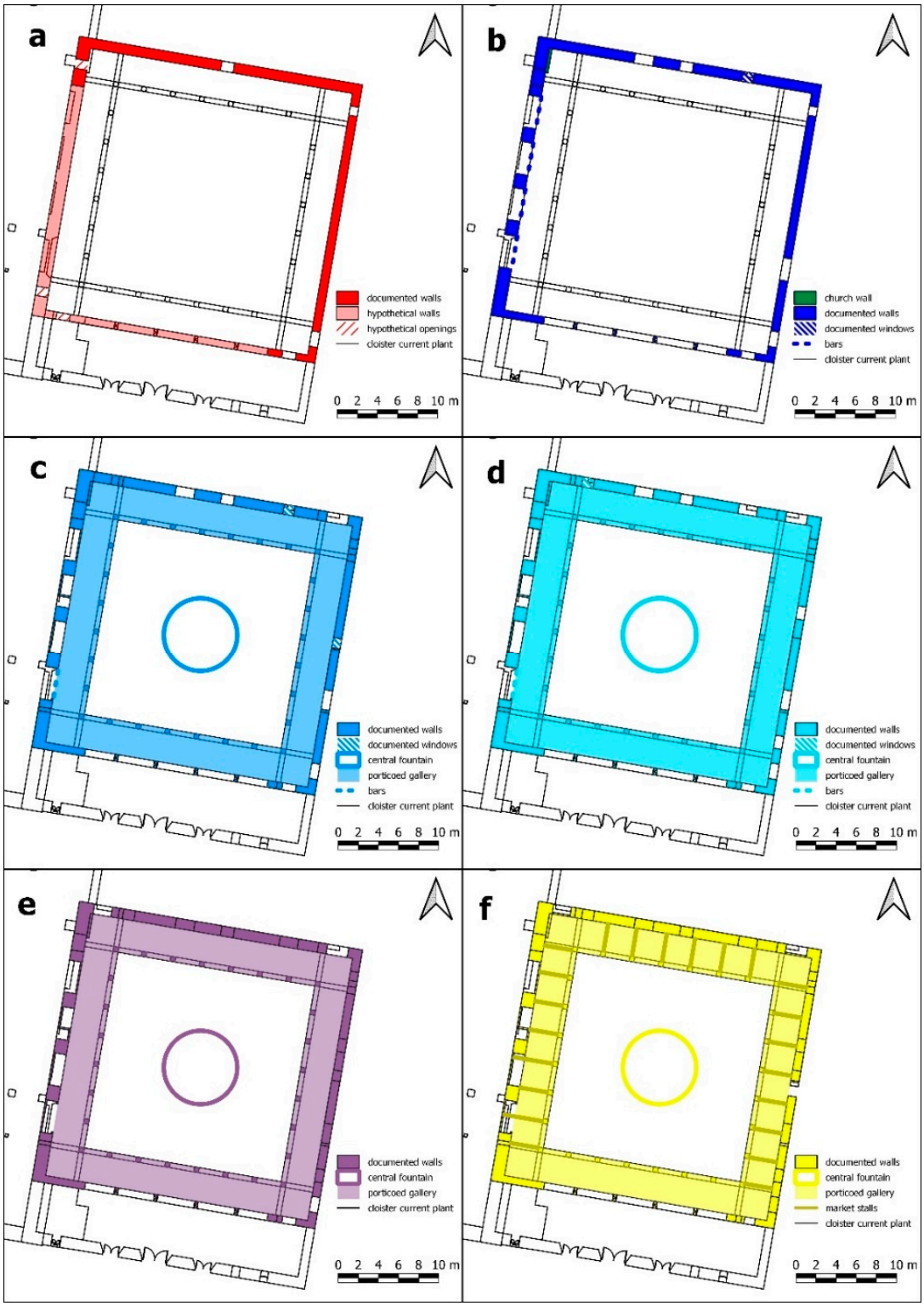

Figure 19. Evolution of the cloister: (**a**) original building, circa 1588; (**b**) first reform of the cloister encouraged by the construction of San Diego's Church attached to its flank W, from 1623 to 1716 (ending year); (**c**) remodeling because of the addition of a porticoed gallery with arcades, during 17th century; (**d**) light reforms from the 18th century; (**e**) remodeling due to the fact of the Spanish confiscations and the implementation of a schnapps factory in its environment, from 1835 and during the rest of the 19th century; and (**f**) transformation for the market's adequacy, circa 1940.

Years later, the definitive reforms of the market were carried out in order to eliminate the stands under the porticoed gallery, the facings of the cloister were flushed by the closure of the hollows that remained in the W facing, and the stands were arranged around the central fountain, which was then eliminated.

This way, an attempt was made to somehow recover the space and appearance of the porticoed gallery in exchange for completely changing the concept of the cloister by installing a roofing system to protect the entire open space in the patio from the weather.

5. Conclusions

In this research work, the advantages of using contemporary geomatic techniques in the traditional tasks of archaeology and heritage recovery were corroborated.

We emphasized the use of topographical instruments such as GNSS and total stations in order to correctly georeference the project, in addition to using or facing similar techniques to obtain point clouds with laser scanners and photogrammetric techniques.

In this sort of study, it is clearly reflected the visual and geometric advantage that SfM has against TLS since, despite being a slower process because of the quantity of inverted time in the aligning processes of images and the generation of a dense cloud of points and after that the mesh and texture, the final result allows us to have a faithful representation of the real aspect of the facings, with a lower cost of materials and equipment than in TLS.

We can highlight that, thanks to the technological revolution we are living through and the appearance of techniques such as SfM and TLS, archaeology and historical heritage can find, in both techniques, the necessary methodology to provide research, conservation and sustainability of our historical heritage, all the advantages in terms of precision, documentation, representation and preservation. The SfM technique, being a low-cost method and easy to apply, is superior, not only economically speaking, but also in terms of a much shorter execution time, for use in analyses aimed at the research or rehabilitation of historic buildings [53].

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