Contents

PART TWO: SURVEYS AND DIAGNOSTICS

Acknowledgments

Credit for initiating this project goes to the three Major Communities of the Holy Sepulchre, namely to His Beatitude Theophilos III, Greek Orthodox Patriarch of Jerusalem, to Fr. Pierbattista Pizzaballa, OFM, former Custos of the Holy Land, and to Archbishop Torkom Manoogian, the Late Armenian Patriarch of Jerusalem.
The Coptic Church of Jerusalem, the Ethiopian Church of Jerusalem, and the Syrian Orthodox Community provided invaluable support, enabling the spaces under their authority to be surveyed and studied. In particular, we are grateful to Archimandrite – now Bishop – Isidoros Fakitas, to Fr. Fergus Clarke OFM, and to Fr. Samuel Aghoyan for supporting us in all the field operations, and facilitating access to the various parts of the buildings. We fondly remember the many cups of coffee we shared during the hours of the night in the company of Fr. Samuel, when the silence and the stones of the Holy Sepulchre were our only fellow adventurers, and the delicious sweets offered by Archimandrite Isidoros as he accompanied us to the inaccessible rooms around Golgotha. We thank Don Gabriele for his care and attention, especially after our working vigils, and Brs. Andrew and John who happily opened the doors of the Franciscan Monastery to us, during our measuring work. Alas, we no longer remember all the names of the people who, over the years, gave us direct and undirect support, as we conducted our operations, and so our heartfelt thanks go to all the members of the Holy Sepulchre Communities, for their hospitality and willingness to help.
Sincere thanks to Fr. Athanasius Macora, for his wisdom and guidance in our dealings with the Communities. Over the years, as the project progressed, he was unfailingly helpful. A special thanks to Fr. Eugenio Alliata, teacher of Christian Archeology, who acted as our guide, and often went over and above the strict confines of his work as historical archivist. He is indeed a first-class scholar, and his engaging modesty only serves to make his contribution that much more valuable. We also thank the architect Theo Mitropulos, who generously gave his time and shared his knowledge, especially with regard to the more recent interventions, that he followed first-hand.
Our thanks go to the Israel Antiquities Authority, and in particular to Arieh Rochman-Halperin, the archaeologist, for his kind collaboration regarding archive research into the structural history of the Holy Sepulchre in the period of the British mandate in Palestine. Dan Bowman (Ben-Gurion University of the Negev | bgu Department of Geography and Environmental Development) and Dan Gill (retired geologist at the Geological Survey of Israel), contributed to the research, making maps and documents available.
The writing of this book would have been impossible without the assistance of the Custody Library, and the archives of the Custody of the Holy Land in Jerusalem.
The editing of this book has been quite a complex task, but also an enormous pleasure, one that I have been fortunate to share with Adriana Toti, our superb production editor. In so many ways I have come to value her suggestions and

Acknowledgments

her meticulous attention to detail. This book is densely illustrated, with a very disparate range of types of content. Her graphic skills helped to give a sense of continuity to the work as a whole, and made the result a pleasure also from the point of view of page layout. The 3D meshes used in the book are the work of Lidia Fiorini, my tireless collaborator who, despite not having taken part in the actual work, devoted a lot of time, with her customary passion, to embellishing the volume with illustrations that convey an idea of the huge potential of all the data that was acquired. To her go my fond thanks.
Interpreting a language other than one's own can often be an unsatisfactory compromise; accordingly, special thanks to our translator, Gavin Williams, who always sought to do more than slavishly translate mere words, to render the true meaning of the content.
We also pay special tribute, with hope in our hearts, to Roberto Sabelli who, having been there at the start of the project, is right now fighting his own, difficult battle for life.
Our affectionate thoughts go to the two wonderful people who first set this undertaking in motion: Father Michele Piccirillo and Prof. Piergiorgio Malesani. To these scholars, to whom this book is dedicated, goes our great esteem and gratitude. Our conversations tigether were always full of new thoughts and ideas, accompanied by their exemplary lives, and by unforgettable experiences. Their contribution, both as people and academics, will be an inexhaustible source of inspiration.
My personal debt is owed to my loving husband, Giuseppe, without whose academic and moral support this book would never have been completed.
Finally, grateful thanks to all those who, although perhaps not mentioned by name, took pains to ensure the success of this volume.

Grazia Tucci

Foreword

It's truly a great pleasure to write a few lines of preface to this wonderful book on "Jerusalem. The Holy Sepulchre. Research and Investigations (2007-2011)". *The pleasure doesn't arise only due to the beauty of the content and the scientific value, but also to my friendship with Piergiorgio Malesani. I perfectly remember when Piergiorgio told me about this projects: his enthusiasm, his devotion to Father Piccirillo, his exceptional knowledge and skills in the field of petrography and its application to cultural heritage conservation, were the perfect ingredients to produce such extraordinary work, that the readers are finally able to look at.*
I remember also that the work was born during the glorious years when at the University of Florence a Centre for Cultural Heritage constituted a marvelous experience where architects, geologists, chemists – as I am –, biologists, physicists, art historians, informatics scholars could dialogue and carry out true inter- and pluri-disciplinary projects. Indeed, the project to which this book deals with has all the peculiarities of a multi-disciplinary approach to a complex conservation and restoration case study.
I am very grateful to Grazia Tucci who succeeded after a long and intense work to end this beautiful story with this publication: it's a deserved prize to the memory of two great men, Piergiorgio Malesani and Father Piccirillo, two persons that I had the luck to meet and with whom I collaborated receiving much more than I was able to do. I hope scholars in all the world, and namely young researchers, can have interesting food for thought allowing new projects and improving their knowledge and skills.

Luigi Dei
Rector of the University of Florence

Foreword

The Holy Sepulchre Church is the most important Christian Shrine in the world; its rich history, though, and the fact that it is governed by an internationally recognised complex sharing system known as the Status Quo, have deeply influenced its architecture.

In 2006 the Heads of the Three Major Communities at the Holy Sepulchre, concerned about the stabilty of the Holy Sepulchre Church in the event of a major earthquake, engaged, through their representatives, in a series of consultations concerning the need for an appropriate evaluation, starting with a preliminary investigation as to what would be required to conduct a complete study. The late Fr. Michele Piccirillo, OFM suggested inviting the Architectural research team of the University of Florence (CABEC) to Jerusalem in order to carry out the seismic study. The proposal to commission the team from Florence required the common agreement of the Three major Communities, given that it would need to extend to all parts of the structure. The Communities did indeed agree to commission and enable CABEC to undertake the study, whereupon the team carried out the first phase of the study from the 16th to the 23rd of April, 2007.

The team, under the direction of the late Prof. Giorgio Malesani, included numerous experts of disciplines relating to architecture and geology. The Communities gave their full cooperation to the team, which carried out one investigative campaign in 2007 and two campaigns in 2008, as well as various other on-site visits required to complete the research.

The study required extensive access to the structure as well as to adjacent spaces. Under the Status Quo regime, access to the common areas was by the consent of the Three Major Communities, whereas access to the areas belonging specifically to one of the Communities, including the many areas not accessible to the public, was by specific invitation of the respective Community. The Communities cooperated fully and harmoniously with the entire research process, thus making for its successful completion.

The final report of CABEC was presented to the Three Major Communities in October, 2009, with the title (as here translated from Italian): Analysis of the Seismic Vulnerability of the Church of the Holy Sepulchre in Jerusalem. The final report was presented in three volumes: I - Geotechnical and geophysical characteristics; II – Three-dimensional relief mapping. III – Structural evaluation of seismic vulnerability.

This book is the fruit of the research done during the seismic analysis. The purpose of this publication is to share these results with a wider public. We, the undersigned, are happy to present it to this public, for the purpose of furthering knowledge and understanding of the Holy Sepulchre. We thank all the experts

who were involved in any and all the stages of the field studies, and in analysing the data thus produced, and that have thereby made the present volume possible. That the study was carried out by our common initiative and agreement give us great satisfaction. Obviously though, we do not necessarily endorse any technical choices and judgements, which are the responsibility of the respective experts, and still less do we mean to approve any comments in this book regarding the Status Quo regime in the Holy Sepulchre, on which we alone are competent to make any statement.

H.B. Teophilos III	Fr. P. Pizzaballa OFM	Abp. T. Manoogian
Greek Patriarch	*former Custos of the Holy Land*	*Armenian Patriarch*

Father Michele Piccirillo
In memoriam

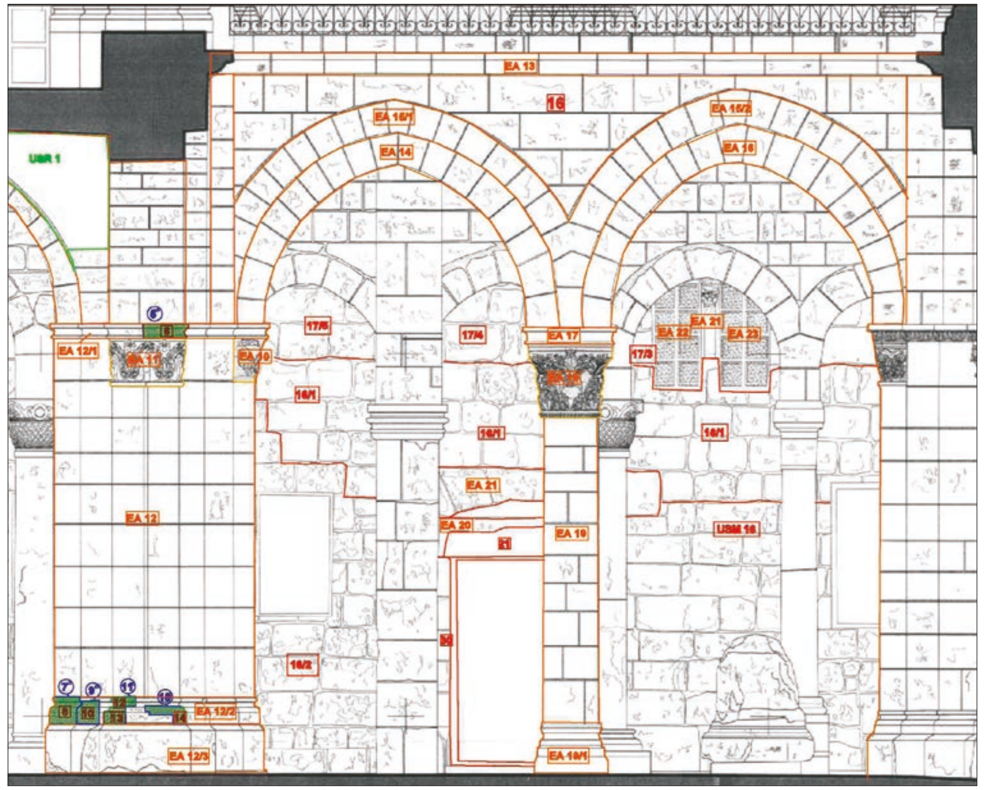
With the publication of this volume, another of the projects of Michele Piccirillo that were left unfinished with his demise, 11 years ago now, is seeing the light of day, albeit in partial form. The plan for a renewed study of the Basilica *complex, setting out from up-to-date findings acquired using the most modern technology, had taken shape more and more in the thoughts of Piccirillo, who, throughout his life as a scholar of Palestine studies, and also as a Franciscan, gave a lot of space, and attached much importance, to the* Basilica *of the* Anastasis *in Jerusalem. Indeed, while already ill, he was working with his friend Franco Scaglia, and the director Luca Archibugi, on the documentary of the Holy Sepulchre. It is even less surprising that the last volume he published – under the title:* La Nuova Gerusalemme. Artigianato palestinese al servizio dei Luoghi Santi *– dealt especially with the models of the Holy Sepulchre, made of olive tree wood and mother-of-pearl. These models were made thanks to the plans and sections carefully drawn up by Fra Bernardino Amico between the 16th and 17th centuries. It was the idea of bringing Amico's work more up-to-date, using the tools and knowledge accumulated over four centuries, that led Michele Piccirillo to entrust Prof. Malesani and a group of academics from Florence University with the task of carrying out the complete 3D survey, conducting geological and seismic investigations, and compiling an analysis of the* Basilica*'s seismic vulnerability. It sometimes happens that a person and a particular part of the world are deeply interconnected, so much so that when one of the two happens perchance to succumb, the other is often also at no small risk. This is the case with Father Michele Piccirillo and the Holy Land. "His" monuments are no longer the extraordinary place that they had become as long as Father Piccirillo made them so alive, and extraordinarily welcoming. When the monuments became laboratories, magical places in which the coexistence of different cultural experiences was made possible, in the interests of a more open vision, with a view to areas of common ground, and broader horizons for collective growth. Father Piccirillo lived in a borderland that «makes the road captivating» (Debray, 2010), the place where differing experiences meet, and are exchanged, where collaboration is practiced, while respecting each other's individuality. Working "for" Father Piccirillo was the same as working "with" him. Father Piccirillo was convinced that any intervention on an ancient building cannot be restricted merely to technical components; instead it has to give sufficient attention also to cultural and socio-economic aspects. Being in the field, on-site, with Father Piccirillo always meant one was in a privileged place for continual actions involving ideas and programmes, founded on respect for the condition of the architectural artefact, on the unique features of the situations that may be encountered, and on real collaboration between people who, in various capacities, and with varying motives, enter the practice of archaeological research and restoration. One way or another, all those who have dealt with that region owe a debt to Father Piccirillo. We cannot fail to recall the frequent, fulsome praise that he continued to receive in scientific circles throughout the world. We are also witnesses to criticisms, that not infrequently concealed jealousy and manipulations of the facts, which Piccirillo himself was accustomed to playing down with smiles, and urgings for collaboration. As well as being extremely well-versed in the history and geography of the Near East, Father Piccirillo had an unusual ability to approach "fragments" in such a way that they became new and original sources of information.*

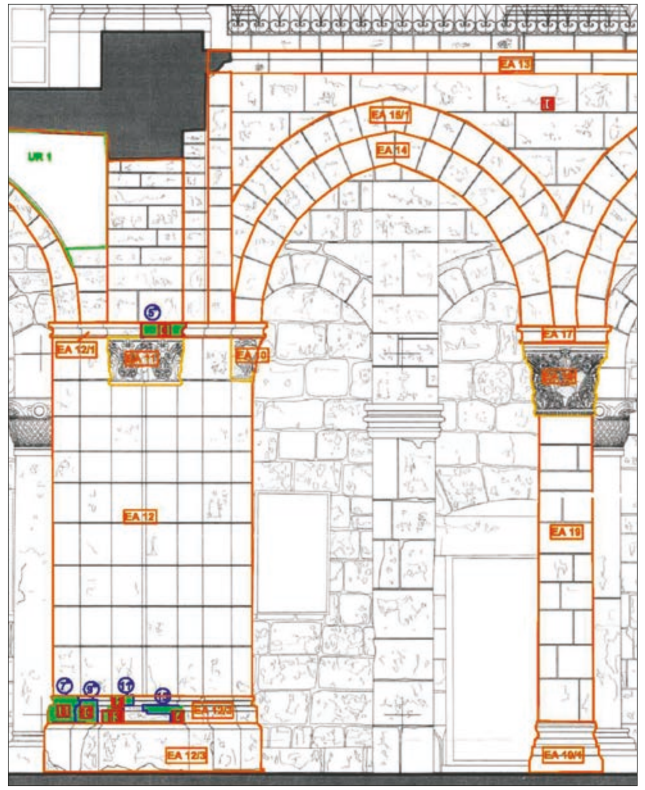
Luigi Marino, Carmelo Pappalardo, Grazia Tucci

Piergiorgio Malesani
In memoriam

In 2007 Prof. Piergiorgio Malesani, as Director of the Centre for Cultural Heritage of the University of Firenze, was commissioned by the Custody of the Holy Land to conduct a study on the Basilica of the Holy Sepulchre in Jerusalem with the main aim of assessing the seismic vulnerability of the entire architectural complex. At the same time he was also asked to carry out a survey of the Grotto of the Annunciation in Nazareth to determine the state of conservation.
The task was certainly arduous and delicate but Piergiorgio was the most suitable man to deal with that type of task. First of all because he had the solid experience and competence that is required in such circumstances and then because he had already given proof of his extraordinary ability to develop interdisciplinary projects and collaborations with all the wide range of professionals (engineers, architects, geologists, geophysicists) that was necessary to deal with such a complex project.
So, if on the one hand the more than 240 scientific contributions, published in national and international journals, certified the quality of the scientist, on the other hand, the numerous institutional assignments received during his career (President of the degree course in Geological Sciences from 1980 to 1986; Director of the Department of Earth Sciences for the three-year period 1989-1992 and for the three-year period 2000-2003; Dean of the Faculty of Mathematical, Physical and Natural Sciences of the University of Firenze for the three-year period 1996-1999) testified to his undoubted management skills.
From the very first operational meetings, Piergiorgio - who in his work always combined the rigour of the man of science with the pragmatism of the brilliant professional - immediately clarified his intentions and expectations. In essence, he frankly asked all of us who were part of the working group to provide concrete answers at certain times to the real and urgent problems we were called upon to face.
In his actions the figure of the professional emerged with extreme clarity. Piergiorgio was in fact a university professor who had matured much of his knowledge directly in the field, dealing with a large number of objectively complex situations within very varied contexts. In short, it was one of those problem-solvers that the best companies constantly contend for. For this reason, he was also an esteemed consultant to various authorities, institutions and companies and has worked, on their behalf, both nationally (with contributions ranging from interventions to secure power lines to the optimization of industrial cycles in the production of cement and brick) and abroad (with interventions for the construction of tunnels, dams, road and rail tracks).
In short, having shared such an extraordinary experience with Piergiorgio - the important results of which are contained in this book - we were able to fully appreciate the qualities of the scholar who is always ready to face the complex situations and the exceptional qualities of the man and of the sincere friend, whom he was able to express also on that occasion.
And it is precisely for this reason that we wish to conclude the memory of Piergiorgio with a greeting imbued with deep esteem, great friendship and sincere affection.

Piero Baglioni, Carlo Alberto Garzonio, Giovanni Pratesi





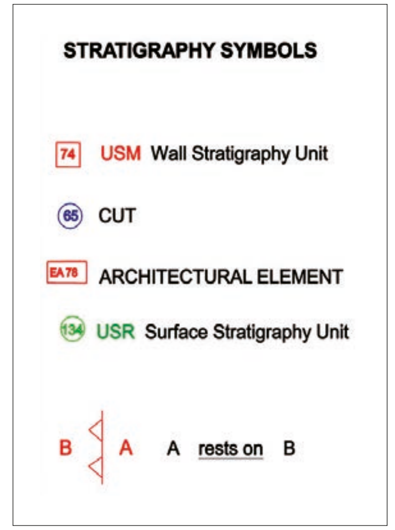
To this end, the wall elevations to be analysed were defined, and subdivided by level (main storey and upper gallery). On these, both the Architectual Elements (EA), displaying homogeneity of construction characteristics, and the Wall Stratigraphical Units (USM)[25], were later evidenced, following a separate numbered sequence for each wall elevation.

In the case of the Holy Sepulchre, the stratigraphical diagram (matrix) recording the sequence of construction, and the physical relations between the parts that were identified, presents no few problems, owing above all to the huge mass of data that would weaken their interpretation. To this end, a further simplification was effected in the numbering of those Architectural Elements which, despite being formed from differing parts that can be defined separately, can clearly be referred to a single phase with homogeneous construction characteristics. This operation is possible above all with the Crusader period elements, which reveal an easily legible construction intention, that is clear in each of its parts. Obviously the features with special architectural or structural importance, and the parts replaced in a different era, were numbered as individual Cuts, USMs and EA[26] (see Tables 2, 3 and 4).
The matrix was then processed to create several diagrams relating to each of the elevations analysed, and also organized as a tool for structural investigation, with an information content that is different from that usually defined.
All of the work of identifying Stratigraphical Units and Architectural Elements is thus based on an interpretation of the stratigraphical relationships that are still observable in the North Transept, highlighting, as a first draft, a relative sequence limited to the main construction events that can be dated clearly, as outlined below in the absolute chronology of the construction phases of the complex, identified by V. Corbo[27] (see Figure 14).

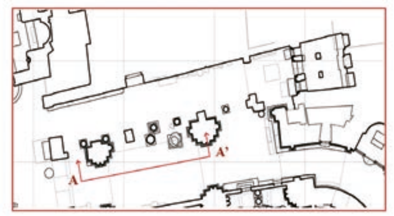
TABLE 2 *(left)* Wall stratigraphy, sample elevation A-A' (drawing by Alessandra Angeloni, based on the original survey courtesy of National Technical University of Athens. This survey was used to produce Tables 2, 3 and 4).

TABLE 3 *(right)* Wall stratigraphy sample at the lower level (from 2011 surveys).

[25] For a definition of EA and USM in architecture, and their recording in the stratigraphical diagram (Harris' matrix), see D. Gallina, 2012, pp. 76-77 and G.P. Brogiolo, A. Cagnana, 2016.
[26] For example, as clearly visible in Table 3, the stratigraphical relationships have been shown between an EA comprising an entire Crusader-period pillar that was cut (Cut: negative Stratigrahical Unit) for the creation of a restoration stone element (USM), in turn numbered and placed in a physical (relative) relationship with EA and T (*Taglio* = Cut).
[27] V. Corbo, 1981, Table 1.



SAMPLE ELEVATION A-A' – LOCATION ON THE PLAN



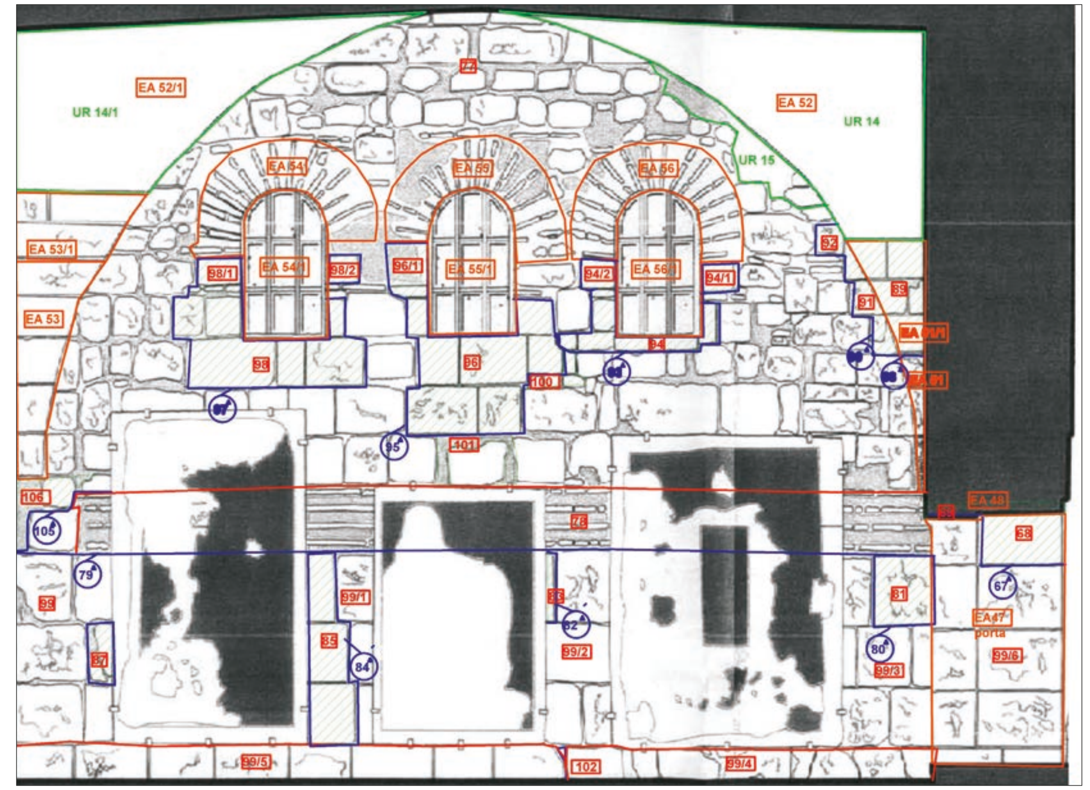


TABLE 4 (right) Wall stratigraphy sample at the upper level (from 2016 surveys) and key to stratigraphic symbols (left).

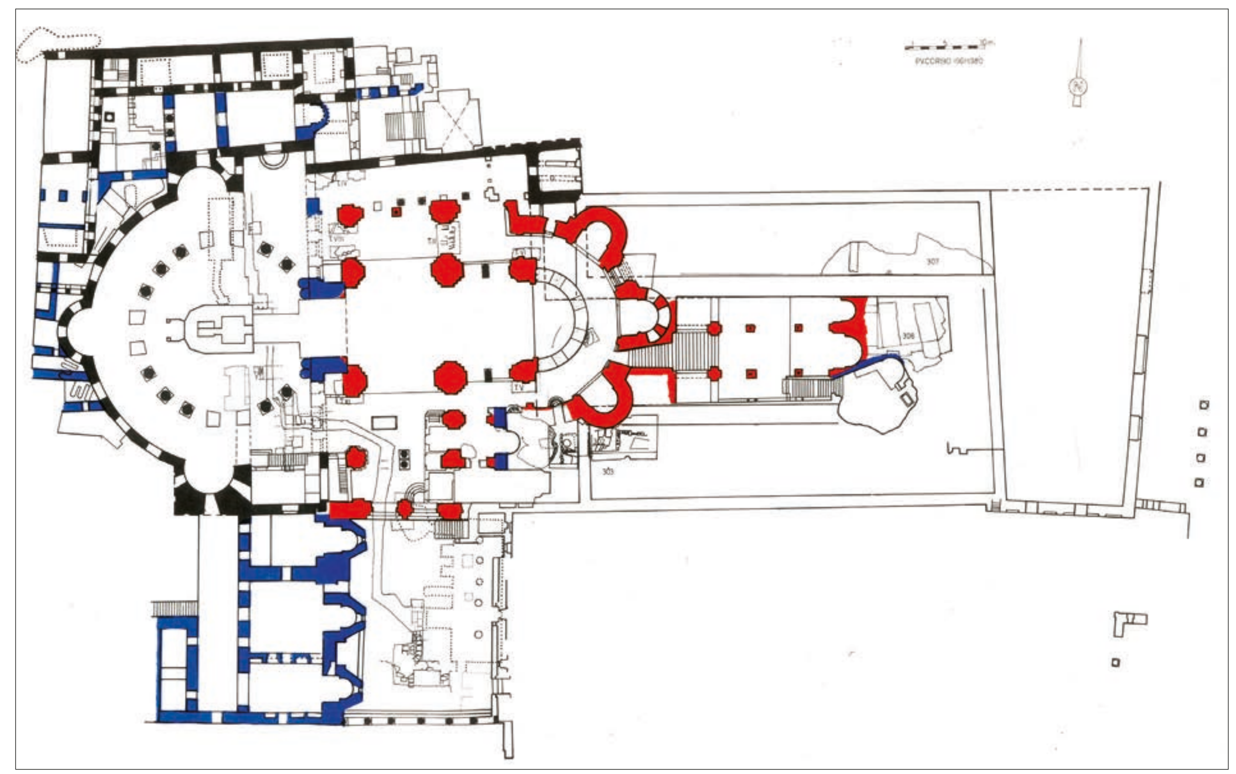


FIGURE 14 Plan showing phases (by V. Corbo):
PHASE I (2nd-4th cent. AD) – The Hadrianic building;
PHASE II (4th cent. AD) – The Constantinian Complex (black);
PHASE III (11th cent. AD) – Restoration by Constantine Monomachus (blue);
PHASE IV (12th cent. AD) – Crusader transformation (red);
PHASE V (20th cent. AD) – Modern restorations
(From V. Corbo, 1981, Table 1).

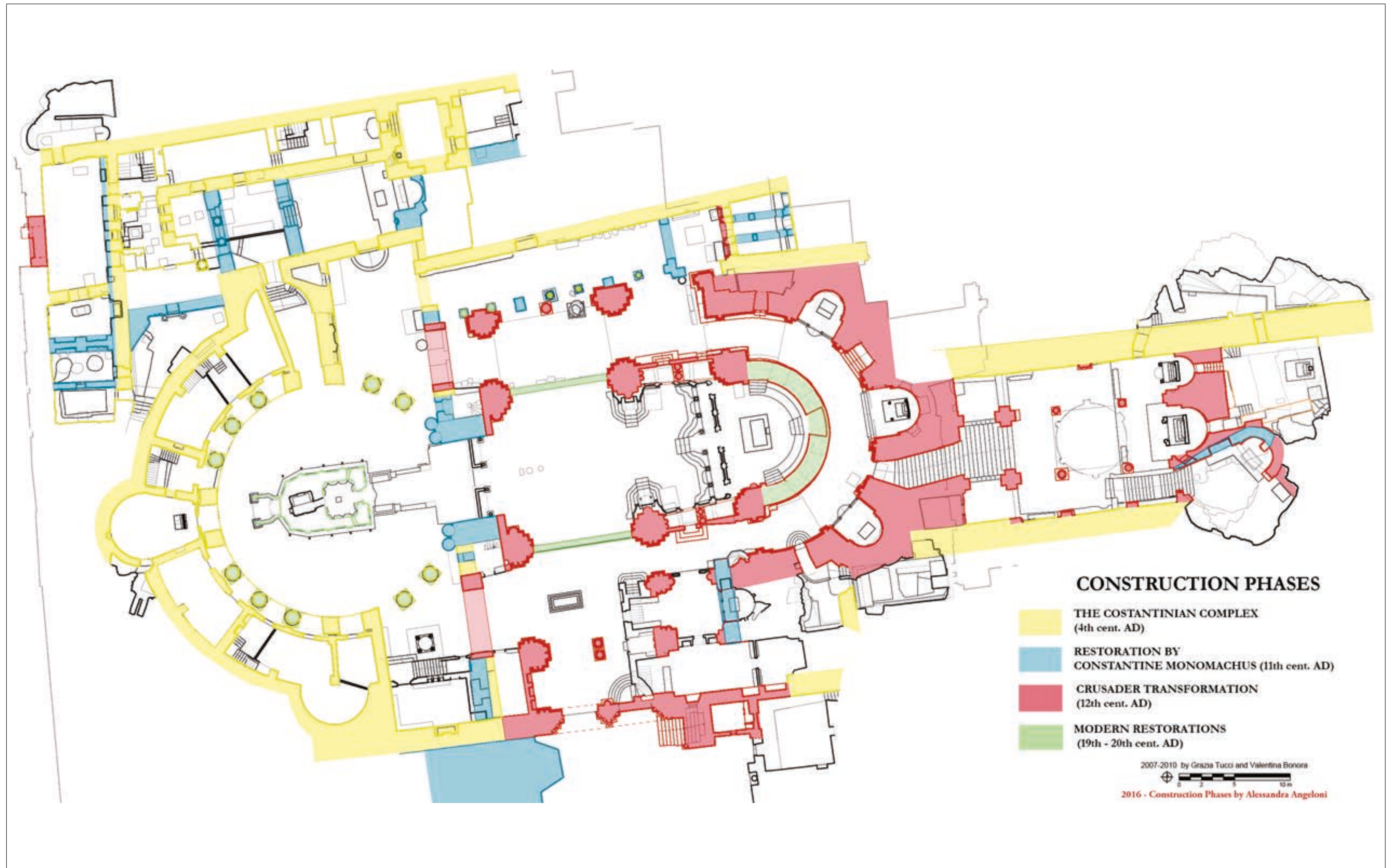


TABLE 1 Plan showing phases (Plan revised by A. Angeloni from Tucci-Bonora surveys 2012 (see below).

It is interesting to note that both the Crusader masons and the 11th century Byzantine masons reused numerous capitals, column bases and column drums from the 4th century *Basilica*.
The sequence of the construction and destruction phases which characterize this extrordinary architectural context can be seen in it, in a clear and orderly form[6] (see Tables 1, 2 and 3).

1.2.2. The stratigraphical sequence

The stratigraphical sequence of the North Transept of the Holy Sepulchre has been subdivided, for a better interpretation of the macro-phases, into *construction* and *destruction activities*, which can be related to actions which are chronologically homogeneous, as documented so far. As mentioned above, this work is only an initial draft based largely on the observations and periodization of the parameters of the context under investigation, using the chronological indicators derived from the extensive bibliography on the subject[7].

[6] V. Corbo, 1981, pp 81, 82.

[7] Despite having referred in depth in the previous paragraphs to the studies on the Holy Sepulchre in Jerusalem, it is opportune here to cite the works used for the study of the construction phases: the monograph on the city by H. Vincent e F.M. Abel, *Jérusalem Nouvelle*, vol. 2 (Paris, 1914); the story of the building summarized in R. Ousterhout, "Rebuilding the Temple: Costantine Monomachus and the Holy Sepulchre", *JSAH* 48 (mar.1989), 66-78 and, by the same author, in 2003, "Architecture as a Relic, and the Construction of Sanctity: the Stones of the Holy Sepulchre", *JSAH* 62 (mar. 2003), 4-23; V. Corbo, *Il Santo Sepolcro di Gerusalemme*, 3 vols. (Jerusalem, 1981), a work which, as mentioned several times, surpassed all previous publications on the subject, and which also documents part of the restorations carried out in the second half of the 20th century. A perhaps slightly less detailed account, in terms of richness of graphic documentation, is provided by C. Coüasnon, *The Church of Holy Sepulchre in Jerusalem* (London, 1974). Finally, S. Gibson and J. Taylor, *Under the Church of Holy Sepulchre* (London, 1994), made important observations regarding the Constantinian building, while Martin Biddle's *The Tomb of Christ* (Sutton, 1999) remains the most significant work, after V. Corbo's own studies, and before the fundamental text on Crusader architecture by D. Pringle, *The Churches of the Crusader Kingdom of Jerusalem: A Corpus. III the City of Jerusalem* (2007). Important observations on the building's chronology are made in J. Folda, *Art of the Cusaders in the Holy Land. 1089-1187* (1995).

TABLE 2 Plan of construction phases on lower level (Original survey plan from the topographical and photogrammetrical survey commissioned by the Orthodox Greek Patriarchate, 2003. This survey was used to produce Tables 4, 5, 6, 8, 10 and 12).

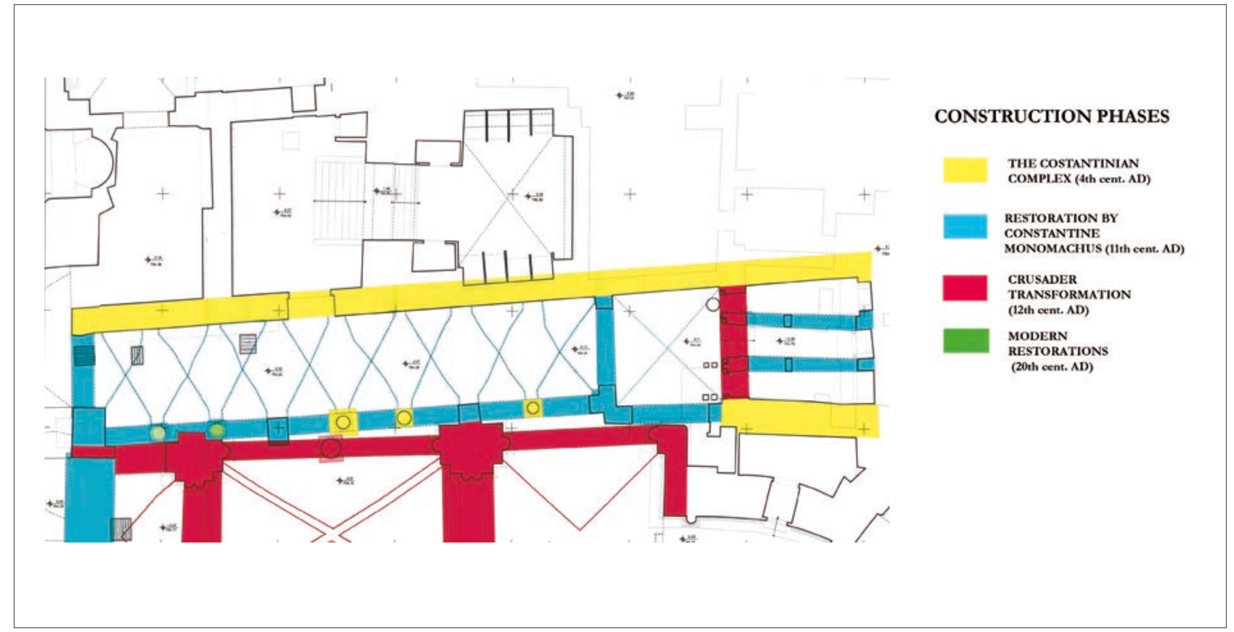
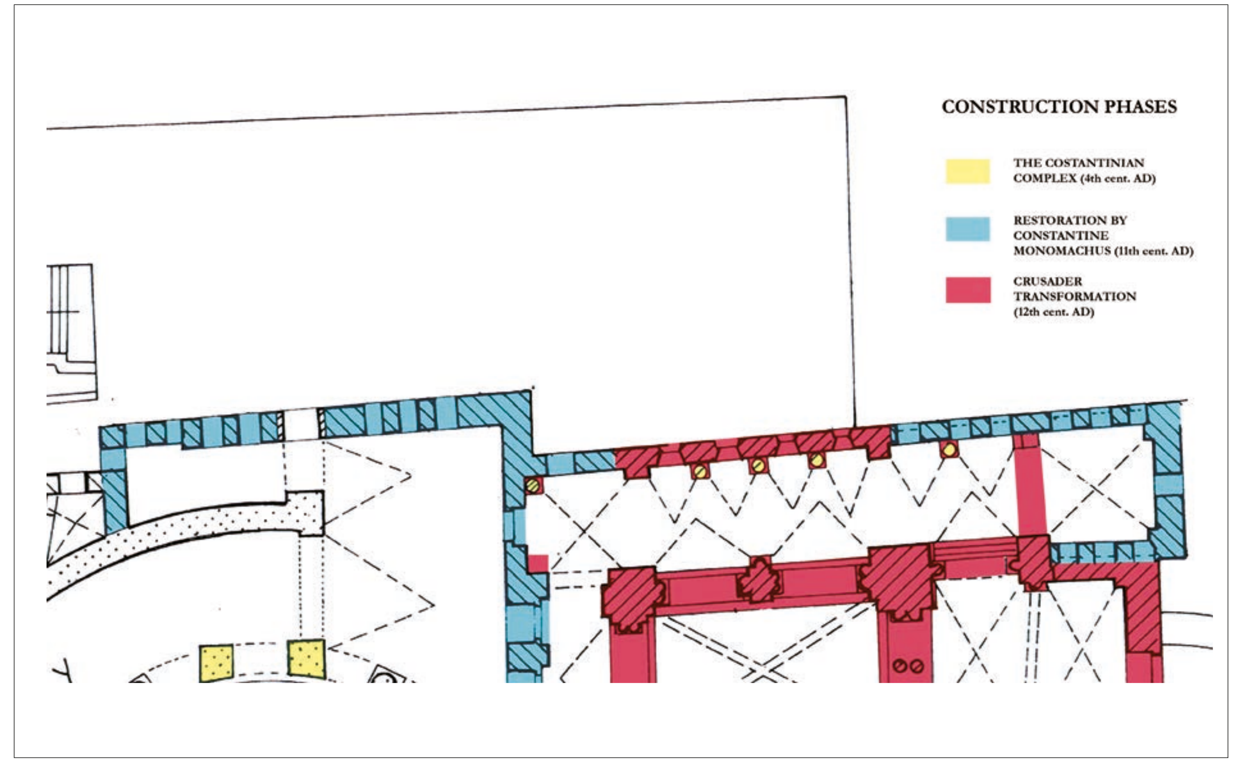
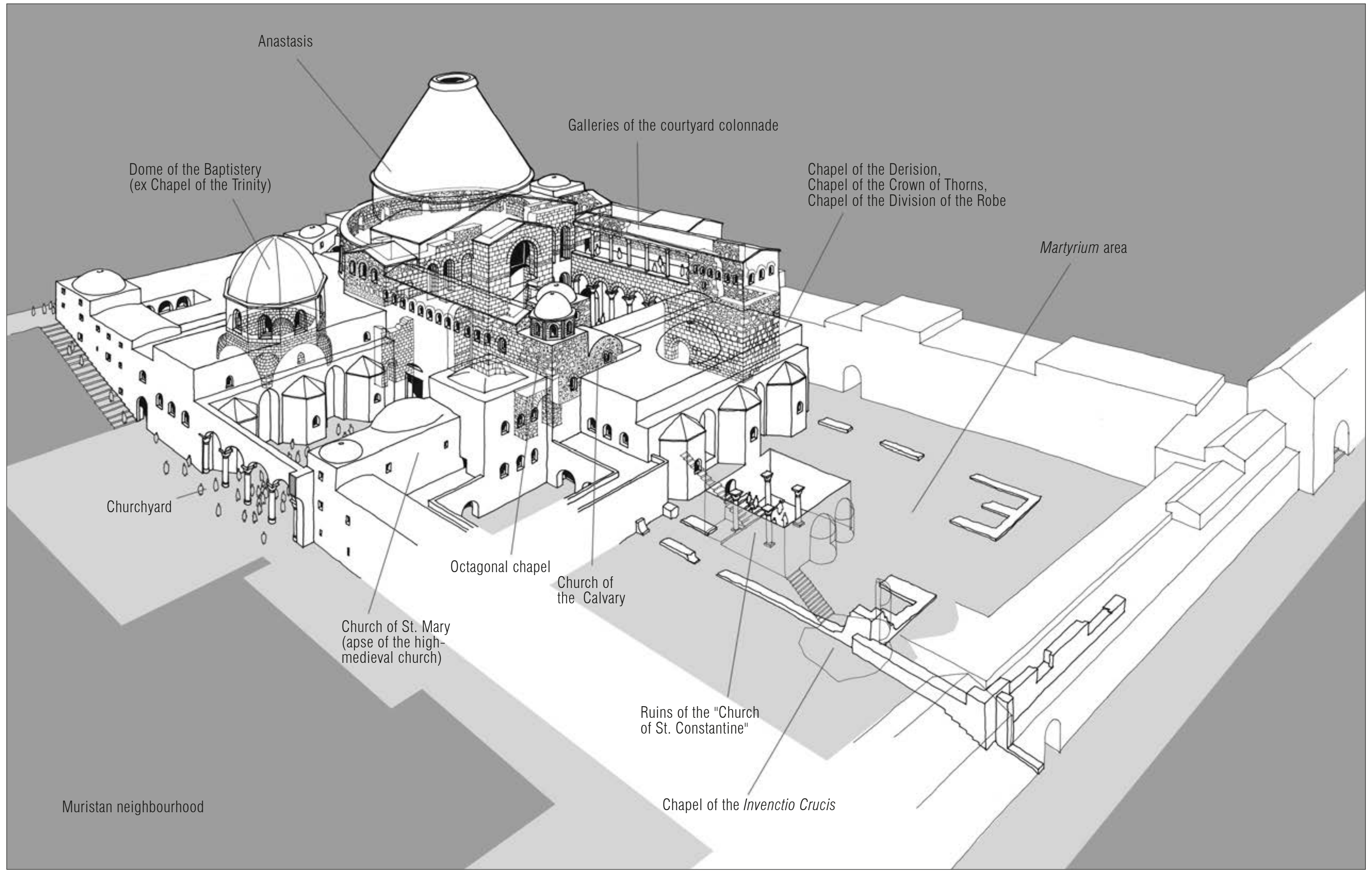


TABLE 3 Plan of construction phases on upper level (Survey revised by V. Corbo, 1981, Table 7, and also revised by Denis D. Pringle, 2007. This survey was used to reproduce Tables 7, 9 and 11).





sader work site began. Saewulfus told that the *Anastasis* was a large church with an open roof so that the rain fell on the *Aedicula* of the Tomb[64] (Figure 22). Abbot Daniel gave a more detailed description of this ceiling shaped like a *pseudo-cupola* and observed that it was made of wood. He specified that the building was circular and was supported by twelve monolithic columns and by six pillars made of stone standing on the ground level; there were other sixteen columns (made of stone?) on the gallery level; finally, the flooring was in marble, it was decorated with frescoes and mosaics, and it had six entrance doors[65]. Two chapels leant against the *Anastasis* northern and southern sides, dedicated to Saint Mary and Saint John the Evangelist, who had witnessed the Passion of the Christ[66]. On the left side of the latter oratory, there was a beautiful chapel dedicated to the Holy Trinity *(«monasterium in quo est locus baptisterii»)*[67], which in turn shared the southern wall with another chapel dedicated to Saint James the Less, first Bishop of Jerusalem[68]. Abbot Daniel stressed that on the Chapel of Saint Mary façade there was the miraculous Image of the Virgin *Deipara*, celebrated in the *Vita* by Mary of Egypt, to whom Mary directed her gaze after retiring *«in angulum atrii Templi»*[69]. The Icon, already mentioned by Anonymous Piacentinus (VI century)[70] and by the monk Epiphanius (IX century), was frescoed above a door in the north-east corner of the porticoed courtyard and had evidently survived the devastation by Hakim.

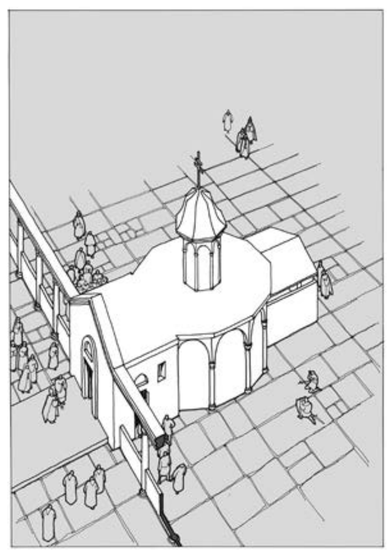
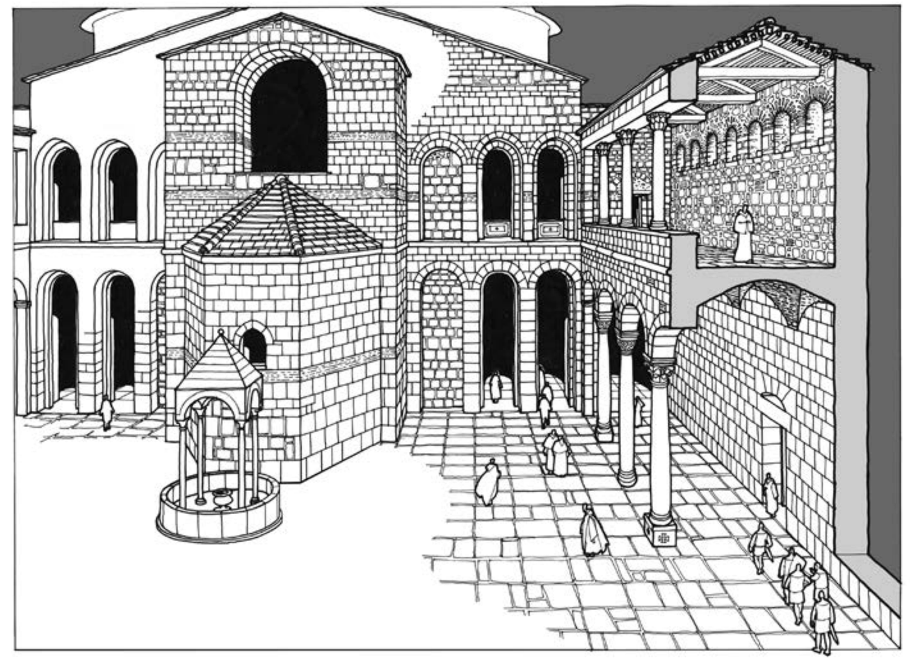


FIGURE 21 The Holy Sepulchre rebuilt by the Byzantines after the Muslim devastation of the 1009 Highlights the masonry of H type.

FIGURE 22 The *Aedicula* at the end of the XI century.

[64] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 2, in: D. BALDI, 1982, p. 655.
[65] DANIEL ABBAS, *Vie et pèlerinage*, 1, in: D. BALDI, 1982, p. 656-657.
[66] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 8, in: D. BALDI, 1982, p. 656.
[67] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 10, in: D. BALDI, 1982, p. 656.
[68] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 10, in: D. BALDI, 1982, p. 656.
[69] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 9, in: D. BALDI, 1982, p. 656); *Patrologia Graeca*, IBIDEM, p. 639.
[70] ANONIMUS PLACENTINUS, *Antonini Placentini itinerarium*, 7, in: D. BALDI, 1982, p. 639.



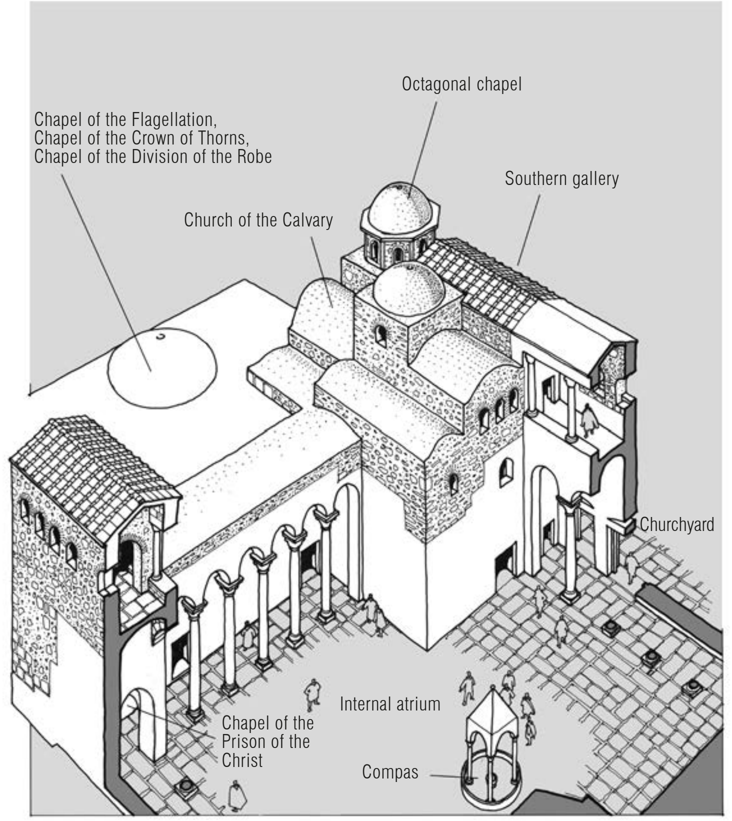


FIGURE 23 Façade of the *Anastasis* view from Triportico (XI century).

FIGURE 24 The Church of the Calvary rebuilt by Byzantines (XI century).

Saewulfus mentioned some chapels located on the western side of the porticoed courtyard. Some of them were already part of the High Medieval complex, others were built by Byzantines. On the northern corner there was the ancient chapel of the *Prison of the Christ*[71] and, on the opposite corner, the church of the Calvary. The latter had probably been rebuilt, since it was one of the buildings that had been destroyed by Muslims thirty years before (Figure 24). The pilgrim noted that this sanctuary was made of two superimposed sacraria: the one above brought to mind the Location of the Crucifixion and where Abraham had built his altar; the one below where, according to tradition, there is *Adam's Tomb*[72]. Abbot Daniel also specified that the Holy Rock was surrounded by walls and covered by vaults, both entirely covered in mosaics. This environment, which must have been the church of the Calvary, had two entrance doors with steps[73], perhaps connected to the porticoes in the atrium. The High Medieval church of "Saint Constantine", which had been built on the *Martyrium* crypt and then destroyed under the command of Hakim, was no longer restored. After the Byzantine works the whole area was simply called «the place where queen Helena had built the great *Basilica* that celebrated the finding of the True Cross»[74]. Walking through the ruins of the old crypt, it was possible to climb down to the *Spelunca* of the *Inventio*, which was still serving as an oratory and sanctuary[75].

Using the volume of the *Martyrium*[76] former vestibule, the Byzantines built three oratories between the Calvary and the *Prison of the Christ*. They were dedicated to three episodes of the Passion of the Christ: the Chapel of the *Division of the Robe*, the Chapel of the *Crown of Thorns*, and the Chapel of the *Derision*, reminding of the soldiers who derided Christ and dressed him in purple. In the crusader reconstruction, the latter would be dedicated to the *Flagellation*, but at that time the Column associated with the torture was still located inside the former vestibule together with other sanctuaries (among which the *Altar of Abraham* and the *Place where the Christ was hit in the face*), although not in the same chapel[77]. On the southern side of the Calvary, there were the remains of the High Medieval church of Saint Mary, described by Saewulfus. The ruins lay on the Holy Place where the body of the Christ, taken down from the cross, would have been anointed with perfumed oils and wrapped in a clean linen cloth[78].

In the internal porticoed courtyard, right below the *Anastasis* apse wall (Figure 23), there is a particular object named *Compas* that symbolizes the *Omphalos* or *Center of the World*. Saewulfus defined this Holy Place as an «oratory»[79]. Abbot Daniel described a small construction covering it, similar to a ciborium, with a vault decorated by rich mosaics. On the vault there is the following inscription: «the sole of my foot serves as a measure for the heaven and for the earth»[80].

[71] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 3, in: D. BALDI, 1982, p. 655.
[72] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 4-5, in: D. BALDI, 1982, p. 655.
[73] DANIEL ABBAS, *Vie et pèlerinage*, 6-7, in: D. BALDI, 1982, p. 658.
[74] SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 3, in: D. BALDI, 1982, p. 655.
[75] DANIEL ABBAS, *Vie et pèlerinage*, 11, in: D. BALDI, 1982, p. 659.
[76] DANIEL ABBAS, *Vie et pèlerinage*, 9, in: D. BALDI, 1982, p. 659.
[77] DANIEL ABBAS, *Vie et pèlerinage*, 8, in: D. BALDI, 1982, p. 658; SAEWULFUS, *Peregrinatio ad Hierosolymam et Terram Sanctam*, 3, in: D. BALDI, 1982, p. 655. Cfr. *Itinerarium Burdigalense*, in: D. BALDI, 1982, p. 474; HIERONYMUS, *Epistulae*, 108, in: D. BALDI, 1982, p. 479; THEODOSIUS, *De situ Terrae Sanctae*, in: D. BALDI, 1982, p. 483; *Vita di Sanctae Elenae et Constantini* (sec. X) in: D. BALDI, 1982, pp. 489, 494-495.
[78] NASIR-I KHOSRAU, *Sefer Nameh, Relation du voyage en Syrie, en Palestine ...*, 6, in: D. BALDI, 1982, p. 656.
[79] NASIR-I KHOSRAU, *Sefer Nameh, Relation du voyage en Syrie, en Palestine ...*, 7, in: D. BALDI, 1982, p. 656.
[80] DANIEL ABBAS, *Vie et pèlerinage*, 5, in: D. BALDI, 1982, p. 658.

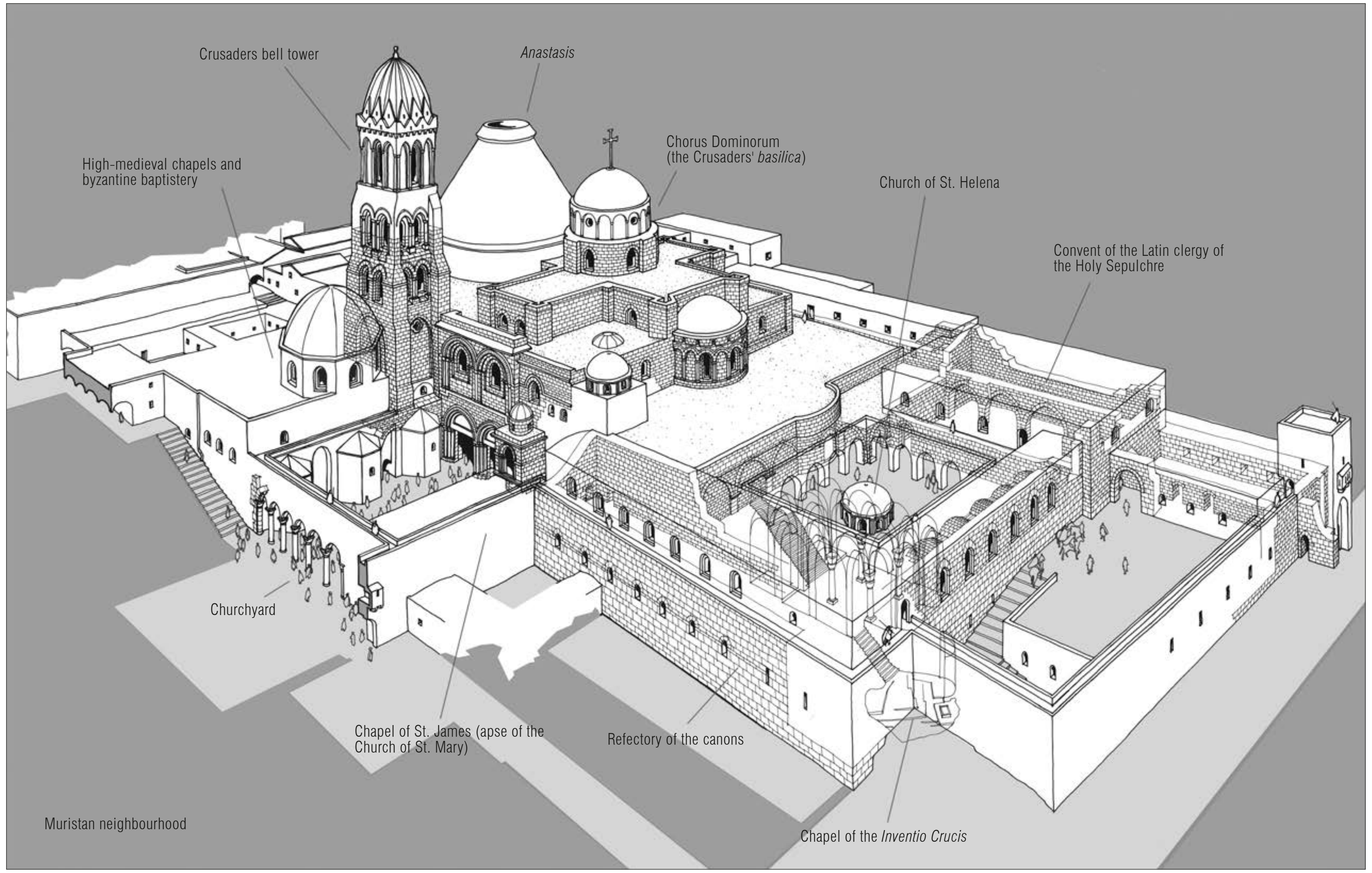


FIGURE 25 The Holy Sepulchre after the Crusaders restoration in the second half of the XII century. Highlights the masonry of I type.

On July 15th, 1099, Jerusalem was conquered by crusaders, who maintained control until October 2, 1187. During these eighty-eight years of Latin governance the Holy Sepulchre was restored in the Romanic form that is still visible (Figure 25). For the first time after many centuries a new consistent renovation project for the whole sanctuary was conceived, instead of the several projects for partial reconstructions or adaptations that had been carried out before. Thus, they created a new magnificent architecture, formally, stylistically, and volumetrically homogeneous. The construction was supported by relevant financial resources. The Crusader *Basilica (Chorus Dominorum)* was built in place of the intermediate narthex and connected to the *Anastasis*. It incorporated the chapels of the Calvary. The new dome raised above the *Compas*: the *Center of the World*. The Holy Places of the *Golgotha*, tied to the memory of the finding of the True Cross, regained their dignity. Above them and all around a colonnade, they built the lodging for the Latin clergy (Figure 26). Judging by the thickness of outside walls (around 3 metres) and by the windows shaped as embrasures in the refectory (today Saint Andrew Greek Orthodox Church), it looks like the complex was meant to be a fortress, dominated by the high bell tower. This is, however, an aspect common to most of the crusader architectures built in the Holy Land [P. Deschamps, 1990].
The whole complex must have been completed by 1172, when Theodoric described it in his *Libellus de Locis Sanctis*[81]. The German pilgrim, in fact, mentioned the crusader *Chorus Dominorum*, which was in front of the Sepulchre and is connected to the *Anastasis* towards east[82]. He noted that in this new *Basilica* the Latin celebrated their liturgies, while some altars of the sanctuary served the Syrian, Armenian, Greek, Syrian Orthodox, and Coptic clergy[83]. He described the chapels of the Calvary or of the *Elevation of the Cross* and of the *Golgotha* or of *Adam*; the new church of Saint Helena with the *Spelunca of the Inventio*[84]; the three western chapels overlooking the southern church yard, on the first of which, next to the *Anastasis*, they had already built the majestic bell tower[85]. He also noted that, among the three other chapels in front of the former three, the central one (the chapel that had been built inside the apse of the VII century church of Saint Mary) was property of the Armenians[86] – as it is today. There are no sources as exhaustive as Theodoric's *Libellus* that concerns earlier times. Nevertheless, according to the guide to the Holy Places *De situ urbis Jerusalem*[87] written between 1130 and 1150 ca, the most relevant construction phase of the crusader work site may not yet have started in the second quarter of the century. The text still described the *Anastasis* and the Calvary as separated from the open-air courtyard[88], therefore demonstrating that the *Chorus Dominorum* did not yet exist. According to the same source, it seems that they were building – or even they had already completed – the church of Saint Helena[89] on the eastern side of the complex.
Scholars have been arguing about the significance of an inscription that once it was possible to read on the arch external to the chapel of the *Golgotha*. The writing was about the consecration that had happened to the «place sanctified by the blood of the Christ» in 1149 [M. Biddle, 2000, p. 50]. It is not clear whether the writing refers to the date of the consecration of the whole complex once completed or to the date of the consecration of the renovated chapels of the Calvary. On the other hand, the epigraphy *«PRAEPOTENS GENUENSIUM PRAESIDIUM»*, which the crusaders inscribed in golden letters on the *Anastasis* eastern altar as recognition of the support by Genoeses while they were conquering the city [T.O. De Negri, 1986, pp. 223-224], may have disappeared during the reign of Almarico (1163-1174), when the apse had been demolished to connect the *Basilica* of the Resurrection to the *Chorus Dominorum*. It is therefore plausible that only at that time the crusader construction site came to an end (Figure 27) [M. Biddle, 2000, p. 52].

What we see nowadays of the Holy Sepulchre (Figure 28) is the result of the archaeological process thus far illustrated, to which uncountable restoration works done between the beginning of the XIX century and the end of the XXI century add on.
This is the monument that the past centuries have given to us: an extraordinary historical document made of stone, which witnessed religious and military events as well as natural catastrophes. A sacred place that people have been using for more than one thousand six hundreds years, almost always an object of dispute. It has been defined as «a majestic metaphor of the human condition and of the History of Christianity in Middle East» [M. Acanfora Torrefranca, F. Ardito, C. Gambaro, 2000, p. 90]. Such is today, and such will be for who knows how long the Holy Sepulchre of Jerusalem.

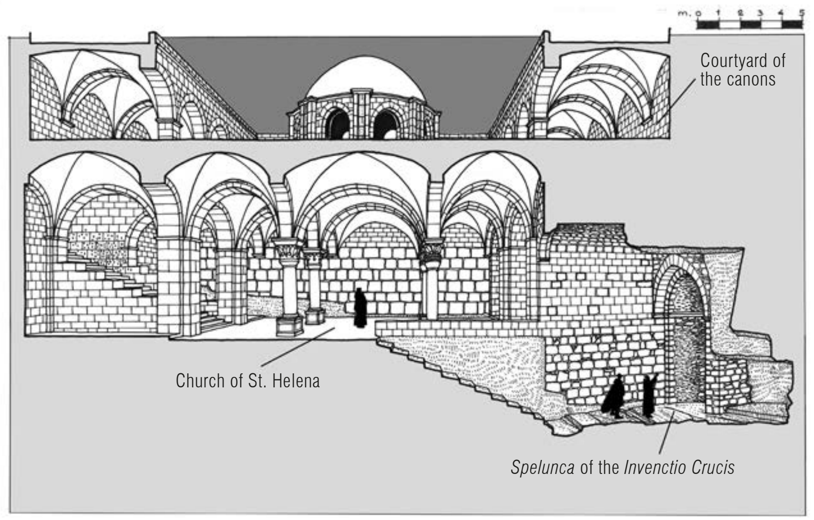


FIGURE 26 The Romanesque structures of the Church of St. Helena, built on the grounds of the ancient crypt of the Constantinian *Martyrium*, still visible today.

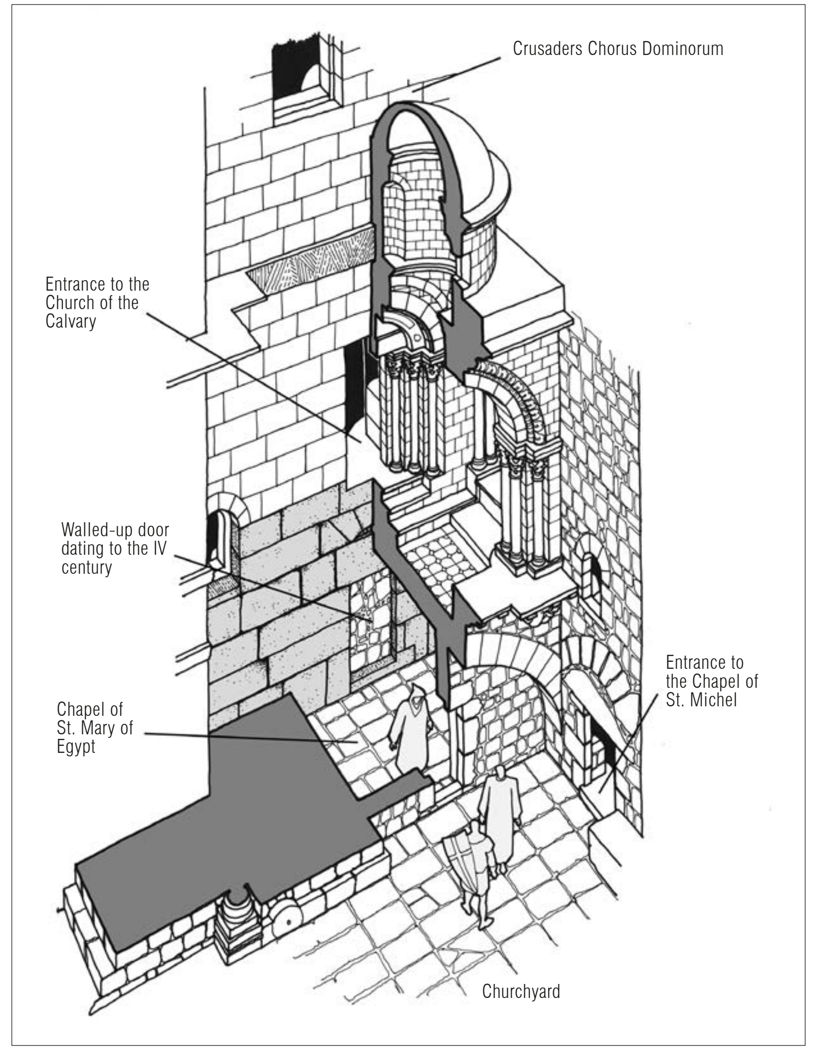
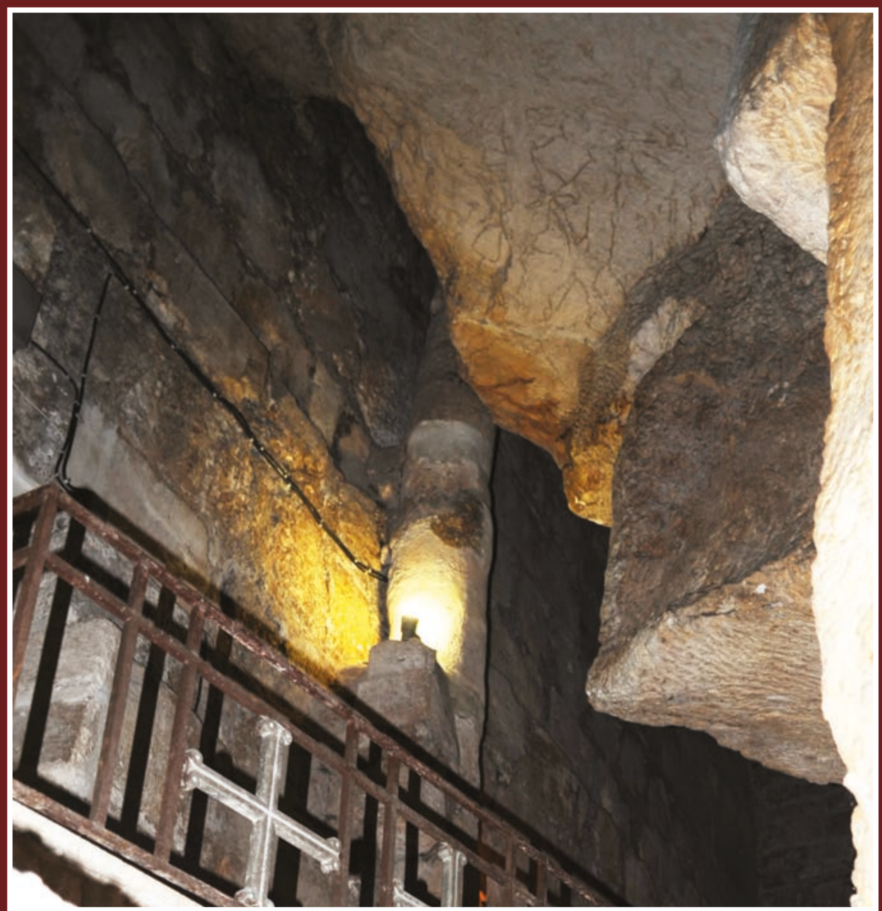


FIGURE 27 Perspective section on the so-called "Chapel of the Franks", which was one of the last Crusaders intervention in the Holy Sepulchre, after the completion of the *Chorus Dominorum*.

[81] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, pp. 661-671.
[82] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, p. 664.
[83] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, p. 666.
[84] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, pp. 667-668.
[85] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, p. 668.
[86] Theodoricus, *De Locis Sanctis*, in: D. Baldi, 1982, pp. 670-671.
[87] *De situ urbis Jerusalem*, in: D. Baldi, 1982, p. 661.
[88] *De situ urbis Jerusalem*, in: D. Baldi, 1982, p. 661.
[89] *De situ urbis Jerusalem*, in: D. Baldi, 1982, p. 661.



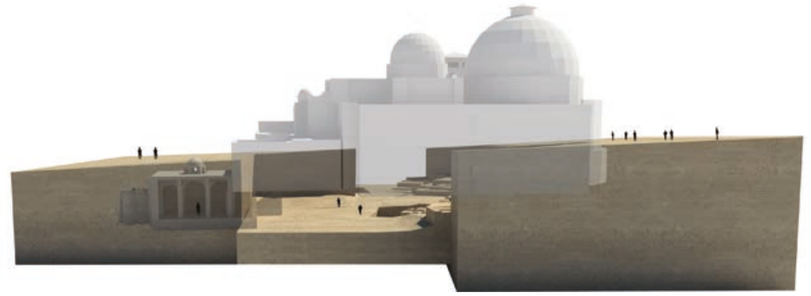


FIGURE 50 Overlapping of model of the ancient cave and the current *Basilica* of the Holy Sepulchre (model of Holy Sepulchre by Google Sketchup).

FIGURES 51A AND 51B Quarry found during excavations in the neighborhood of Ramat Shlomo Jerusalem (http://www.antiquities.org.il/article_Item_eng.asp?sec_id=25&subj_id=240&id=1280&module_id=#as).

FIGURES 52 AND 53 Quarry found in Shmuel HaNavi Street (http://www.antiquities.org.il/article_Item_eng.asp?sec_id=25&subj_id=240&id=1586&module_id=#as)

Opposite page:

FIGURE 48 *(above)* Details of the rock section still visible in the Chapel of St. Vartan (photo CABeC).

FIGURES 49A AND 49B *(below)* Quarry up St. Vartan: details of the bedrock that closes the top (photo CABeC).

1.3.4. The quarry and its transformations

Simonetta Fiamminghi

1.3.4.1. The ancient cave

It is possible to have an idea of the quarry as it appeared in the past thanks to the discovery of two ancient quarries dated to the end of the Second Temple period, which were excavated by the Israel Antiquities Authority. These caves were opened in the area north of the Holy Sepulchre, outside the ancient walls, and allow a more precise visualization of the quarry morphology on the site of the *Basilica* (Figure 50).
The first quarry was found during an excavation in Shmuel HaNavi Street, in the neighbourhood of Ramat Shlomo, Jerusalem. It was at least 5 dunams (1 dune = 1000 square meters)[123]. The quarry dates back to Second Temple period, in the first century AD. Here, they found 8 meters long blocks, similar to the ones that were used in the lower parts of the Temple Mount[124] (Figure 51A).
The second quarry was opened in Shmuel HaNavi Street and also dates back to first century AD. Extracted blocks measured 3x2x2m. Evidences suggest that many miners used to work in this quarry.
These two quarries produced blocks of various sizes, which were quarried by creating wide detachment channels. The blocks were then marked by means of a chisel that weighed approximately 2.5 kg[125] (Figures 52-53). Methods of quarrying the stone remained largely unvaried until the introduction of modern techniques The Romans refined the techniques used in the ancient times standardizing the various methods of quarrying throughout their Empire.

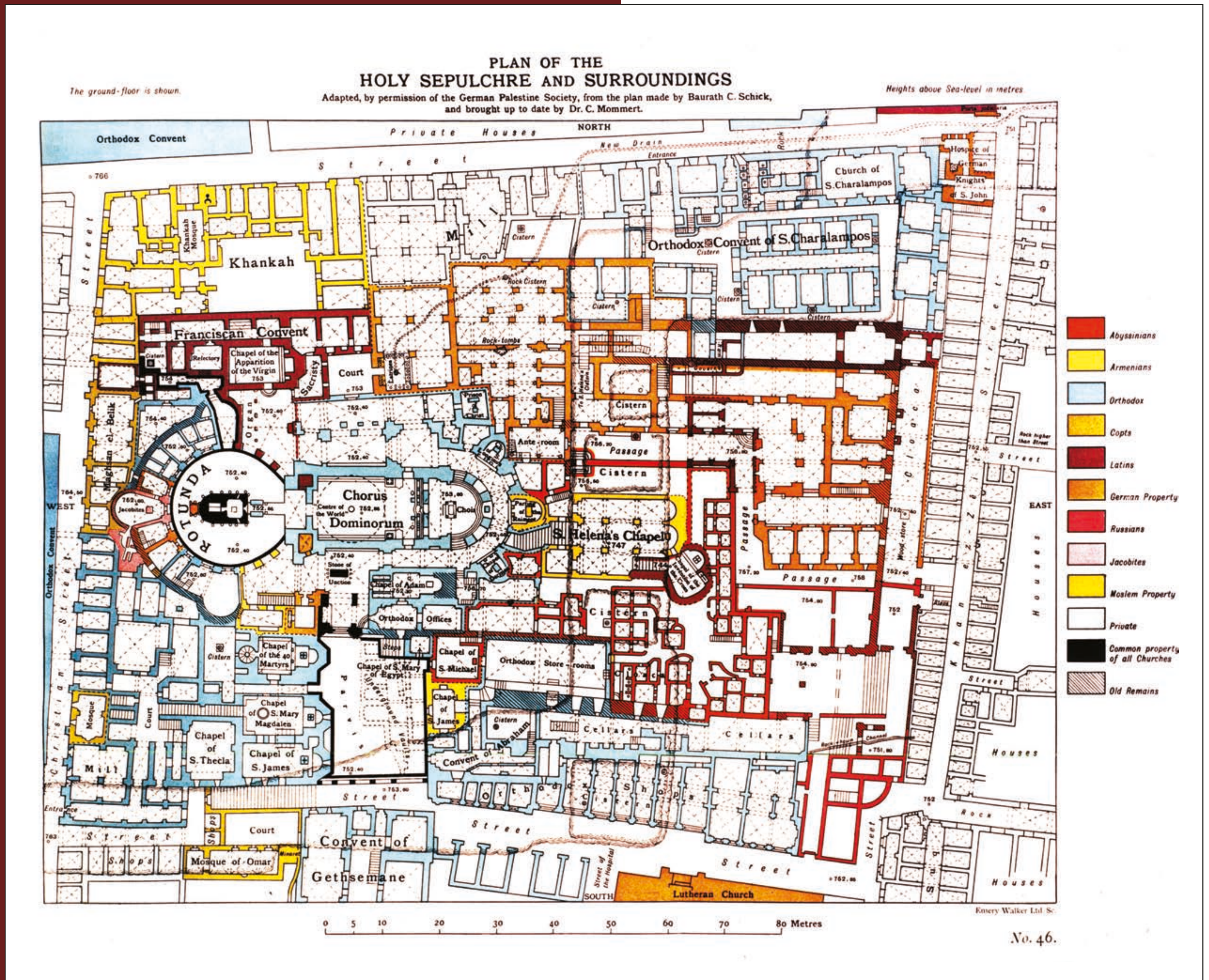
In the first phase of the extractive process the smaller blocks were quarried, in order to level the surface. Then, the bigger blocks were extracted, creating wide detachment channels. The channels, marked by means of chisels too, were cut all around the blocks except for their bottom, probably because of a natural discontinuity in the rock stratification. To facilitate the extraction, wooden wedges would be placed inside the channels and then soaked with water. The pressure generated by the wood natural enlargement would have helped to detach the block. Finally, the wedges would have been beaten until the complete detachment of the block (Figure 51B).
The quarrymen would use first the natural discontinuities of the rock to insert wedges, therefore blocks were usually extracted along their natural stratification.

[123] The excavation has been realized before the construction of residential buildings, under the direction of Dr. Ofer Sion and Yehuda Rapuano of the Israel Antiquities Authority.
[124] According to the Bible, the Temple of Solomon or First Temple was built by King Solomon in the tenth century BC. It was completely destroyed by Nebuchadnezzar II in 586 BC. The works for the Second Temple started in 536 BC. It was completed on March 12, 515 BC. It was then restored on November 21, 164 BC by Judah Maccabee. The Temple of Herod was an important expansion of the Second Temple; it was started by Herod the Great around 19 BC and completed in all its parts only in 64 AD. The Second Temple was destroyed in 70 AD by the Emperor Titus. Today only its western wall remains, knows as Wailing Wall.
[125] http://www.antiquities.org.il/article_Item_eng.asp?secid=25&subjid=240&id=1586&module_id=#as

Part one

Chapter IV

FIGURE 1 "Plan of the Holy Sepulchre and Surroundings" Adapted, by permission of the German Palestine Society, from the plan made by Baurath C. Schick, and brought up to date by Dr. C. Mommert, drawn by Conrad Schick in 1863 on behalf of the Ottoman authorities. This plan was designed to help the authorities to understand the distribution of the church complex among the different Christian groups.



THE "STATUS QUO" IN THE CHURCH OF THE HOLY SEPULCHRE

14

Athanasius Macora

1.4.1. The *"Status Quo"* in the Holy Sepulchre Church

The Holy Sepulchre Church in Jerusalem, the Nativity Church in Bethlehem and the Tomb of the Virgin in Gethsemane are unique in that they are the only Christian shrines in the world that are shared by different Christian Communities. In the Holy Sepulchre we find six Christian Communities who share the Church complex in complete agreement as to the importance of the Holy Place. Here we find different Christian Communities often worshipping the same God under the same roof at the same time. However, this sharing of the Church, which is one of its most fascinating aspects, is also something that generates incomprehension and negative publicity. This sharing is known as the *Status Quo.* Almost everything concerning operations in the Church is regulated by this reality. Therefore, defining what the *Status Quo* means is important.

1.4.2. The *"Status Quo"*

In February of 1852 the Sultan of the Ottoman Empire, Abdul Majid, issued an imperial decree *(Firman)* by which he obliged the Ottoman Governor of Jerusalem and other members of the Ottoman government in Jerusalem, as well as the Christian Communities, to «maintain things in their actual state» and «to introduce no changes» in the holy places that were held in common.

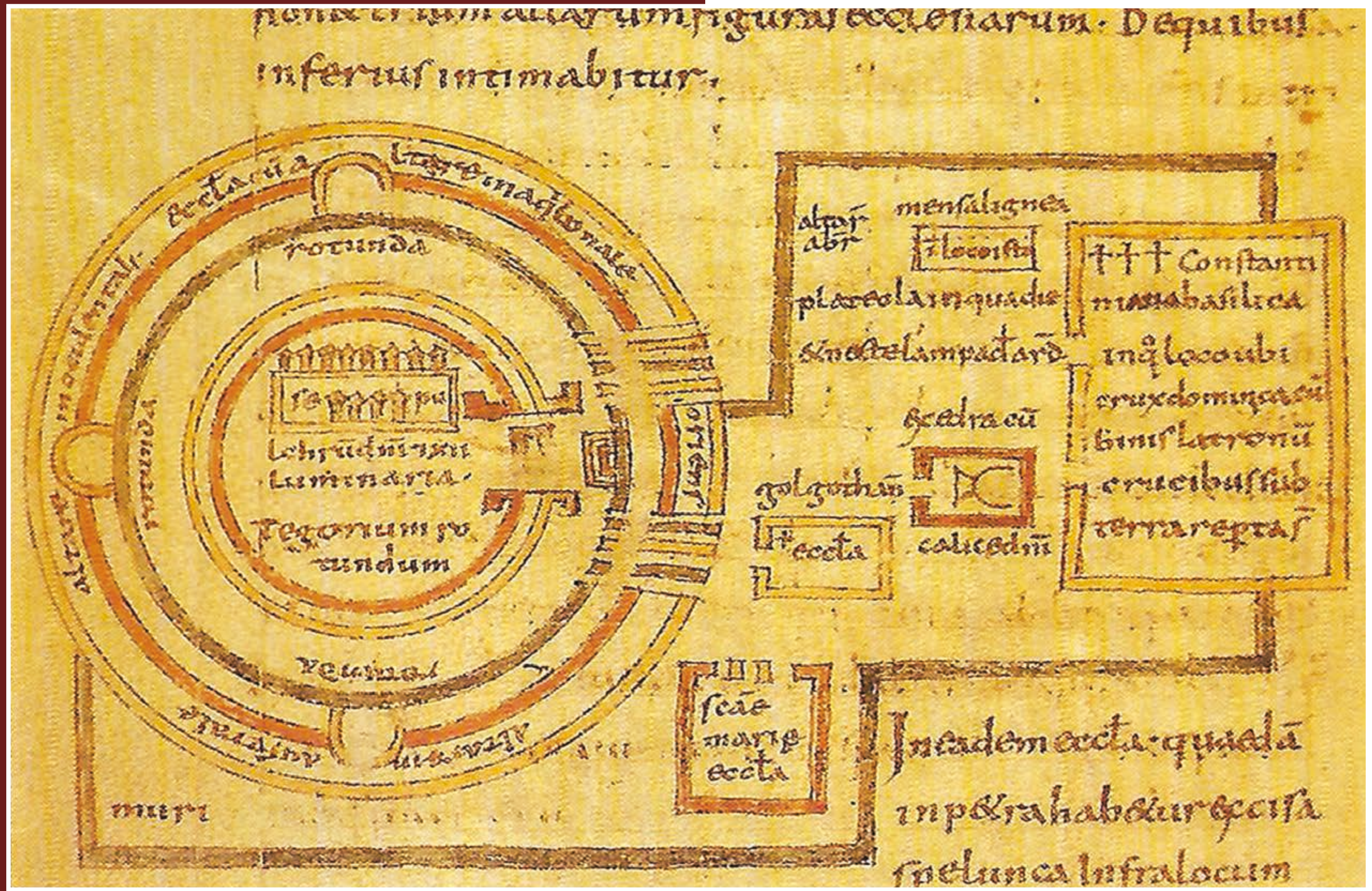
The decree is very short – translated into English it counts about 1,000 words – and it contains very few details. The decree affirms that the Church of the Holy Sepulchre, the *Basilica* of the Nativity, the Tomb of the Virgin and the Dome of the Ascension should remain in their existing state, as they were in February 1852. Of the four above-mentioned shrines, only the Dome of the Ascension is not possessed by Christians, but rather by Muslims. This concept that «there is to be no change» is repeated six times in reference to the shrines mentioned in the decree. The substance of the decree was later called the «*Status Quo*» in the Treaty of Berlin in 1878.

The *Status Quo* therefore imposed on all the Communities present in these four above-mentioned shrines that they remain as they were, with no changes of possession or use in the widest sense of the term. Hence, it is interpreted to mean that there would be no changes in possession, prayer schedules, cleaning, repairs, and so forth.

Part one

Chapter V

FIGURE 1 Plan of the Holy Sepulchre, from Adamnan's manuscript (IX century) based on Arculf's report about his pilgromage to the Holy Land (VII century).



15

SURVEYS OF THE HOLY SEPULCHRE IN JERUSALEM FROM THE XVI CENTURY TO PRESENT TIMES

Grazia Tucci

This chapter presents an overview, in chronological order, of the most important surveys of the Church of the Holy Sepulchre since the latter part of the 16th century, beginning with those by Jean Zuallart (1586) and Bernardino Amico (1591-1597)[1], and ending – after a list of works, almost none of which are first-hand studies, published before the fundamental *Jérusalem Nouvelle* (1914) by Vincent and Abel – with an examination of new contributions in the 20th century.

Among the later works, much space is given to the reports by W. Harvey (1935) and the supplementary checks by L. Marangoni (1937) on the building's structural stability after the 1927 earthquake, and the associated disagreements over the risks of collapse, also in view of the excess load of the stone dome that it was planned to erect over the *Anastasis*, and the forces that would thereby be transmitted to the adjacent structures (the transepts and *Katholicon*). Of more recent work, the list includes, after the investigations by C. Coüasnon[2] and the excavations by Father Corbo (1960-1980)[3], the accurate photogrammetry surveys by M. Biddle (1989-90), restricted only to the *Aedicula*, and the work of A. Georgopoulos and G. Lavvas, before finally covering the topographical measuring campaigns and laser 3D scans carried out (2007-2010), under my own supervision, by the GeCo Laboratory of the University of Florence for diagnosis of the seismic security of the monument, as commissioned by the Custodianship of the Holy Land from the C.A.Be.C., directed by Prof. Malesani.

In choosing the surveys, consideration was given to their accuracy, and whether information about measurements is given in the plates and/or in the text, omitting studies on the topography of Jerusalem and the resultant city maps, starting with the famous one by Antonino De Angelis[4] (1578), and the more sketchy illustrations, or those taken from previous works, and renderings of supposed original layouts, including those outlined by Vincent and Abel (1914), Kenneth J. Conant (1956)[5] and Terry Ball, a collaborator of Coüasnon. Nor was consideration given to diagrams in essays and volumes by architectural historians (G.A. Dehio, A. Grabar, E. Dyggve, etc.), and the suppositions advanced regarding the Holy Sepulchre site in the mid-1800s by Edward Robinson, James Fergusson and Charles Wilson[6], which at the time were the subject of fierce controversies, that disputed the location of the Tomb of Christ and the site of the original

[1] The first edition of B. Amico's *'Trattato'* appeared in Rome, printed by the Typographia Medicea. The authorization was issued by the Vicario Generale on 20 July 1609, and the printing was completed on 28 March 1610. It took Fra' Bernardino almost four years to prepare the work (B. Bagatti, *Fra Bernardino Amico disegnatore dei Santuari Palestinesi alla fine del '500*, "Studi Francescani", Florence, 1938, pp. 307-25, reprinted in: M. Piccirillo, *La nuova Gerusalemme*, Custody of the Holy Land, 2007, pp. 233-238).

[2] Charles Coüasnon (Rennes 1904 - Jerusalem 1976) was an architect and a Dominican friar. A student at the École Nationale des Beaux-Arts in Paris (1927-33), he arrived in the Holy Land in July 1950 to follow the third excavation campaign at Tell el-Raha. In 1954 he was appointed by the Custodianship of the Holy Land, having been chosen by P. Coupel (replaced the following year by Jean Trouvelot), to oversee the on-site investigations and restoration works, which were undertaken in 1962, in line with the programme adopted in 1959 by the three Christian Communities. The works, concerning the static reinforcement and restoration of the Crusader church (the *Rotunda* and Transept with the choir of the Canon Fathers) in its 12th century appearance, were completed in 1992, after being broken off in 1980 owing to disagreements regarding the dome of the *Anastasis*. Contributing to the delay in the restoration work, the subject of unfortunate friction between Coüasnon and the Custodianship, in the person of P.A. Rock, was the disagreement on the part of the Greeks, who wanted work to be restricted to repairing the existing structures. Nevertheless Coüasnon managed to establish a productive relationship with Leonidas Collas, the new architect of the Orthodox Patriarchate (1961-64). Together with him, he decided to conduct a trial excavation of the foundations, thereby establishing that the original building was built over an abandoned quarry, around the year 100 BC. He appointed Terry Ball to make the drawings (1964-67). A detailed report on the surveys and the works under way at the time was published by Coüasnon in the magazine *Terra Santa* (no. 10, 1964, pp. 284-294), followed two years later by his report "Les travaux de restauration du Saint-Sépulcre" to the Académie des Inscriptions et Belles-Lettres (*Comptes-rendus des Séances...*, année CX, n. 2, 1966, pp. 209-226). Regarding the ups and downs in the history of this work, see: R. Cohen, *Saving the Holy Sepulchre*, Oxford University Press, 2008.

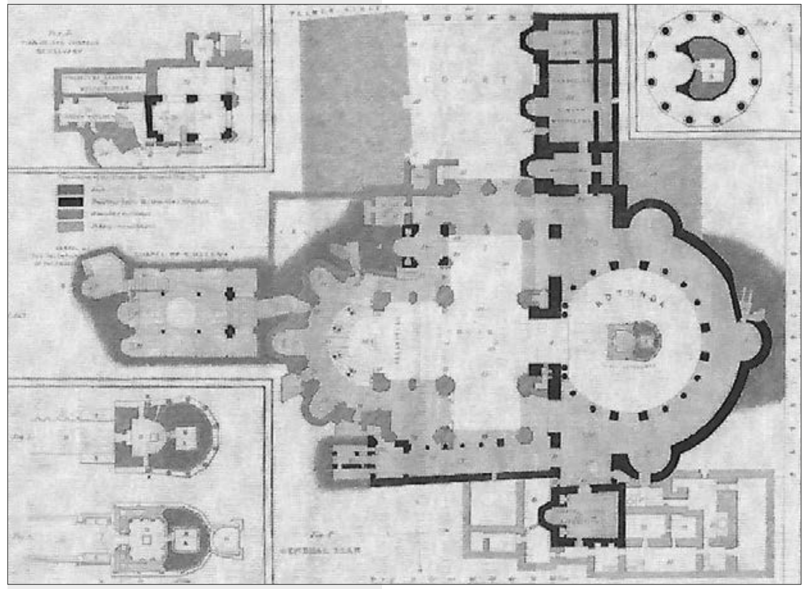
[3] Starting in 1963, the Franciscan architect Virgilio C. Corbo (1918-1991) supervised, on behalf of the three religious communities (Catholic, Greek Orthodox and Armenian), the surveys and excavations inside the building and in the area of the monumental Complex.

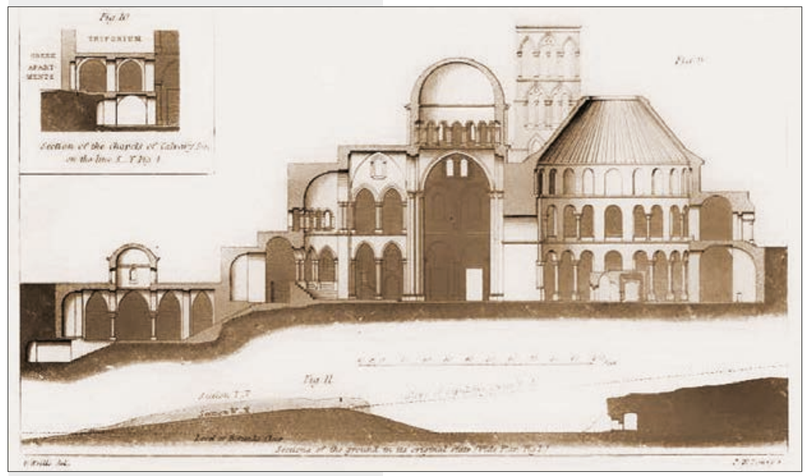
[4] The map by Antonino de Angelis (1578) is regarded as one of the most accurate topographical maps of the city of Jerusalem. Having lived about 8 years in these lands, Fr. Antonino made the plan of the city of Jerusalem with the help of Fr. Francesco della Salandra, who later became Guardian (i.e. Superior of the Convent of Residency), living 40 years in the Holy Land. Soon after its publication, the Map was certainly known and used everywhere in Europe, due to its innovations compared to previous maps. Maldovan, the Map's editor, noted that the impact of De Angelis' work on subsequent plans of Jerusalem was considerable. Cf. M. Piccirillo, "The role of the Franciscan in the translation of the sacred spaces from the Holy Land to Europe", in *New Jerusalem Hierotopy and iconography of sacred spaces*, Edited by Alexei Lidov, published by "Indrik", Moscow, 2009.

[5] K.J. Conant, "The Original Buildings at the Holy Sepulchre in Jersusalem", in *Speculum* vol XXXI, no. 1, 1956, pp. 1-48). Conant had undertaken the investigations, making special

12
JOSEPH J. SCOLES
(1798-1863)

J.J. Scoles, "Rilievo della Chiesa del Santo Sepolcro" published by Robert Willis in: *The architectural history of the Church of the Holy Sepulchre at Jerusalem*, J.W. Parker, London 1849.





Above:

General Plan of the Church and its adjacent Chapels, as they existed before the fire of 1808. Insets: Plan of Calvary Chapels upon the mezzanine floor; Plan of the present Holy Sepulchre; conjectural Plan of the Holy Sepulchre as originally fitted up by Constantine.

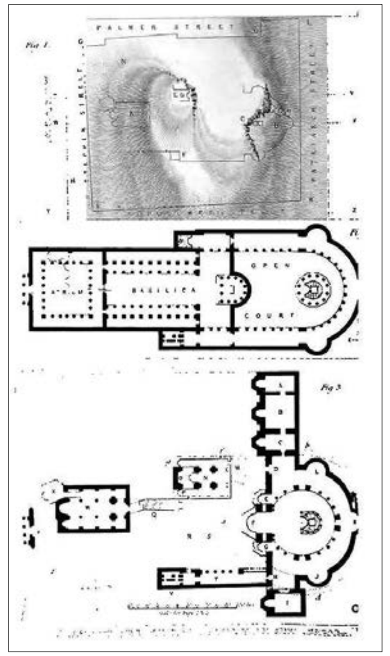
Below:

A Section of the church from East to West. Insets: a Section through part of the rock of Calvary and its Chapels; a set of East and West Sections of the original state of the ground placed upon the same level.

Joseph John Scoles was an English Gothic Revival architect, who designed several Roman Catholic churches. He was apprenticed in 1812 for seven years to his kinsman, Joseph Ireland, an architect largely employed by Dr. John Milner, the Roman Catholic bishop. In 1822 Scoles left England and devoted himself to archaeological and architectural research in Rome, Greece, Egypt, and Syria. He published in 1829 an engraved "Map of Nubia", and a map of the city of Jerusalem. In 1826 he returned home and resumed his practice. Scoles was elected a Fellow of the Royal Institute of British Architects in 1835, was honorary secretary, and vice-president in 1857-8. To the society's proceedings he contributed papers principally on the monuments of Egypt and the Holy Land, the outcome of his early travels[1].

His measured map (1825) of the church of the Holy Sepulchre, Jerusalem, with his drawings of the Jewish tombs in the valley of Jehoshaphat, was used by **Robert Willis**[2], as the basis for plates 1, 2 and 3 of his treatise *The architectural history of the Church of the Holy Sepulchre at Jerusalem* (London 1849). In note C, in the appendix, R. Willis gives some history of the materials from which he compiled the Plans and Sections in his Plates. He cites the work of Father Bernardino for its known characteristics of completeness, and because it was accompanied by detailed descriptions and measurements. However, while he regards the plan as reliable because it is accurately drawn, and because it was not significantly altered in the reconstruction after the fire of 1808, the same cannot be said for the elevations, which he believes to be wrongly surveyed in part, and in part the product of a Classical interpretation. To this end, he backs up his observations by comparing Bernardino's surveys with those of Le Bruyn and other authors, and to compile his tables he makes use of the particularly accurate work of Scoles. Finally, Willis emphasises that the drawings are a personal elaboration based on «my own view, although based upon fairly correct data», and that he submits them «to the criticism of future observers, and shall be most grateful for corrections, or for additional information». The text by Willis appears in the second edition (1849) of the volume by G. Williams, *The Holy City*. The surveys by Scoles, published by Willis, are also reproduced in chapter three of Charles M. De Vogüé's work: *Les églises de la Terre Sainte*, Paris, 1860 (pp. 118-232). See especially plates XVIII, XIX and X, which Jeffrey corrects on the basis of observations made on the scene, for the layout of the vaults.

From above: Plan of the supposed state of the ground at time of the Crucifixion; Plan of the *Basilica* of Constantine; Plan of the churches, as rebuilt by the Caliph Hakem in 1010.



[1] Biographical information in: http://www.victorianweb.org/victorian/art/architecture/scoles/index.html; Nicholl, Samuel Joseph (1897). "Scoles, Joseph John". In Lee, Sidney (ed.). Dictionary of National Biography. 51. London: Smith, Elder & Co.

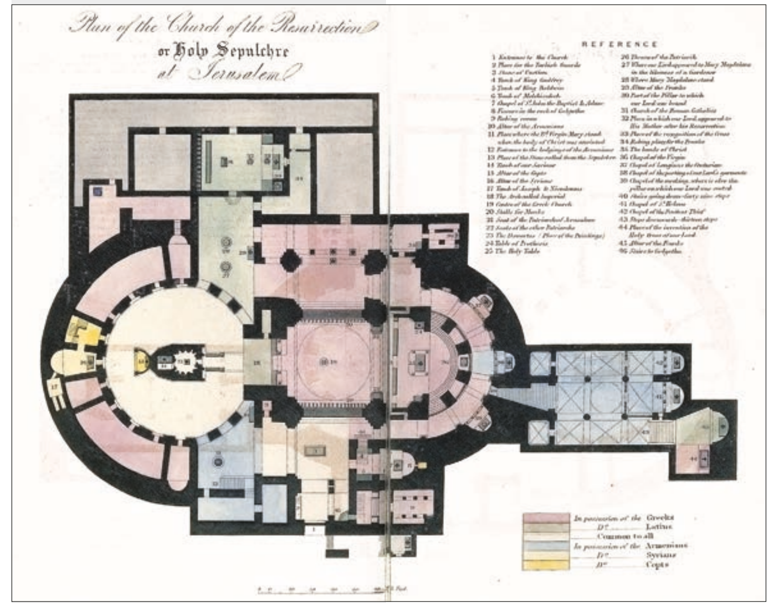
[2] See note 11 p.127 of this volume.

13
GEORGE WILLIAMS
(1814-1878)

G. Williams, *The Holy City: or, historical and topographical notices of Jerusalem; with some account of its antiquities and of its present condition*, with additions, including *An architectural history of the Church of the Holy Sepulchre, by R. Willis*, London, J.W. Parker, West Strand, Cambridge, T. Stevenson, 1845.

On p. 296 there is a colour floor plan of the Church, more accurate than the previous illustration by Scoles. The different colour washes indicate the properties of the different faiths.

Colour Plan of the *Basilica* of the Holy Sepulchre, each hue individuating the properties of the different Communities.



George Williams (1814–1878) attended King's College, Cambridge. He was ordained in 1837, and accompanied Bishop Alexander as chaplain to Jerusalem from 1841 to 1843. He was England's greatest authority on the topography of Jerusalem in his day, and received a medal from the King of Prussia for literary merit based on his two-volume work, *The Holy City*. In this well-illustrated work, he draws on both physical and literary evidence to conclude that the case for the traditional site is sound, while also surveying the great city's history and character. Throughout his career, he served many posts at various academic institutions, including King's College and Cumbrae College, and was made honorary canon of Winchester Cathedral in 1874.

This work supports the traditional location of Calvary against the challenges of contemporary scholarship. Since the opening up of Palestine to foreign travellers in the 1830s, there had been intense interest in locating places described in biblical narrative. The author's intention was to carefully study the topography of the ancient city, and assess the veracity of the location of the places in the Passion of Christ. He investigated the likely location of the city walls (whether or not they included the site that was being studied), and presented and debated a wide range of suppositions, comparing them to each other (Dr. Robinson, Dr. Schultz, Mr Smith…), before concluding that "the tradition relating to the Holy Sepulchre, so far from being invalidated by the consideration of its locality, is much confirmed" (p. 69). He analyses the various moments in history, connecting them to the descriptions of pilgrims and travellers, and with the historical sources of Eusebius, the Bordeaux Pilgrim, Cyril's, and Arculfus. He criticises the approach of Mr. Fergusson (who had never been to Jerusalem), and does not approve of his hypothetical recontructions, and says his theories cannot hold. He confirms the reliability of the Architectural History of the Church of the Holy Sepulchre, as written «from the pen of Professor Willis», who so fully established the identity of the present site with that of the original Sepulchre.

14
CHARLES J.-M. DE VOGÜE
(1829-1916)

Ch.J.M. de Vogüé, *Les églises de la Terre Sainte. Fragments d'un voyage en Orient*, Victor Didron, Paris, 1860.

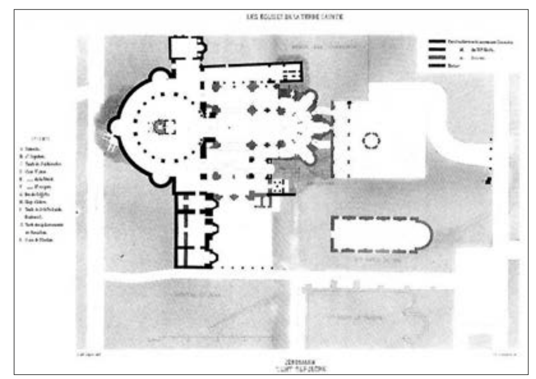
Charles-Jean-Melchior de Vogüé (Paris 1829–1916) was a French archaeologist, diplomat, and member of the Académie Française. In 1849 he was attached to the French Embassy in St. Petersburg. After his father's arrest during the French coup of 1851, de Vogüé gave up diplomacy to focus on archaeology and history in Syria and Palestine.

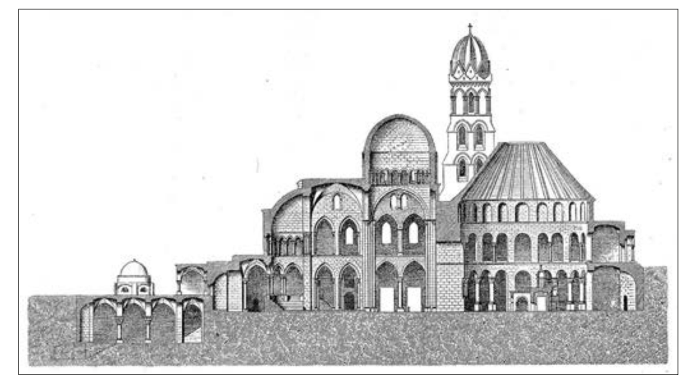
Named as a member of the Académie des Inscriptions et Belles-Lettres in 1868, he continued to publish learned articles on churches in the Holy Land, the Temple of Jerusalem, and Central Syria. After the fall of the Second Empire, Adolphe Thiers

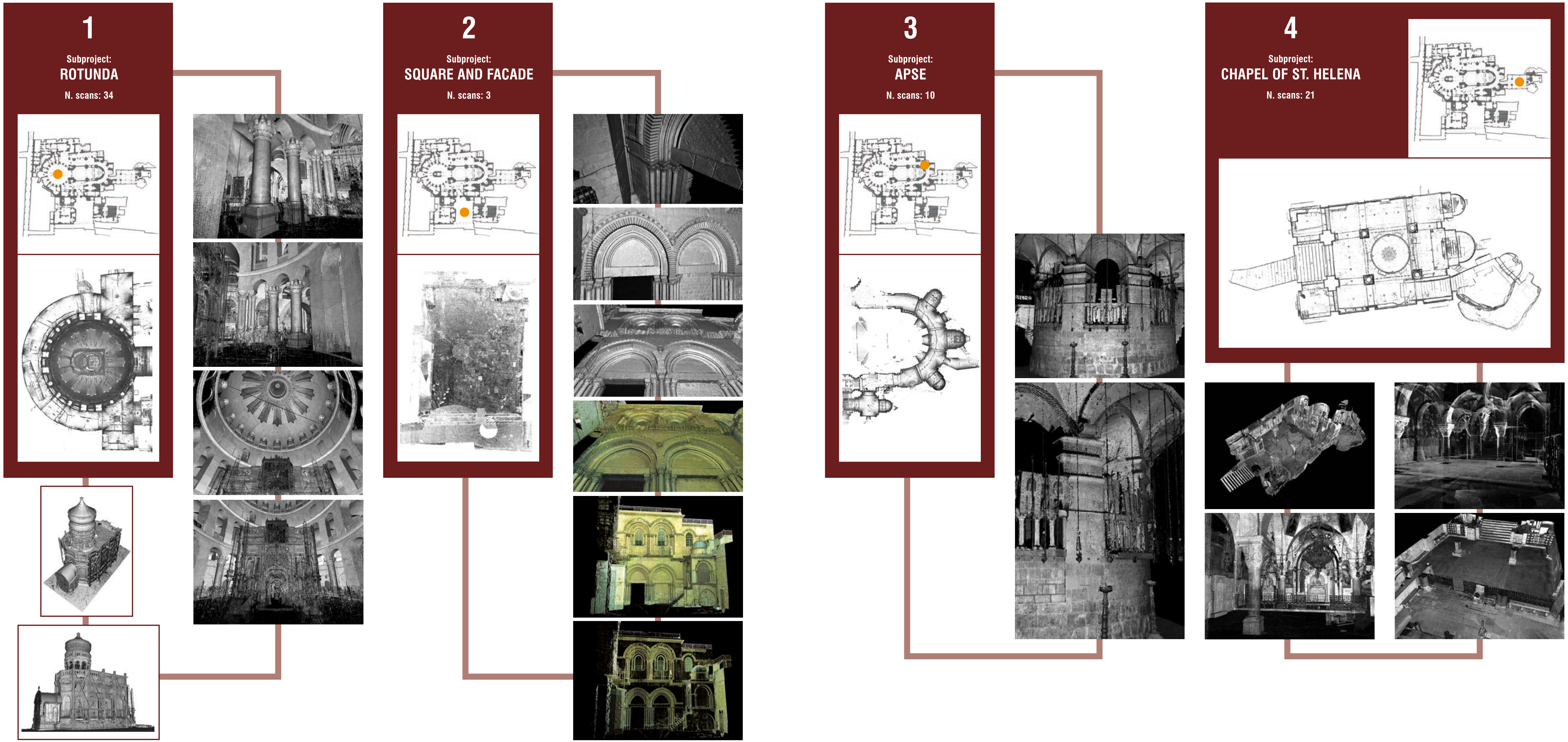
From left:

Plan of the *Basilica* of the Holy Sepulchre, with individuation of the different building phases.

Longitudinal Section of the *Basilica* as it was in the XII century.



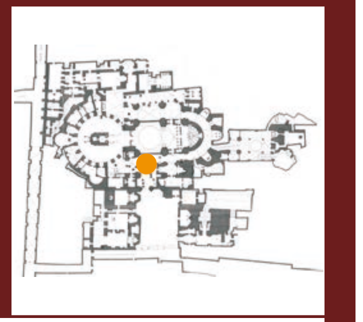


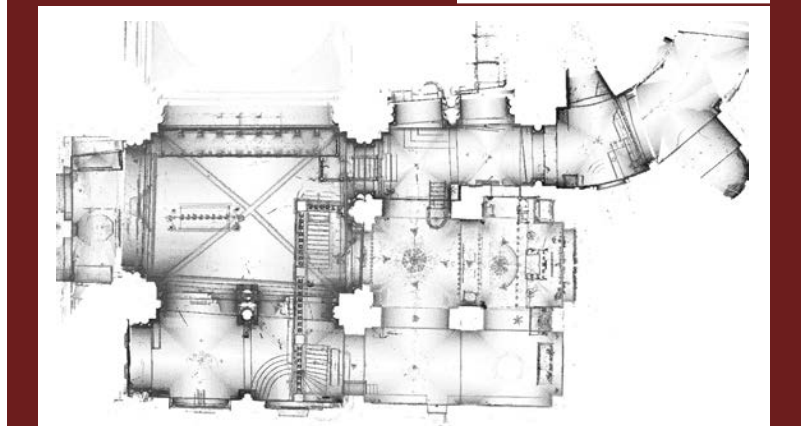

1
Subproject:
ROTUNDA
N. scans: 34
2
Subproject:
SQUARE AND FACADE
N. scans: 3
3
Subproject:
APSE
N. scans: 10
4
Subproject:
CHAPEL OF ST. HELENA
N. scans: 21

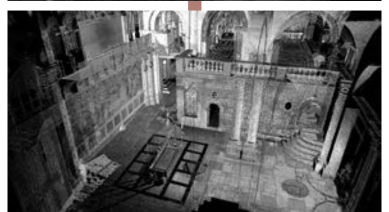
5

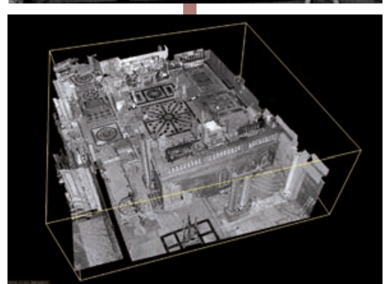
Subproject:
ENTRANCE AND GOLGO-THA

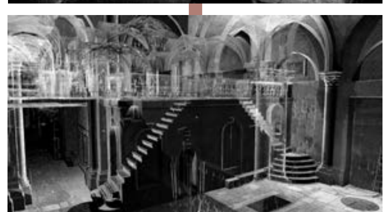
N. scans: 10+5







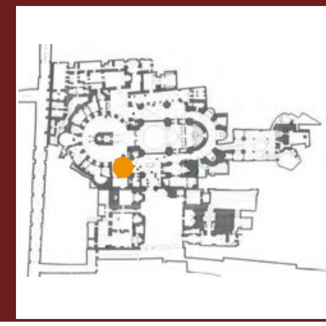


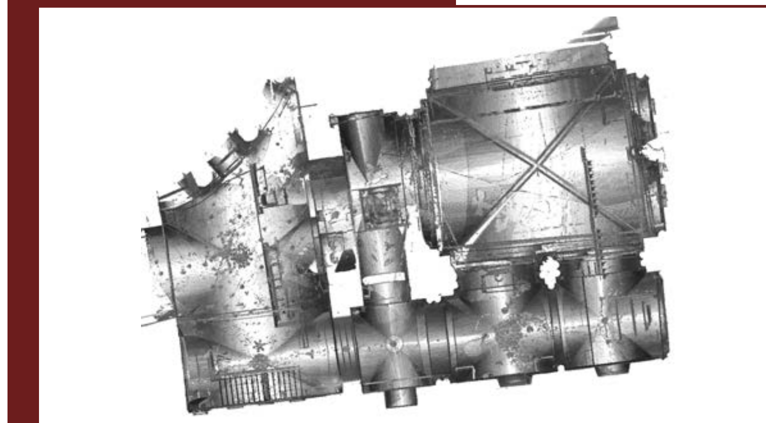


6

Subproject:
ARMENIAN CHAPEL

N. scans: 8

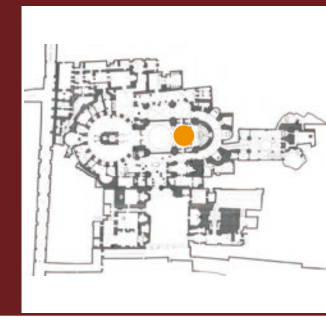


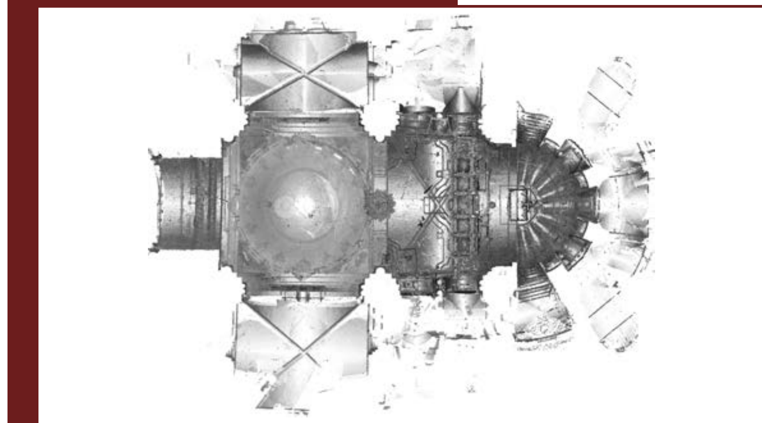


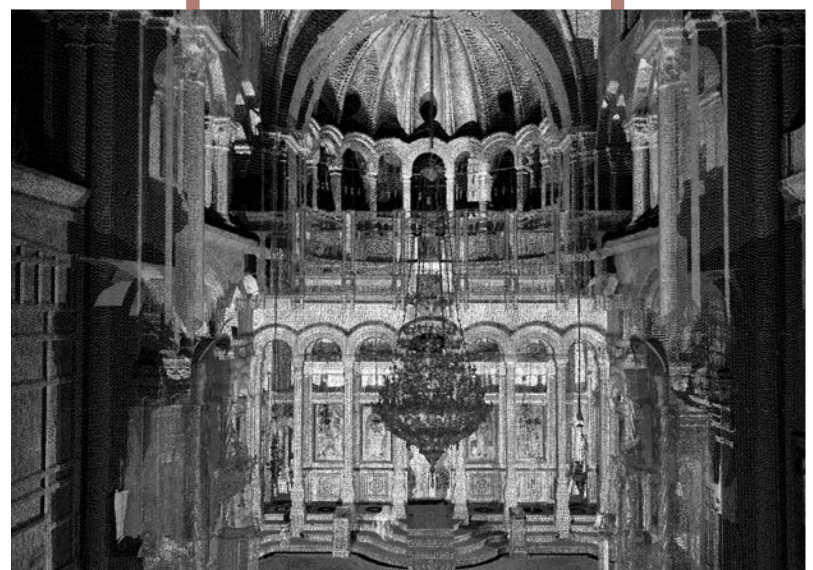
7

Subproject:
CATHOLICON

N. scans: 15



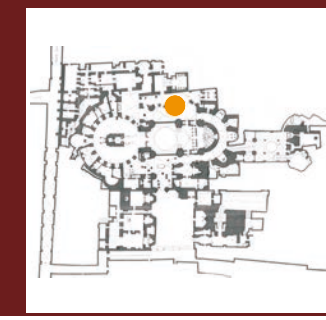


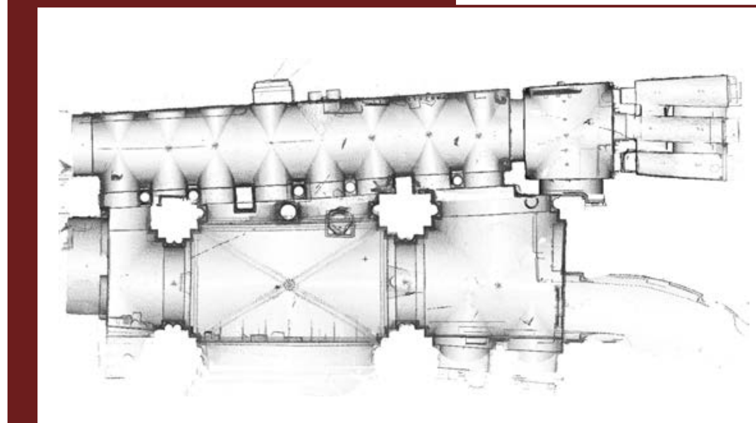


8

Subproject:
ARCHES OF THE VIRGIN

N. scans: 9





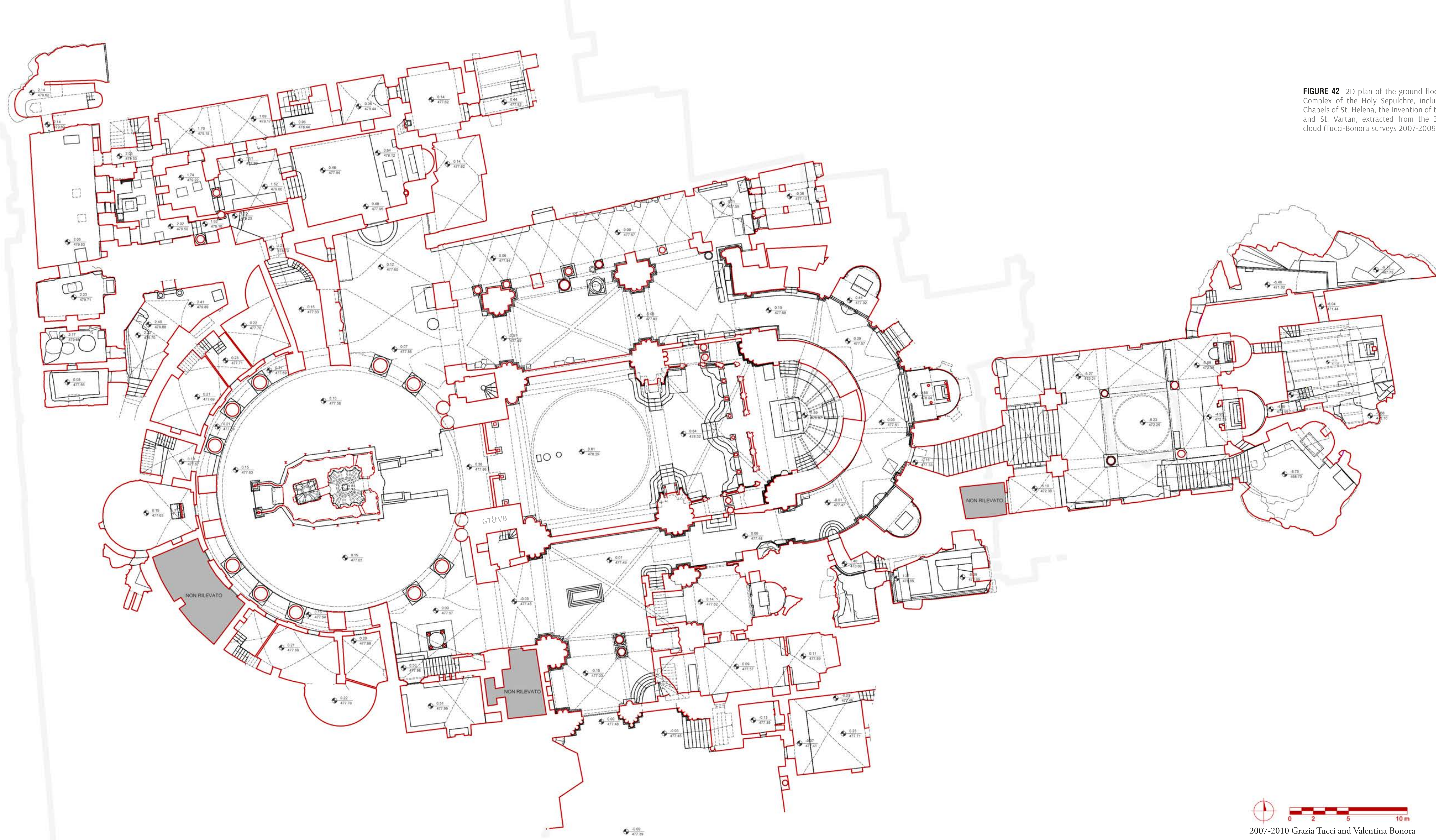


FIGURE 42 2D plan of the ground floor of the Complex of the Holy Sepulchre, including the Chapels of St. Helena, the Invention of the Cross and St. Vartan, extracted from the 3D point cloud (Tucci-Bonora surveys 2007-2009) .

2007-2010 Grazia Tucci and Valentina Bonora

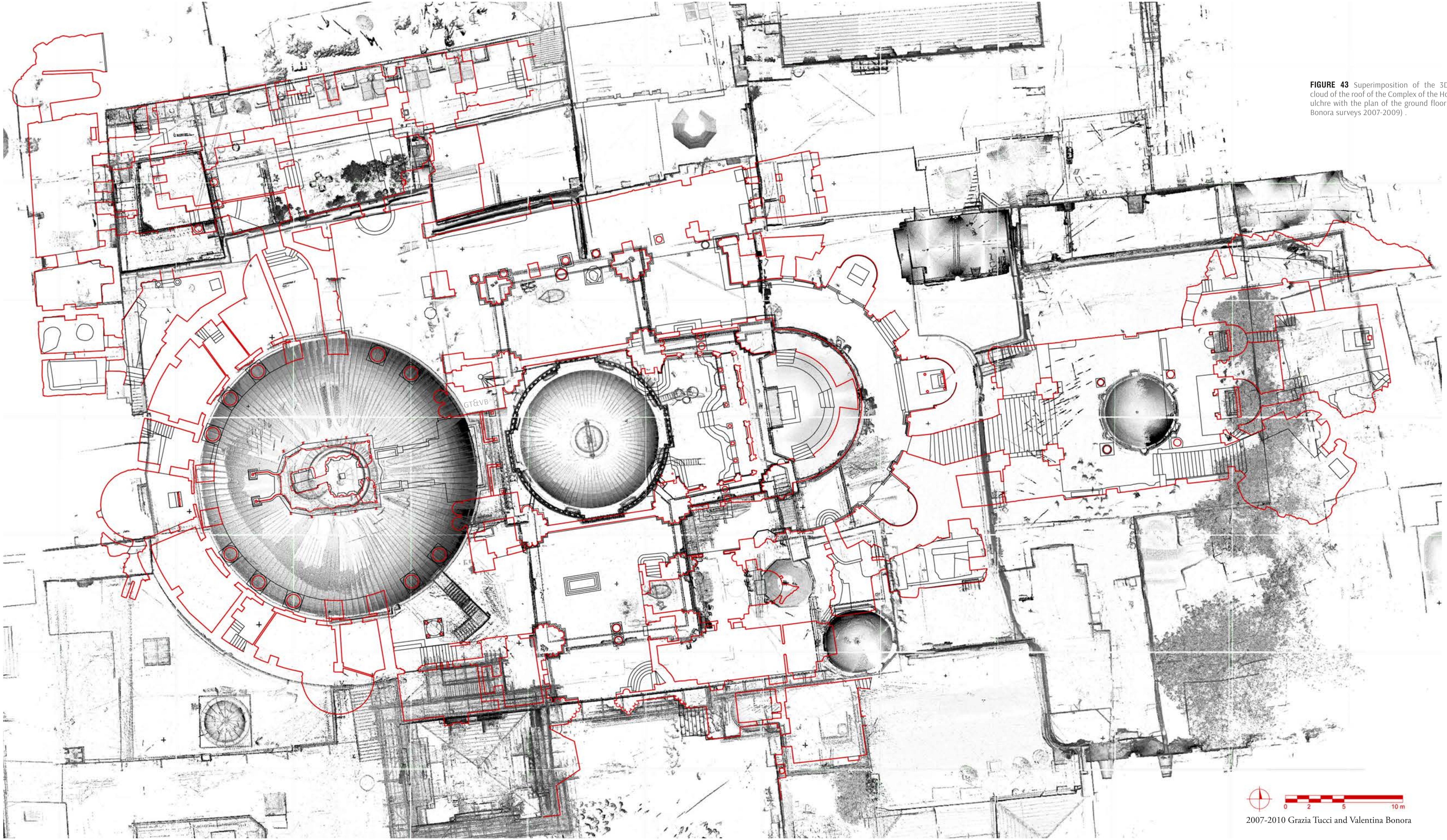


FIGURE 43 Superimposition of the 3D point cloud of the roof of the Complex of the Holy Sepulchre with the plan of the ground floor (Tucci-Bonora surveys 2007-2009) .

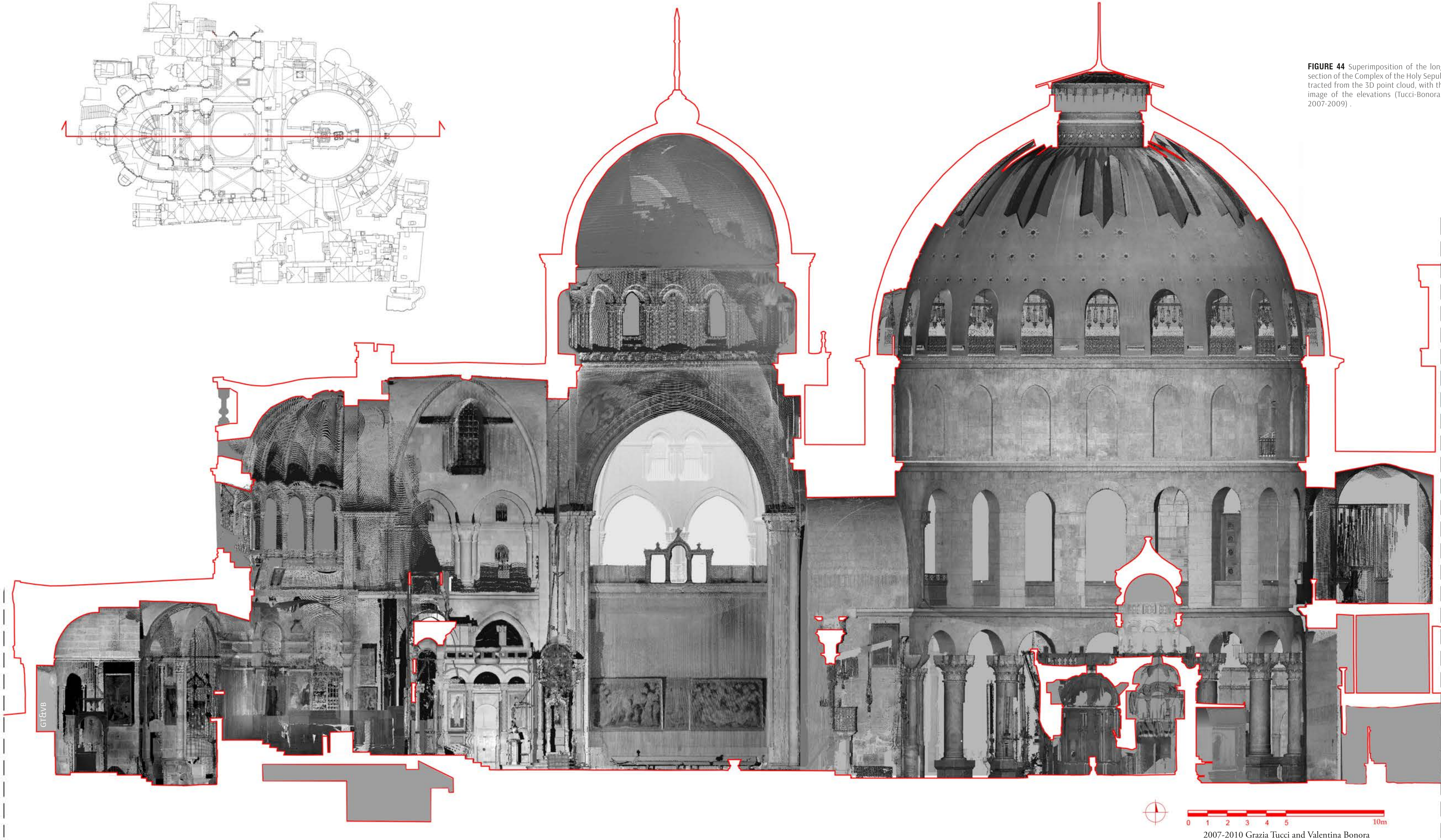


FIGURE 44 Superimposition of the longitudinal section of the Complex of the Holy Sepulchre, extracted from the 3D point cloud, with the ortho-image of the elevations (Tucci-Bonora surveys 2007-2009) .

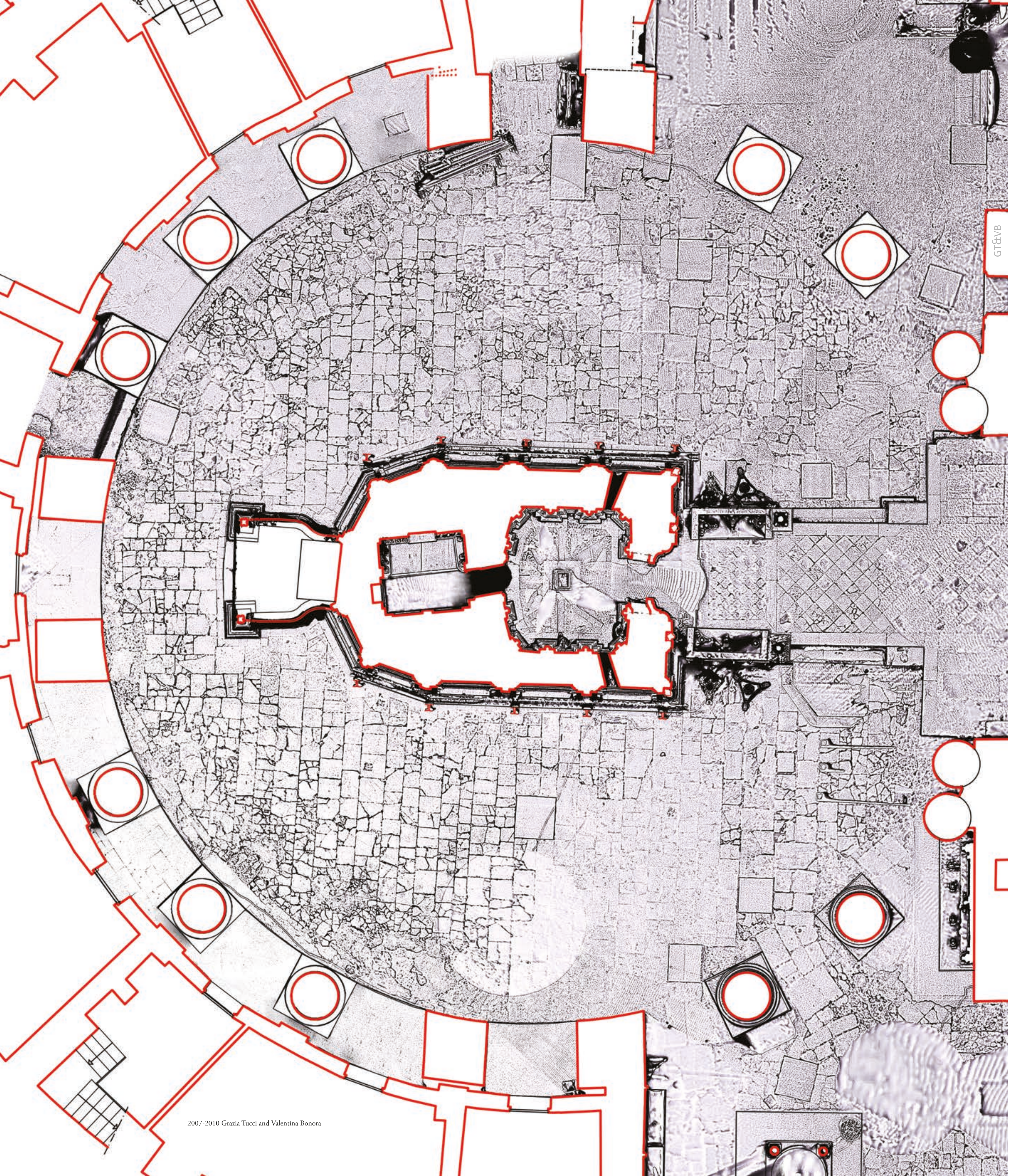


FIGURE 46 Superimposition of the longitudinal section of St. Helena Chapel, extracted from the 3D point cloud, with the orthoimage of the elevations (Tucci-Bonora surveys 2007-2009) .

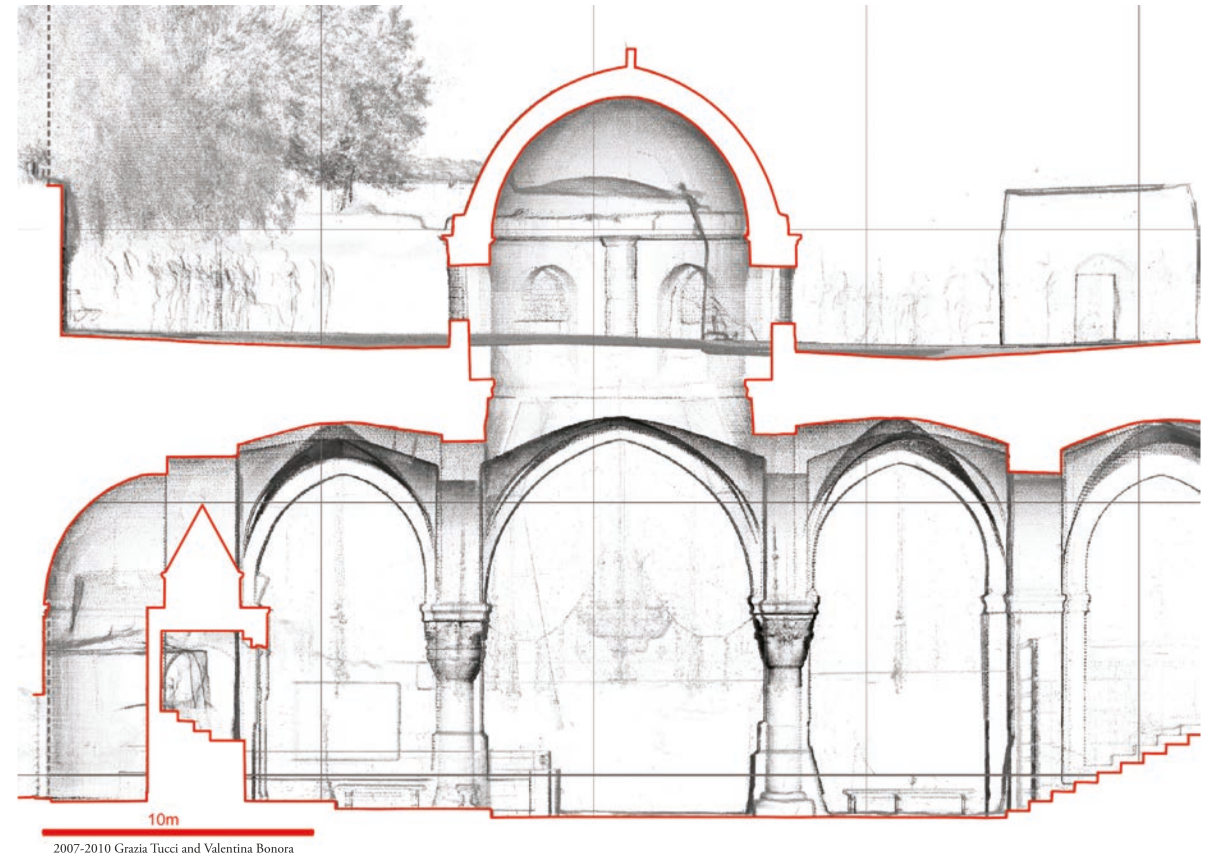
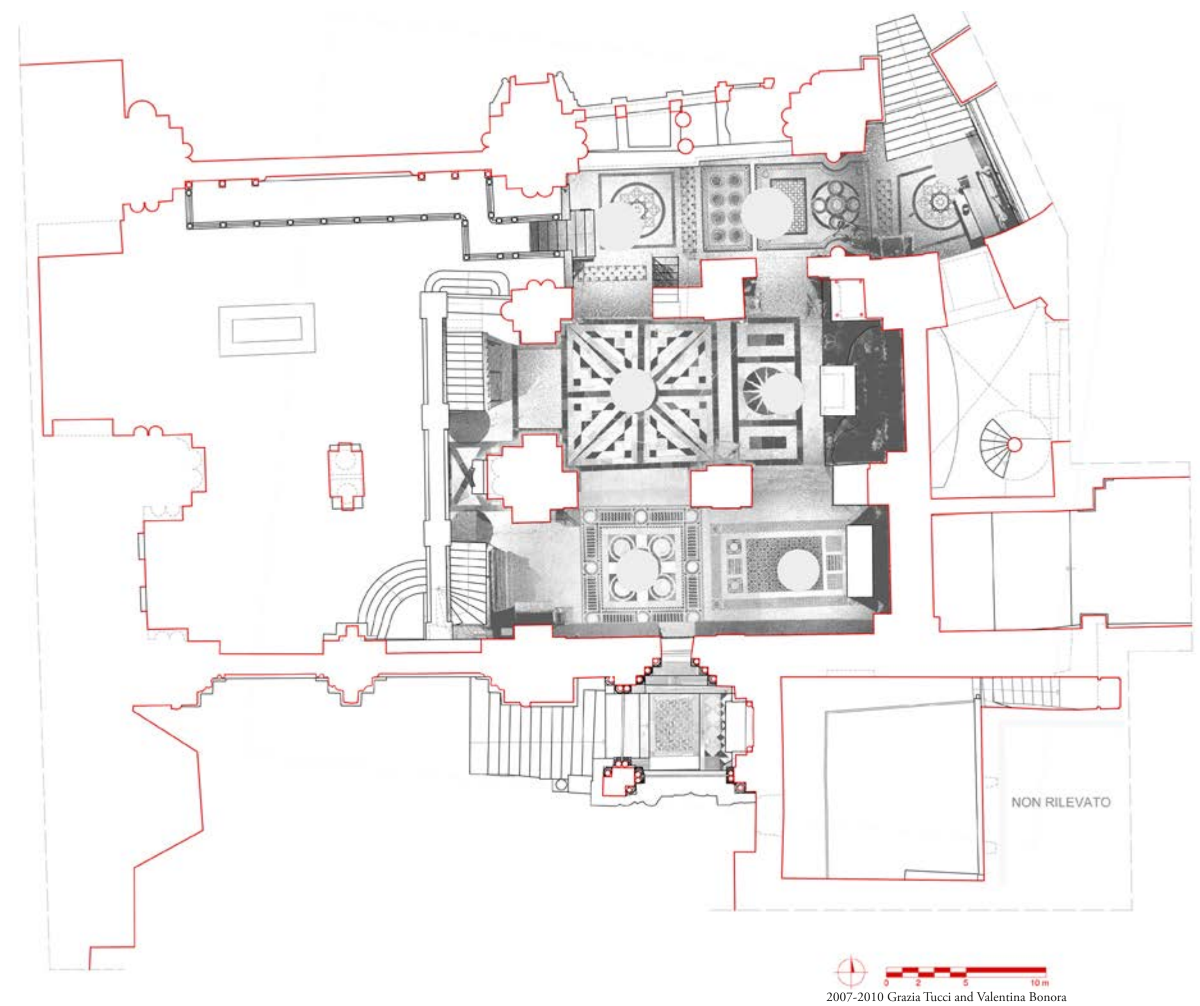


FIGURE 47 Superimposition of the plan of the 1st floor of the Golgotha, extracted from the 3D point cloud, with the orthoimage of the floor (Tucci-Bonora surveys 2007-2009) .



In the previous page:

FIGURE 45 Superimposition of the plan of the *Rotunda*, extracted from the 3D point cloud, with the 3D mesh of the floor (Lidia Fiorini from Tucci-Bonora surveys 2007-2009) .

FIGURE 14 A blocking out approach in modelling the *Aedicula*: starting from a very simplified model, small details are progressively added.

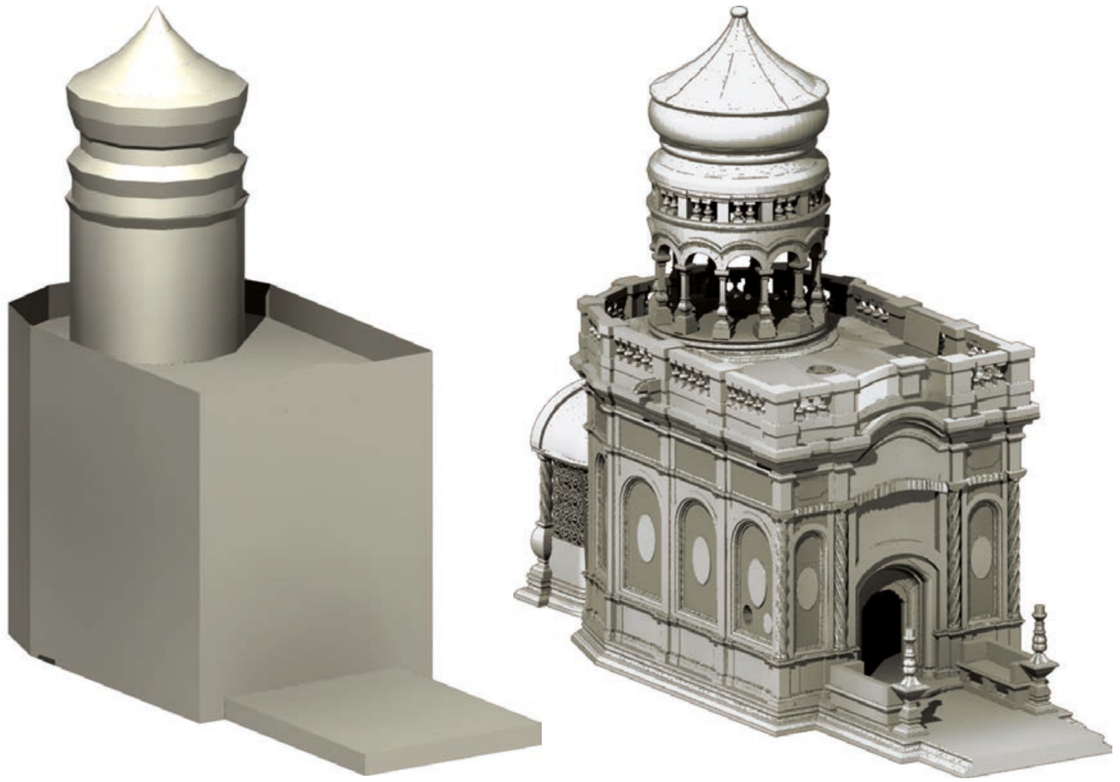
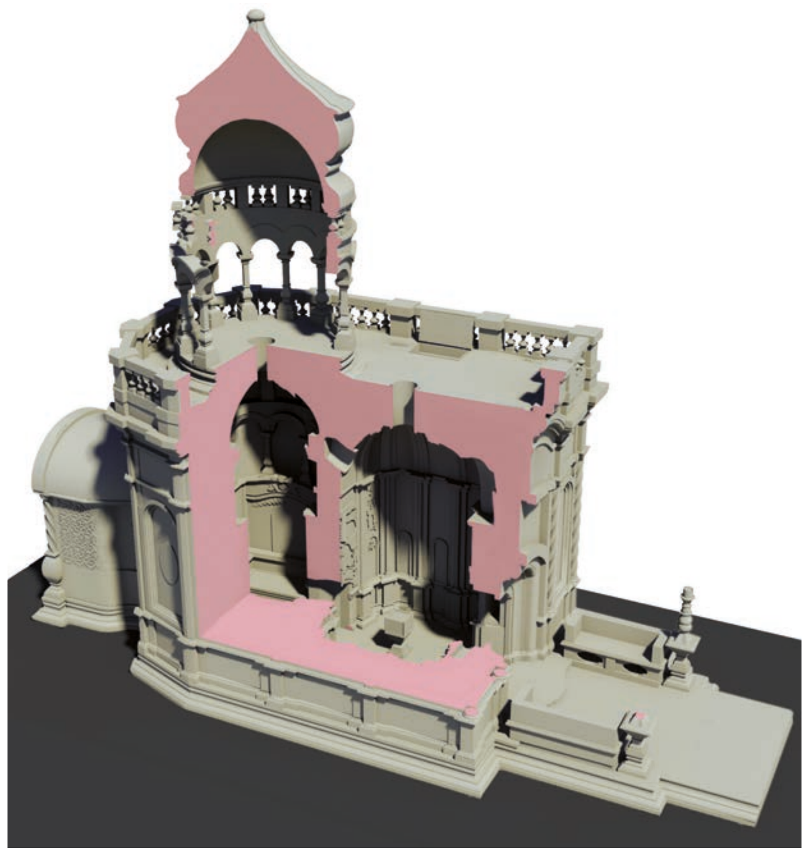


FIGURE 15 *(below)* View of the inside and outside of the 3D model of the *Aedicula*.



2.3.3. State of progress in modelling and future prospects

Over the three survey campaigns, the three-dimensional data acquisition extended to the whole of the Holy Sepulchre complex. Thanks to the technical characteristics of the tools used, at the same time we were able to survey buildings and structures not directly concerned by the studies underway. Thus we were able, for example, to survey the whole width of the street marking the western edge of the complex, the surrounding buildings and the roofs in a large area around the church, up to the minaret on the Omar mosque. Hence, we acquired an enormous database, which at first was just used for the structures analysis considered in the seismic risk vulnerability analysis (see the Survey Chapter).

In a subsequent phase, we pinpointed 3D modelling as a tool that could be the basis for a complex communication project aimed at the variegated target of visitors to the monumental complex. The high resolution and accuracy of the data available has led us to try out different modelling approaches, test new software that has become available during the research, and, after various attempts, define the level of detail with which it seemed correct to represent the building.

In this connection, it is important to underline our choice to model the *Aedicula* in a different manner to the rest of the monumental complex. We concentrated the first tests on the small sacellum, which is interesting owing to its rich decoration and the significant deformations caused by earthquakes and fires. Therefore, we decided to ignore the deformations of the stone cladding and render the geometry of the *Aedicula* with the 3D model after calculating a triangulated model from the surveyed points. The first illustrates the original building, at least in its last configuration, while the second documents its present state, with the numerous oil lamps that adorn it and the metal support structures surrounding it.

For the rest of the building, the non-negligible limits of managing the hardware for a high-resolution model meant we had to set a lower degree of detail, even though no geometrical schematization was introduced: the columns are not cylinders, the irregular layout and outline of the barrels of the cross vaults reflect the real configuration of the spaces, and the points of the arches correspond to reality. Instead, for the moment we have not modelled the bases, capitals and cornices which may, nevertheless, thanks to the approach followed, be detailed subsequently, or rendered with texturing techniques.

The model completed to date concerns the *Rotunda*, with the *Aedicula* in the centre, the *Katholicon* and the so-called transept of the Virgins. We hope that the significant experience gained to date may be useful in order to complete a model of the whole complex. This in turn could lead to the creation of new educational/entertainment tools to guide visitors and pilgrims, as well as virtual visitors and scholars, in finding out and understanding spaces that they can observe and explore and intuitively link to the enthralling historical events and religious tradition of the site.

FIGURE 16 A view from the front of the *Aedicula*: the final model represents the architectural structure and the sustaining steel beams as well; only decorations as lamps and candles were disregarded.



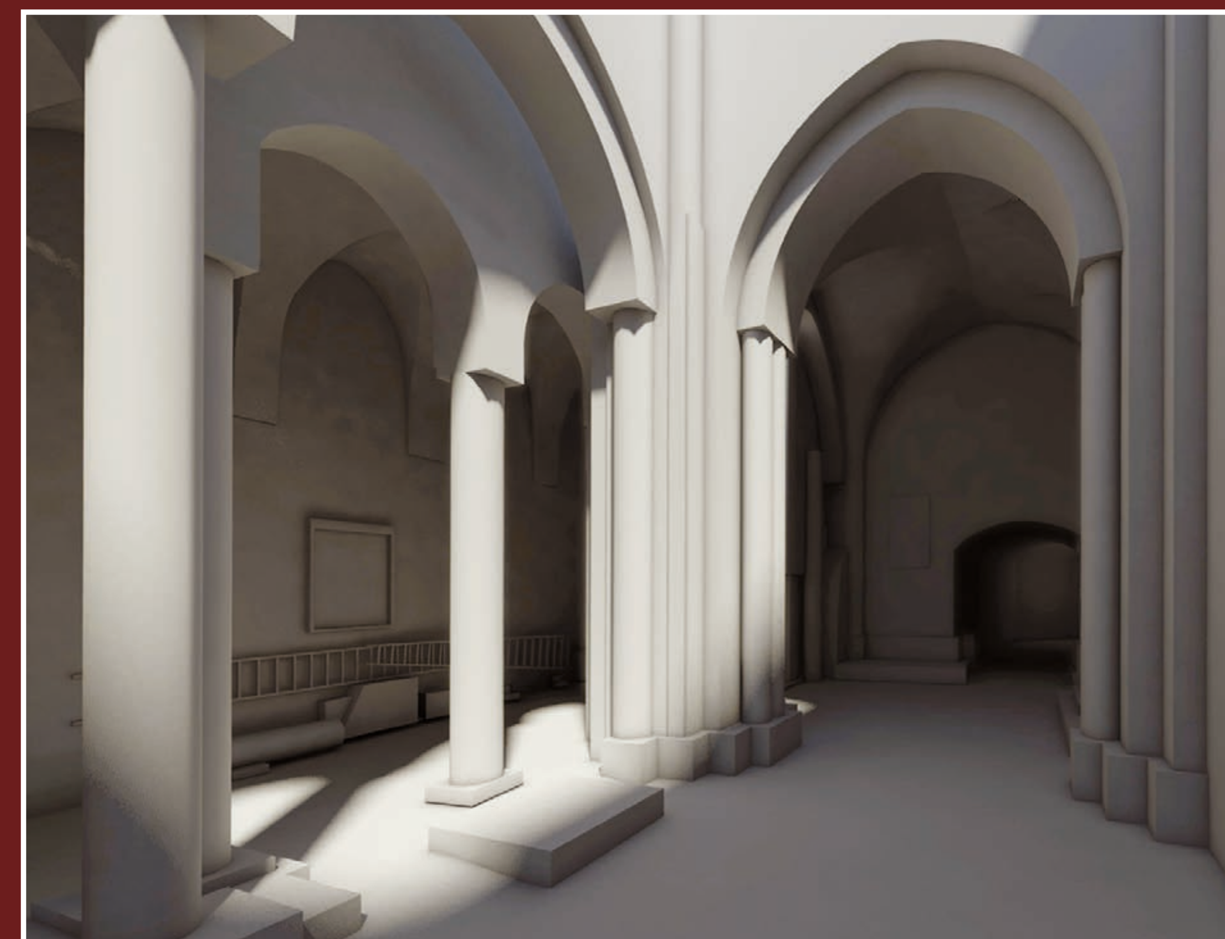



TABLE 2 DURATIONS IN SECONDS OF THE STRONG SHAKING (>0.05g) for epicentral distances of less than 10 km. (From CHANG & KRINITZSKY, 1977).

MAGNITUDE	DURATION ON FIRM ROCK	DURATION ON GROUND
5.0	4	8
5.5	6	12
6.0	8	16
6.5	11	23
7.0	16	32
7.5	22	45
8.0	31	62

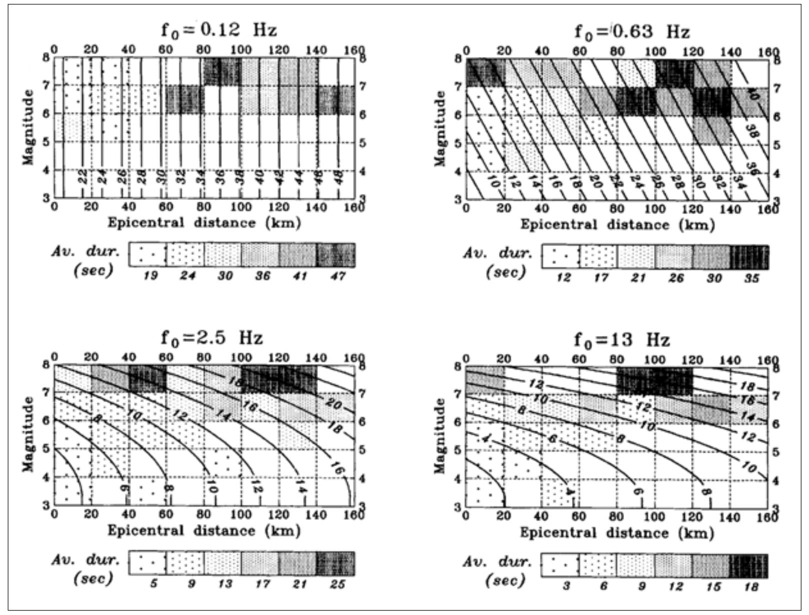


FIGURE 2 Isolines of the duration (in sec) of the horizontal component of strong earthquake ground motion. The observed duration is shown averaged in the ranges of M and Δ, specified by the dashed mesh. (From NOVIKOVA & TRIFUNAC, 1994).

on occasion of a seismic event will not only depend on the extent of the PGA [KRAMER, 1996], but also on its association with a frequency that is hazardous for the building (with relation to its natural modes of vibration) as well as the duration of the shaking itself, linked to the cubic root of the seismic moment.

Since there is no simple way to calculate the duration of the strong shaking, it is worth remembering the duration in which the 0.05 g threshold value is exceeded for different magnitudes (Table 2), as found in the study by CHANG & KRINITZSKY [1977+. It needs to be noted that the durations proposed by CHANG & KRINITZSKY [1977+ have been criticized by some authors who prefer to refer to the durations found by TRIFUNAC & BRADY [1975].

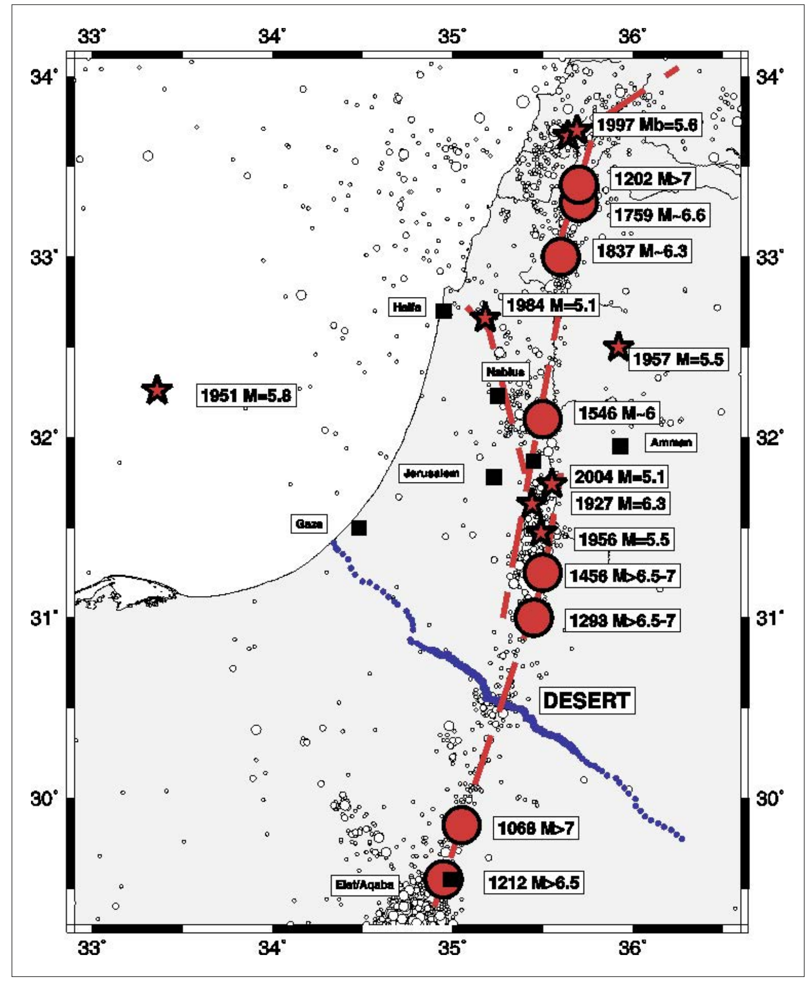
Above all in light of the data collected in subsequent years, NOVIKOVA & TRIFUNAC [1994] proposed rather accurate tables (Figure 2), in which the durations are related not only to the magnitude, but also the distance from the epicentre, as well as the site conditions and geometry.

In earthquake engineering studies, particular significance is given to spectral acceleration, namely the amplitude of the response spectrum (spectral ordinate) obtained directly from the spectrum of acceleration. The importance of the response spectrum for assessing seismic vulnerability can also be deduced from the consideration that in the regulations of many countries the project spectrum (generalized response spectrum, obtained from the envelope of many spectra; for calculating individual spectra we used a damping corresponding to 5% of the critical damping) is the basis for calculating the forces to apply when designing structures.

A decisive step consists of analysing the interactions that can be produced between the expected shaking – generically formulated starting from a "benchmark" earthquake while applying the various available attenuation relationships [ABRAHAMSON & SHEDLOCK, 1997; MCGUIRE, 2004; BRAGATO & SLEJKO, 2005] – and the morphological and lithostratigraphic characteristics of a site that are able to produce an amplification at specific frequencies. Therefore, it is also necessary to obtain amplification spectra which refer specifically to the site where the monumental complex of the Holy Sepulchre is situated (see the paragraph on site effects and modal analysis by FIASCHI & AL., in this volume).

2.5.2. History of earthquakes in the Jerusalem Area

Seismic activity in the areas subject to the study is attested to by documents covering a period of over 4,000 years [RUSSELL, 1985; BEN MENAHEM, 1991; AMIRAN & AL., 1994; AMBRASEYS, 2005]. Together the historical information and instrumental earthquake data clearly demonstrates that a conspicuous number of destructive earthquakes have taken place in recent centuries along the Dead Sea transform faults system (Figures 3 and 4). Palaeoseismic studies have always confirmed the elevated seismicity of the region; in particular, both the drilling carried out in order to investigate the late Pleistocene sediments of Lake Lisan (Dead Sea palaeo) – which highlighted a palaeoseismic sequence of 50,000 years [MARCO & AL. 1996] – and the exposed section on the Ze'elim Terrace identified a frequent recurrence (from every 100 years to every few thousand years) for seismic events with a M>5.5 [KEN-TOR & AL., 2001].



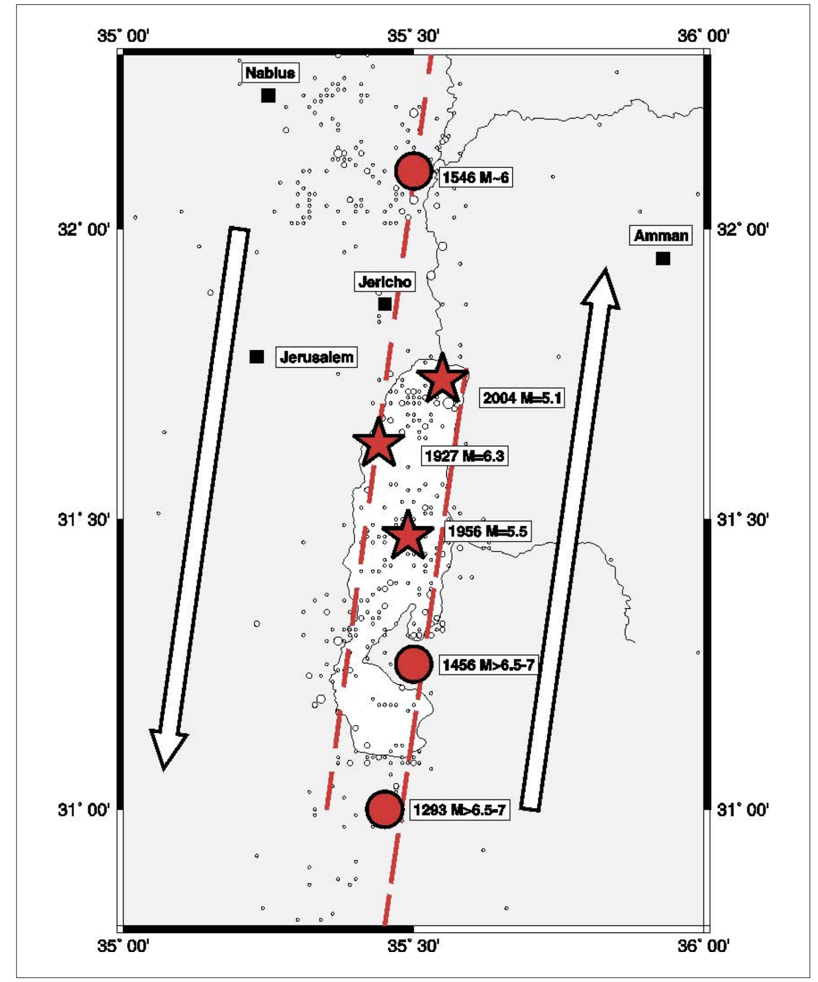


FIGURE 3 Seismicity in the Middle East: the earthquakes which occurred from 1000 to 1900 are depicted as red circles with an associated magnitude. The big earthquakes that happened from 1900 to 2004 are shown as stars with an associated magnitude. The general seismicity from 1984 to 2004 is shown as small white circles. The dashed red lines represent the main faults. (Taken from the DESIRE PROJECT).

FIGURE 4 Seismicity in the Dead Sea area. The map shows both the big earthquakes which happened from 1000 to 1900 (red circles) and those that took place from 1900 to 2004 *(red stars)*. The seismicity recorded in the 1984-2004 period is represented as small white circles. The dashed red lines indicate the main faults while the white arrows show the direction of the shift, of around 100 km, that the plates have undergone in the last 20 million years. (Taken from the DESIRE PROJECT).

Nevertheless, it is very difficult to establish the effects and damage caused by the historical earthquakes, especially in a region such as that under examination permeated by profound spirituality. Indeed, as some authors have already widely demonstrated with regard to the 1546 earthquakes [AMBRASEYS & KARCZ, 1992; AMBRASEYS, 2005], the effects were at times emphasized in order to give the natural events a theological or politico-moral meaning. If a city has a long history – with a relative long history of seismic events – this can create a false perception of extraordinary vulnerability. The considerations just set out have even led some authors to conclude that Jerusalem has suffered relatively modest damage when compared to other towns nearby [SHALEM, 1949].

Nonetheless, there is no doubt that, while no active faults have been discovered in the Jerusalem area [BARTOV, 2002], the immediately adjacent areas display an elevated seismicity, with epicentral concentration peaking in the proximity of the Dead Sea Transform (DST) just 25 km away; this very proximity makes it fundamental to calculate the extent of the hazard linked to the area. Indeed, both the seismicity along the Dead Sea fault system and the presence of neotectonic faults indicate a state of activity with significant events concentrated in a thin strip along the DST [GILL, 2006; BARTOV & AL., 2001; SALAMON & AL.,1996]. Therefore, the DST is not just the biggest seismogenic structure in the region but also the source of strong earthquakes closer to Jerusalem [SALAMON & AL., 2010].

Among the strongest earthquakes gener-

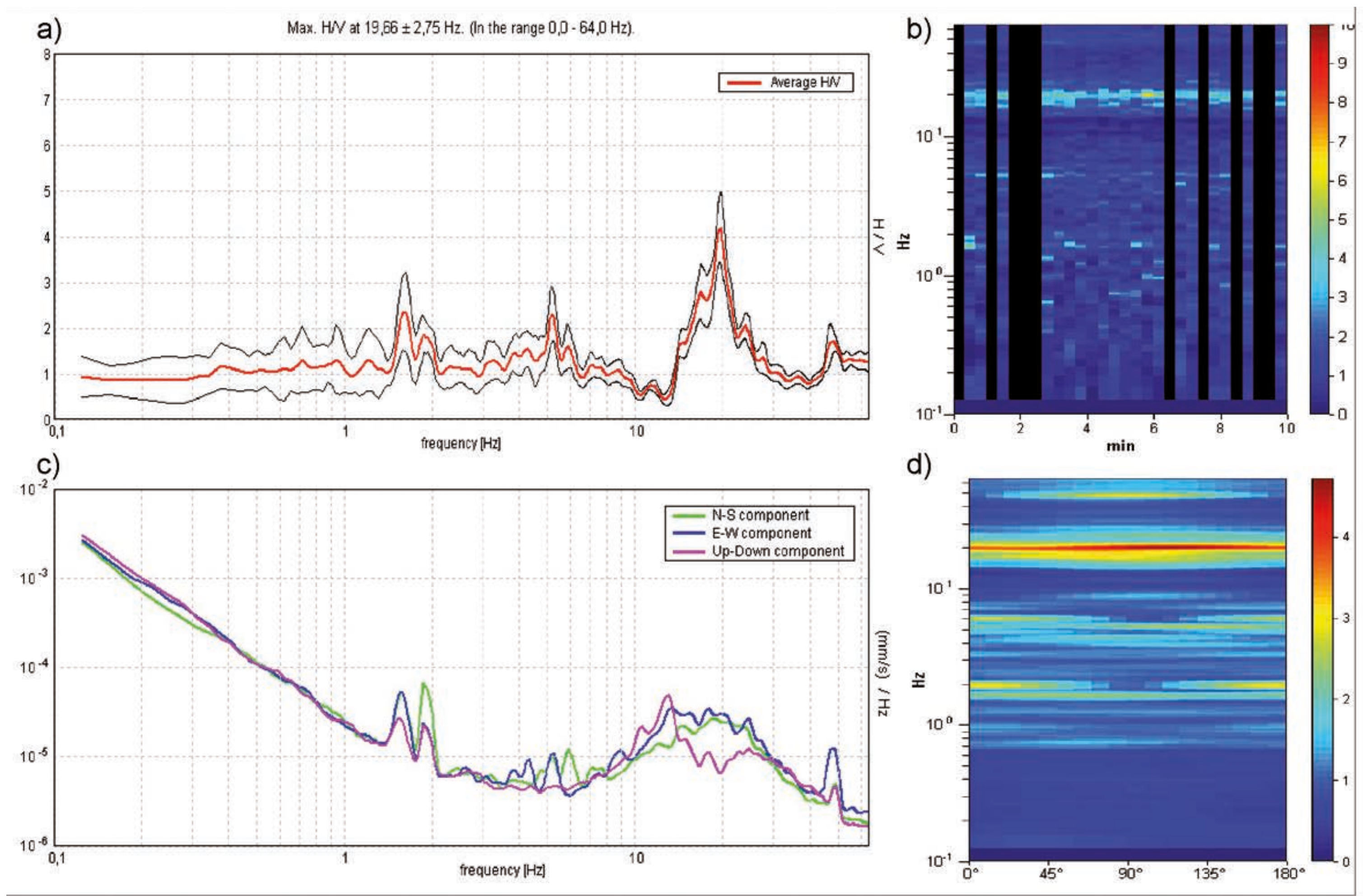


FIGURE 4 Example of results of analysis of the seismic noise measurements: H/V ratio – frequency plot (a), HVSR stability plot (b), H/V ratio – frequency plot by spectral components (c), H/V value stability by frequency and directionality (d).

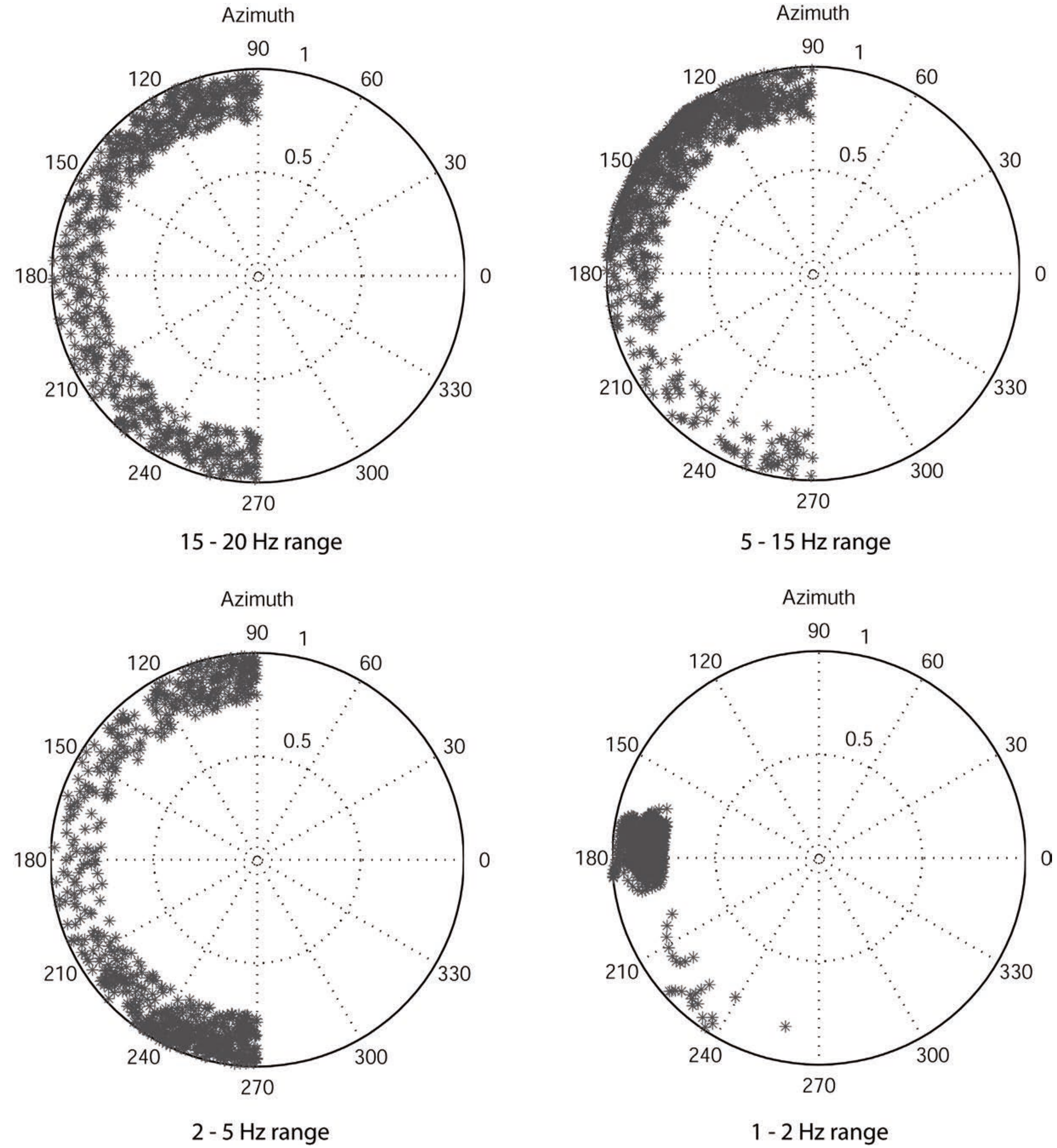
- amplification/frequency graph obtained using the spectral ratio between the geometric mean of the horizontal components and vertical component (Figure 4a);
- stability graph of the HVSR measurement showing the variability of the amplification value (colour scale) relating to the frequency and the duration of the measurement in order to highlight potential signal disturbances linked to well-localized noise sources and/or with a characteristic frequency that can have a negative influence on the measurement (Figure 4b);
- graph of the single spectral components (Figure 4c);
- directional graph showing the variability of the amplification value (colour scale) depending on the frequency and directionality, in order to highlight the contribution provided by each of the two horizontal components to the mean datum (Figure 4d).

2.6.3. Noise study

Opposite page:

FIGURE 5 Direction of origin of the seismic noise by frequency range.

The first point of evaluation concerns the direction from which the seismic noise originates. As well as being necessary for methodological requirements, this analysis is also needed to attach a meaning to the most recurrent spectral characteristics.
The method used is based on calculating the covariance matrix, which is linearized by calculating the eigenvalues and eigenvectors and applied to signals filtered on preset frequency bands. The result is shown in Figure 5 and demonstrates a substantial lack of polarization in the whole selected frequency band except between 1 and 2 Hz.
If we are to focus our attention between 1 and 2 Hz, it has been noted that at times in this range there is a recurrence of asymmetrical peaks centred around 1.6 and 1.9 Hz, with the second particularly polarized on the longitudinal component. This evidence shows exceptions in the eastern part of the building, in particular in the corridor area, the Chapels of St. Helena,



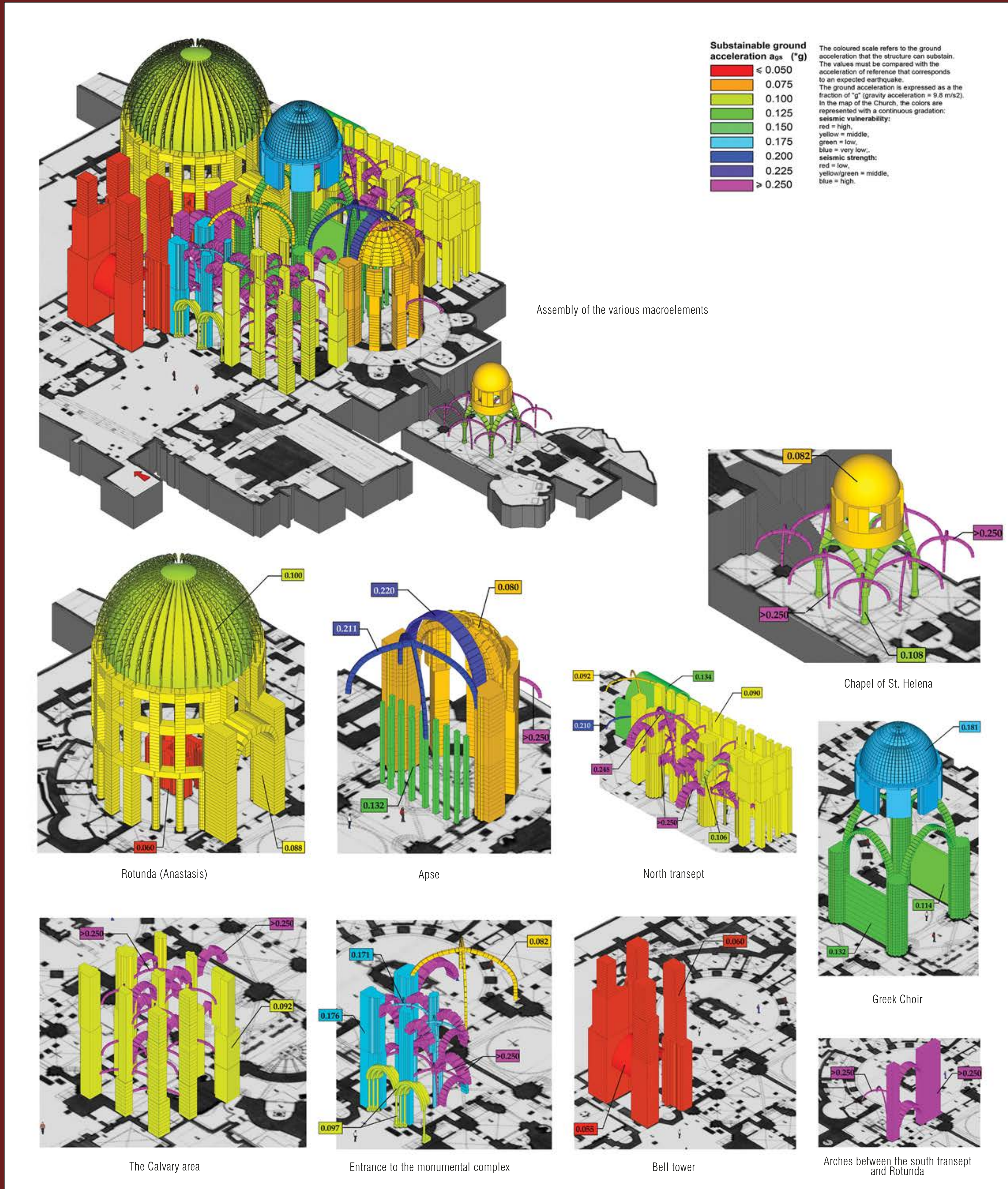


TABLE II – LIST OF THE MACROELEMENTS SET OUT IN ORDER OF DECREASING VULNERABILITY

Macroelement	ags,X (· g)	ags,Y (· g)	ags (· g)
Bell tower: interior barrel vault		0.055	**0.055**
Bell tower	0.060	0.079	**0.060**
Aedicule	0.060	0.060	**0.060**
Apse: semicircular dome on pillars	0.080	0.148	**0.080**
South Transept: highest cross vault	0.082	0.158	**0.082**
St. Helena: dome and drum	0.082	0.082	**0.082**
Anastasis: masonry structures below dome	0.202	0.088	**0.088**
Latin Gallery: considering both hypoteses	0.094	0.090	**0.090**
Upper cross vault in front of the Chapel of the Apparition	0.092	0.098	**0.092**
Calvary: considering both hypoteses	0.092	0.184	**0.092**
Entrance: arches and small columns in the openings	0.097		**0.097**
Anastasis: dome	0.100	0.100	**0.100**
Barrel vault V6: upper floor, corresp. to V5, with lunettes		0.106	**0.106**
St. Helena: arches on circular columns	0.108	0.108	**0.108**
Greek's choir: north transept masonry wall		0.114	**0.114**
Greek's choir: arches supporting dome	0.178	0.132	**0.132**
Iconostasis		0.132	**0.132**
Barrel vault of the Chapel of the Apparition		0.134	**0.134**
South Transept: cross vaults on Crusade-era pillars	0.176	0.148	**0.148**
South Transept: cross vaults on entrance, upper floor	0.171	0.185	**0.171**
Entrance	0.228	0.176	**0.176**
Greek's choir: dome with drum underneath			**0.181**
Lower cross vault in front of the Chapel of the Apparition	0.210	0.438	**0.210**
Apse: cross vault	0.211	0.222	**0.211**
Apse: arch between Crusade-era pillars		0.220	**0.220**
North Transept: cross vault on Crusade-era pillars	0.346	0.248	**0.248**
St. Helena: rectangular vault	0.289	0.280	**0.280**
North Transept: highest cross vault	0.300	0.356	**0.300**
Arches of the Virgin: T1C (in front of the apse, X direction)	0.330		**0.330**
South Tr.: arches and vaults, VS21 (vault on Station of the Holy W	0.372	0.372	**0.372**
South Tr.: arch of the Armenians towards Rotunda (S1T1, S3T1)		0.372	**0.372**
Vault V2: beteewn T1C and the apse	0.376	0.538	**0.376**
St. Helena: square vault	0.637	0.637	**0.637**
Corridor (deambulatory): vaulted structures	0.772	0.772	**0.772**
South Transept: all the other arches and vaults			**> 0.250**
Arches of the Virgin: LDX1, PRI1, T1A, T1B			**> 1.000**
Arches of the Virgin: V1 type vault on ground floor			**> 1.000**
North Transept: LDX2, T2A, T2B, LSX2			**> 1.000**
Cross vault V5: upper floor, corresponding to V1			**> 1.000**

TABLE 2 LIST OF THE MACROELEMENTS SET OUT IN ORDER OF DECREASING VULNERABILITY.

2.10.2.2. Scale of priorities for possible retrofitting interventions

The list of the results of the sustainable accelerations for the different macroelements is ordered in terms of decreasing vulnerability and underlines the most vulnerable structures of the Monumental Complex of the Holy Sepulchre.

Table II allows an immediate comparison of the performances of the various structures with respect to a benchmark ground acceleration value (e.g. 0.13 g or a modified value).

As already underlined previously, the evaluation of the seismic vulnerability realized from the analysis had to be framed within the sphere of validity of the analysis itself: this aspect is considered in the following paragraph, which deals with the sphere of validity of the results of the analysis and proposes guidelines for future developments.

2.10.2.3. Analysis summary

As for every structural analysis, the reliability of the results depends on two important aspects:

1) on the completeness (quantity) and on the quality of the available data;
2) on the fitness of the calculation procedures applied.

For point 1), the following sets of data were available:

visual data taken from on-site surveys;

Opposite page:

FIGURE 5 Map of the sustainable accelerations.

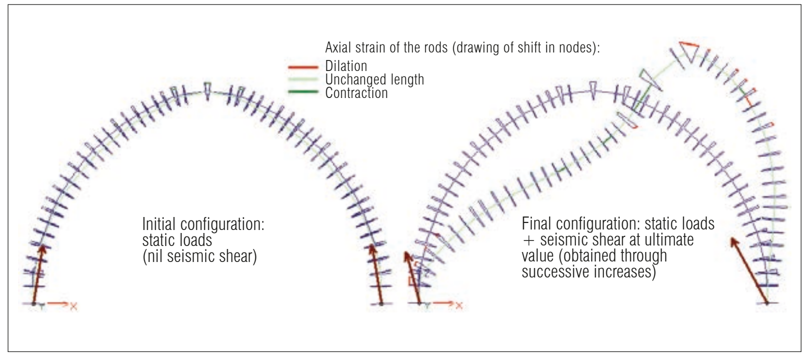


FIGURE 17 Seismic Analysis Results: reactions of the springer and shifts.

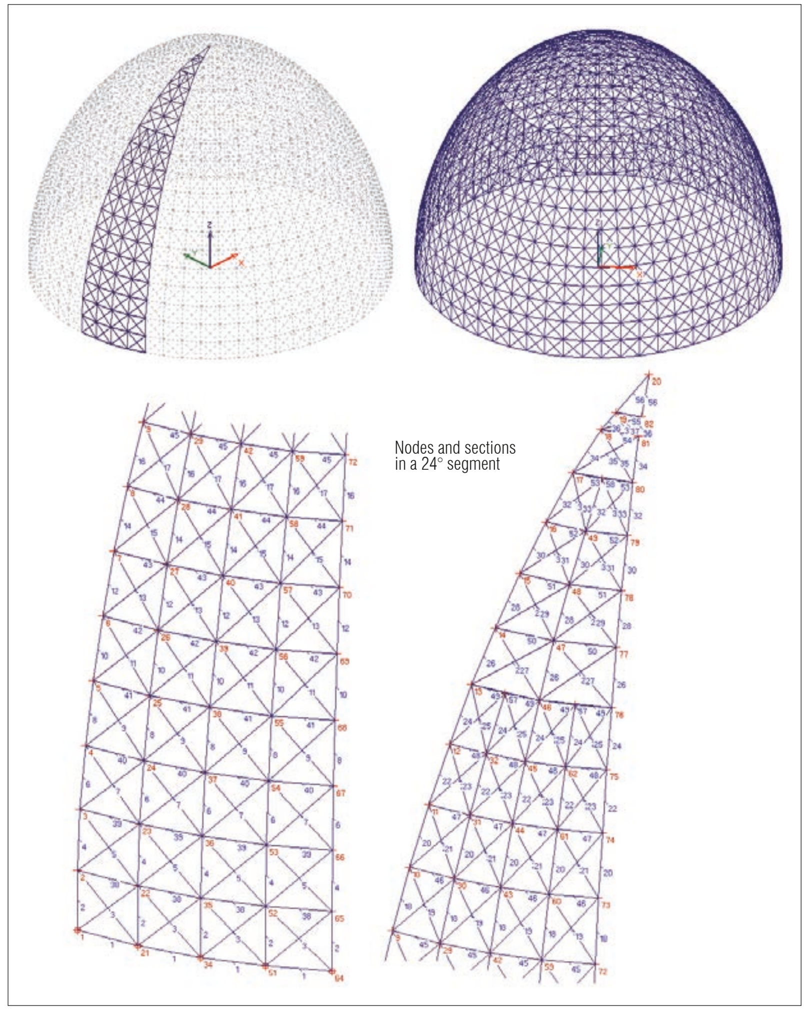


FIGURE 18 Complete dome in reticular masonry, shown as a lattice/trellis diagram. The basic units are identified by a meridian every 6°, and by a parallel every 50 cm (measured on the curved surface).

FIGURE 19 Steel reinforcement rings.

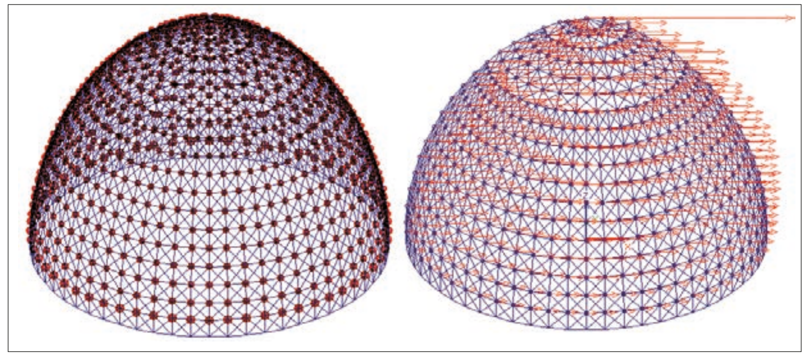


FIGURE 20 Seismic masses (concentrated at the nodes) and distribution of the seismic forces.

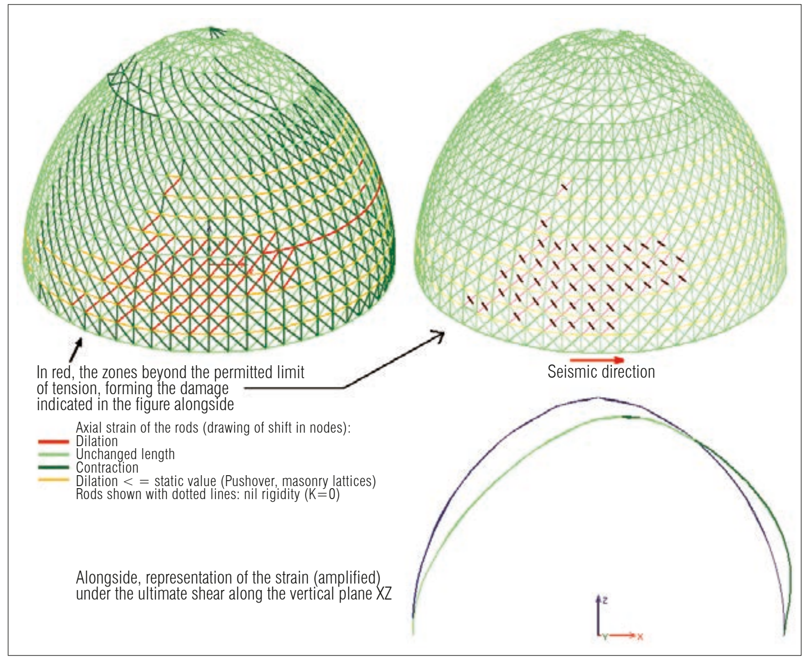
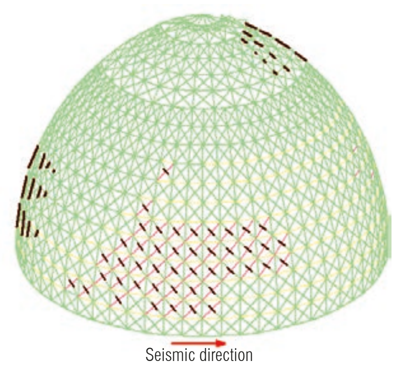


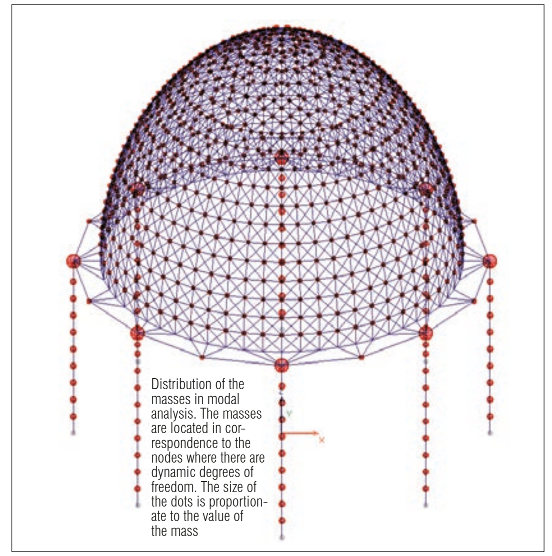
FIGURE 21 Coplanar seismic analysis.

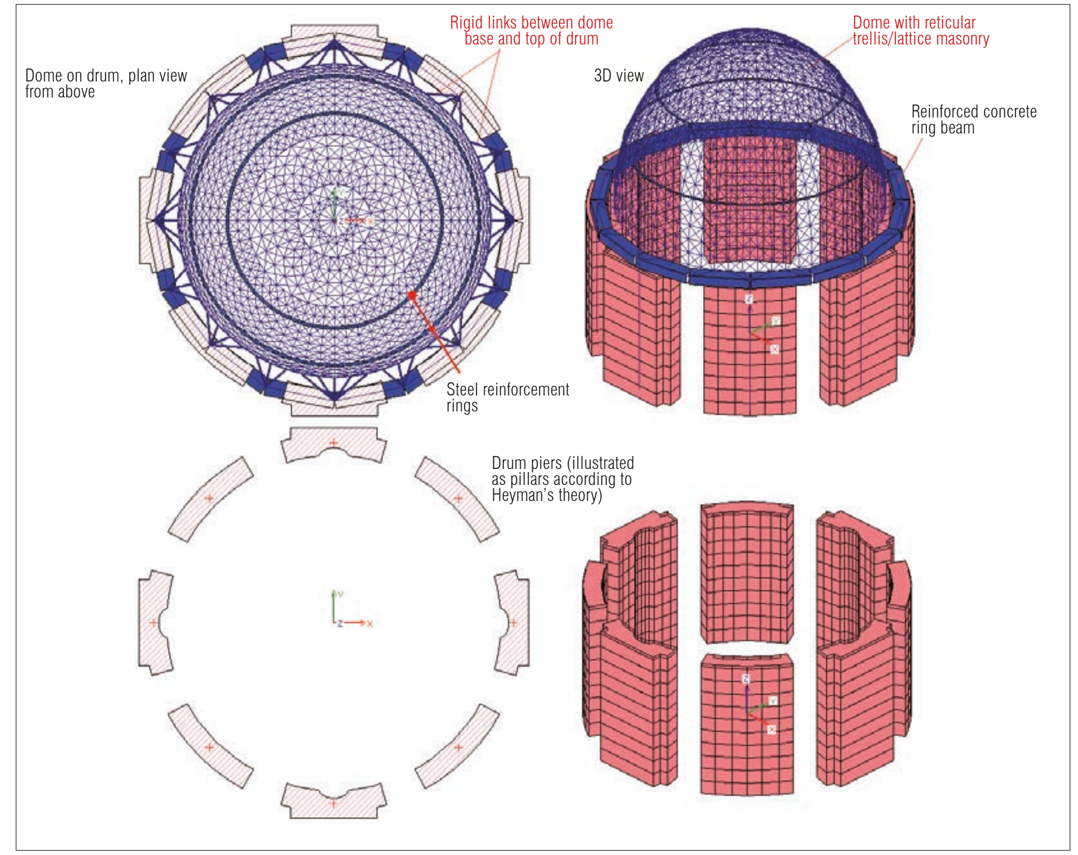
FIGURE 22 Overall illustration of the cracking.



in-plane mechanism can in itself display a lower collapse multiplier. This prevents the analysis from being performed in ranges of strain that are unacceptable.

Knowledge of the areas of damage of the structure in correspondence to the ultimate shear shall enable the hypothesis of breakage in an orthogonal direction to be integrated, providing exhaustive information on the expected damage. The two steel rings in the structure are also identified, positioned at a height of approximately 2.50 and 4.50 m above the 0.00 of the springer. The rings have a square section of 100x10 mm (Figure 19). The illustration of the damage expected owing to membrane effects is shown in Figure 21.





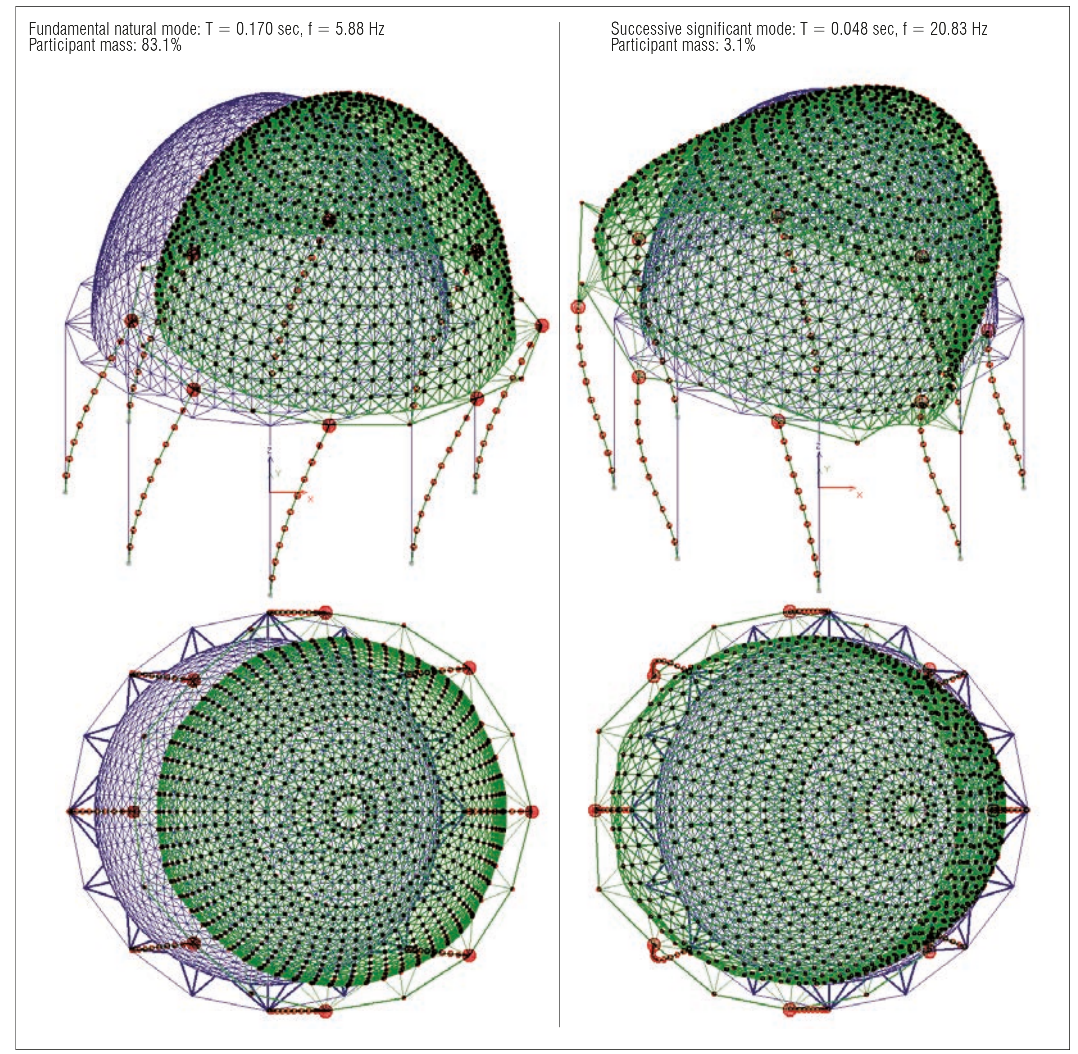


FIGURE 23 Distribution of the seismic masses.

FIGURE 24 Modelling of the dome/drum together.

FIGURE 25 Results of the modal analysis.

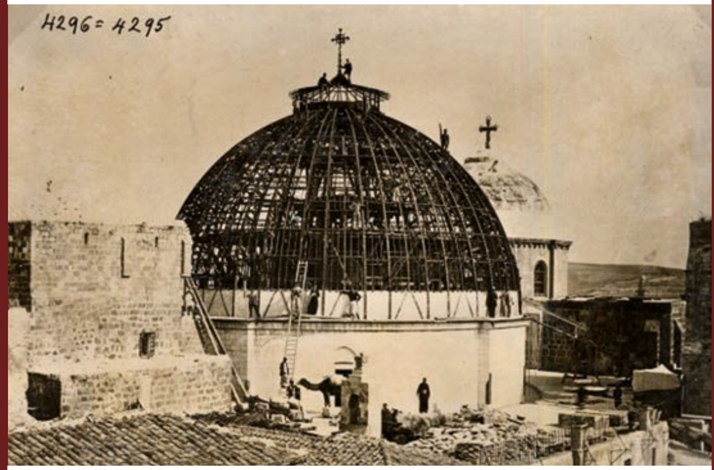
2.10.3.1.2. The Dome with drum underneath

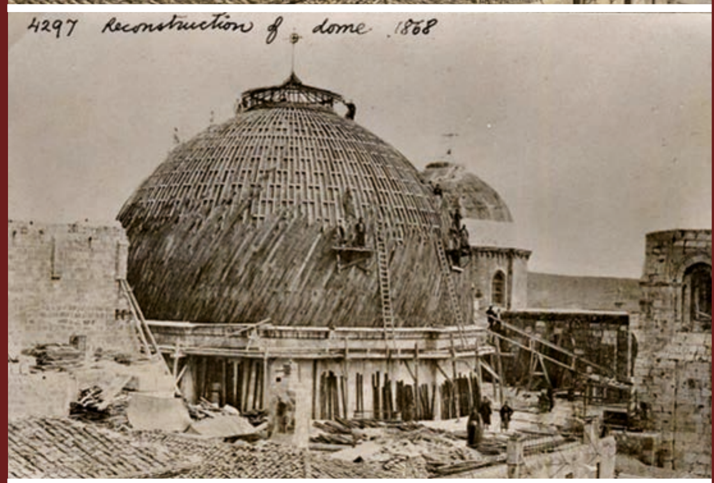
A modal analysis was performed to define the period of vibration. A non-linear seismic analysis defines the collapse mechanism owing to the instability caused by the dislocation of the thrust line from the geometry of the structure.

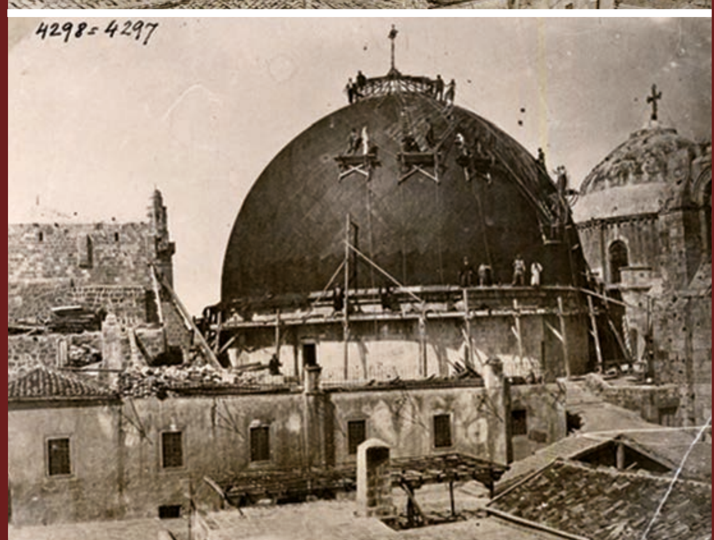
An additional model investigated the limit behaviour, with the kinematics hypothesized beforehand, with regard to the orthogonal collapse mechanism at the middle level of the structure ('out of plane').

The analysis was conducted on the portion of the structure relating to a 45° slice, comprising a pier[2] of the drum and the two openings alongside it: it is hypothesized that the detachment would take place halfway along the architrave.

[2] A wall between two openings.







1) the restructured dome was subject to a specific in-depth study carried out with modern engineering tools and approaches;
2) the data possessed and processed by the engineers, regarding the geometry, the state of strain of the single metal trusses, the physical and mechanical parameters of the materials (defined through experimental investigations) certainly featured a greater level of knowledge than can be reproduced in this chapter.

Instead, in this work, the analysis of the *Rotunda* supporting structure underneath the dome is of primary interest.

Left, from above:

FIGURE 51 The *Anastasis* dome in 1868, after the damage and prior to reconstruction (Israel Antiquities Authority).

FIGURE 52 The *Anastasis* Dome in 1868. First phase of reconstruction. The structure with wrought iron arches can be seen.

FIGURE 53 The *Anastasis* Dome in 1868. Second phase of reconstruction.
This shows the wooden structure used for the external shell, which would then be destroyed in a fire in 1947.

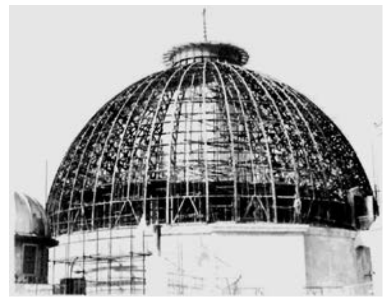
FIGURE 54 The *Anastasis* Dome in 1868. Last phase of reconstruction.

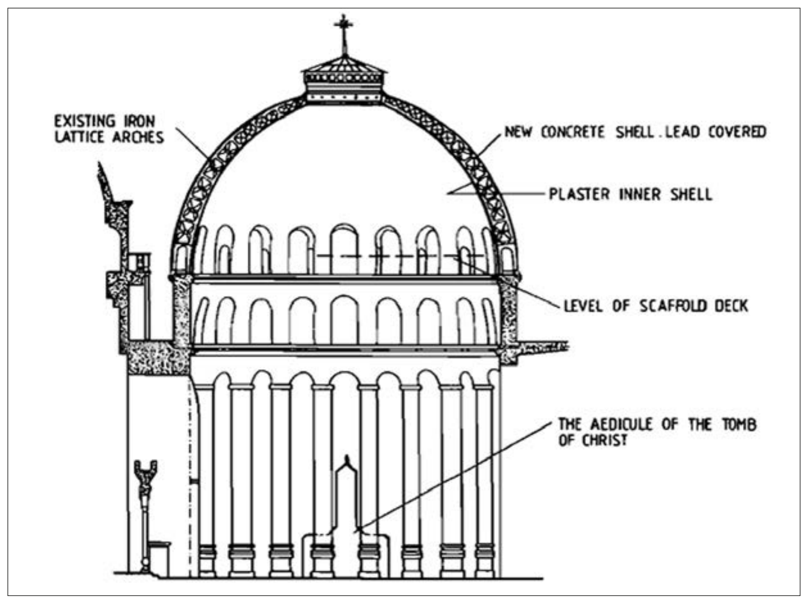
Right:

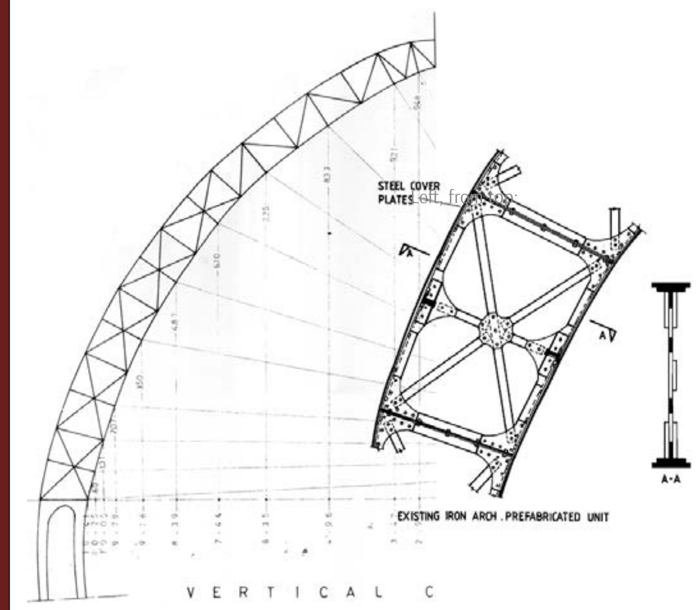
FIGURE 55 Restructuring the Dome in 1980. The wrought iron arch structure is uncovered once more after the removal of the previous external concrete shell (I.H. Reith, 1982).

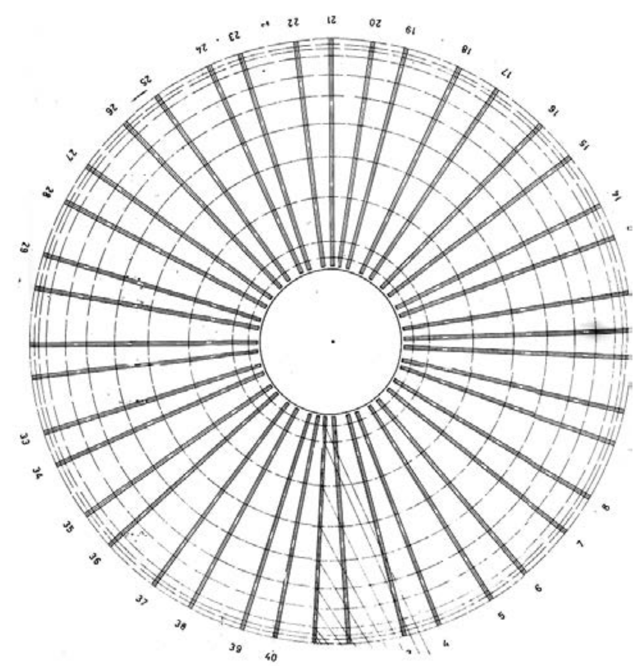
Bottom:

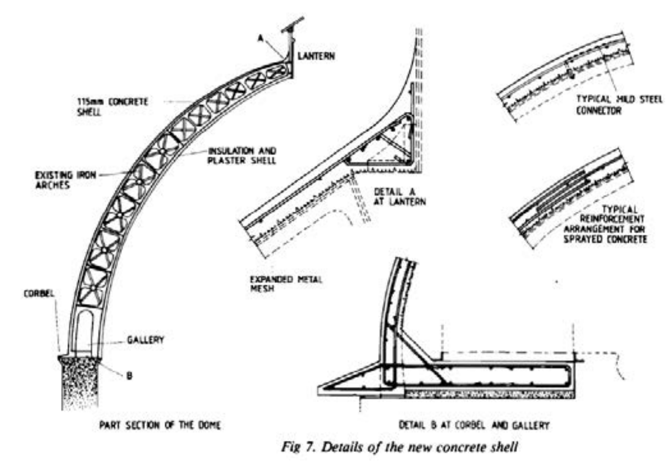
FIGURE 56 Configuration of the restructured dome (I.H. Reith, 1982).









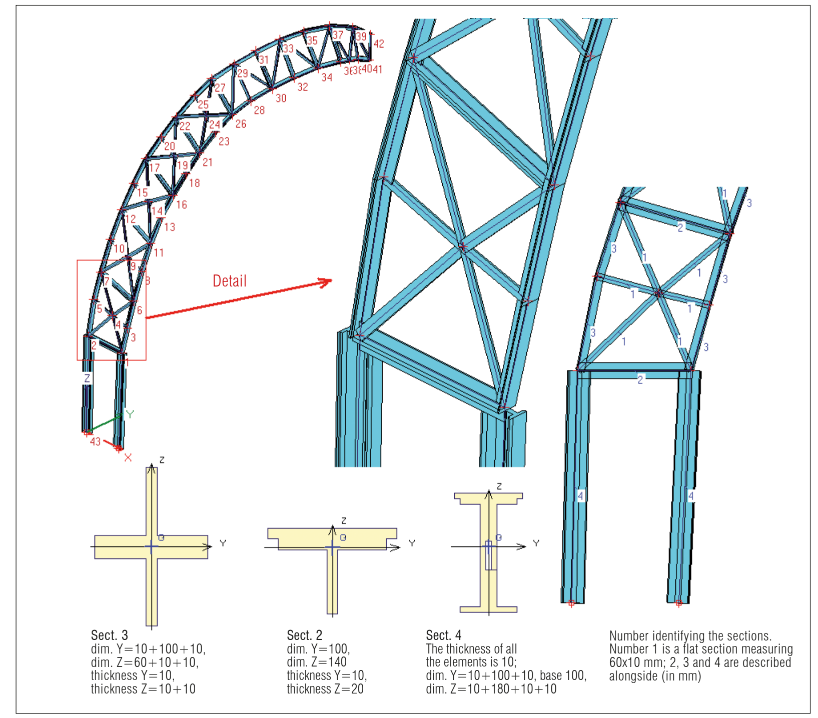


Left, from above:

FIGURE 57 The wrought iron arches. Left, a static diagram from the Common Technical Bureau (1977); right, detail of the existing structure drawn during the restructuring project (I.H. Reith, 1982).

FIGURE 58 Plan of the arches. Common Technical Bureau, 1977.

FIGURE 59 Restructuring project, 1980 (I.H. Reith, 1982).



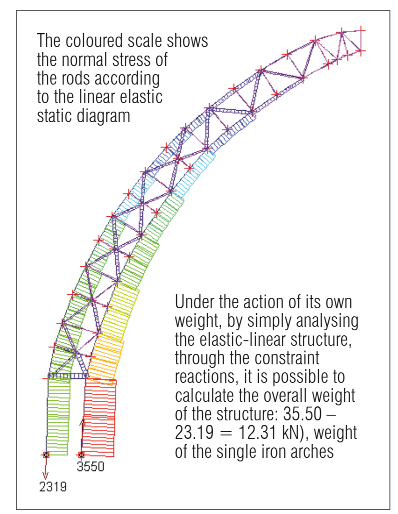


FIGURE 60 *(above)* Structural model of the iron arch.

FIGURE 61 *(left)* Assessment of the weight of the arch itself.