THE GREAT MOSQUE OF ṢAN‘Ā’

Conservation intervention

(2005-2015)

ISTITUTO
VENETO
PER I BENI
CULTURALI

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Conservation intervention (2005 - 2015)

To the people of Yemen

SOCIAL FUND FOR DEVELOPMENT - REPUBLIC OF YEMEN
ISTITUTO VENETO PER I BENI CULTURALI

THE GREAT MOSQUE OF ṢAN‘Ā’

Conservation intervention (2005-2015)

edited by
Renzo Ravagnan and Maurizio Merlo

ISTITUTO VENETO PER I BENI CULTURALI

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PREFACE

I would like to begin the preface to this volume with a quote, taken from the wonderful book by Paolo Costa and Ennio Vicario, *Yemen. Land of Builders* (Milan 1977, p. 11):

> *… The Yemen has been made by its inhabitants. They have not, however, carved it out, but rather built it, placing stone on stone so that building has gradually become as natural to them as breathing.*

The task for all of us – especially scholars and restorers – is to reflect on these words, to acknowledge the profound significance of a nation's cultural heritage and to recognize our responsibility to protect and preserve it for future generations.

Ancient Yemen was the cradle of the civilization that defined the identity of the entire Arabian Peninsula. From the end of the 2nd millennium BCE, Yemen was the land of powerful kingdoms, including the Kingdom of Saba, famous for its Queen whose story is shared in the collective memory of Christian, Islamic, Jewish and Ethiopian traditions.

The relative isolation of the country during the period of the Imams preserved Yemen's singular cultural heritage, shielding it from potentially disruptive western influences. It is a unique land characterized by inestimable antiquities, rich architectural traditions and distinctive building techniques rooted in ancient practices.

The geomorphological and climatic differences that characterize the country – from the hot and humid region of Tihama on the west coast, the temperate zone of the central plateau, to the desert area of the Ramlat Sab'atayn in the east – are the decisive factors that have shaped Yemen's architectural diversity. Each region, with its peculiar geographic and climatic features, developed its own locally appropriate building practices utilising regionally sources, natural materials. The result is a unique architectural vocabulary developed in harmony with the environment in which it is rooted, enriching and adorning the country's cultural identity.

Since March 2015, the ongoing conflict in Yemen has resulted in unimaginable suffering for the people, and the devastation of the country's infrastructure and cultural heritage. Islamic monuments are among the most endangered structures and they are in need of urgent damage assessment and documentation. Furthermore, a large number of pre-Islamic South Arabian archaeological sites have also been severely damaged and many of these may be lost forever, erasing key elements of the historic identity of the people of Yemen.

Many of these historic monuments exist within the context of their connected communities. Therefore, there is a deeper aspect of the national identity that is threatened the tragic loss of both the oral and first-hand transmitted knowledge and skills of the local architectural traditions.

This is what inspired the creation of the project *People's Identity at Risk. Documentation and assessment of Islamic monuments at risk* promoted by Monumenta Orientalia, together with the Yemeni Social Fund for Development (SFD - Culture Heritage Unit) funded by the Aliph Foundation.

The main objective of this project is to enable Yemeni scholars and experts to carry out a thorough survey on the state of conservation of a number of Islamic monuments that have been badly damaged during the war, in order to establish a standardized assessment tool and provide the basis for prioritizing and planning both recovery and conservation efforts.

Full documentation of all the monuments that have been affected by the conflict will take several years. So, as a first step, the project aims to deliver the essential data urgently required by the Yemeni Institutions such as the SFD, the General Organization for the Preservation of the Historical Cities of Yemen (GOPHCY) and the General Organization of Antiquities and Museums (GOAM). These Institutions have already drafted a list of high priority national monuments that are in a critical state. The creation of a standardized assessment methodology will also provide them with the base data to enable them to plan for the future restoration and reconstruction of all national monuments at risk.

This important project is accompanied by the publication of *The Great Mosque of Ṣan'ā'. Restoration Project (2005–2015)*, documenting the restoration work undertaken at the *Al-Jāmi' al-Kabīr bi-Ṣan'ā'*, the Great Mosque of Ṣan'ā' – the most important Yemeni religious monument, and one of the oldest mosques in the world. This included major structural reinforcement to the building as well as restoration of its wooden ceiling.

The restoration work, conducted by the Instituto Veneto per i Beni Culturali (IVBC) in Venice and financed by the Social Fund of Yemen, began in 2005, but was abruptly interrupted in 2015 due to the conflict that is still ravaging the country. The publication of *The Great Mosque of Ṣan'ā'. Restoration Project (2005–2015)* will establish the model for both extending the damage assessment work to other monuments, and initiating similar restoration interventions on monuments at risk when the country returns to normality.

The restoration carried out in the Great Mosque of Ṣan'ā' would not have been possible without the extraordinary commitment of the Istituto Veneto per i Beni Culturali, and the economic and technical support of the Yemeni Social Fund for Development. I would also like to thank the Aliph Foundation for their generous support for the publication of this volume.

Sabina Antonini de Maigret
Scientific Director for the Project
People's Identity at Risk
Rome, 26 November 2021

THE GREAT MOSQUE RESTORATION PROJECT IN ṢANʻĀʼ

The importance of the Great Mosque
Foreword

The Great Mosque in Ṣanʻāʼ manifests exceptional and high values from religious, scholar, historical and archaeological perspectives since it was built in the sixth Hijri year (c. 627–628 AD) with an accurate description of its location and determination of the direction of its Qiblah by direct instructions and guidance from the Prophet Muhammad, peace and blessings be upon him. This means that it is one of the oldest mosques in Islam, and perhaps the only one that still retains many of its original characteristics and elements over the past centuries. It is also of great importance on the Arab and Islamic levels and on the humane level in general. Due to the Great Mosque's exceptional architectural, archaeological, and artistic values, it is considered one of the most important archaeological sites in the old city of Ṣanʻāʼ. It is also one of its oldest buildings.

This high archaeological and aesthetic value was – at the end of the last century – on the verge of being eroded if the comprehensive expansion and renewal process, which was seriously considered and almost carried out, was implemented. It was a plan that did not take into account the internationally-recognized principles of preservation by any means. This in itself was more dangerous and harmful to the mosque than natural deterioration due to the factors of time and natural effects.

The management of the Social Fund for Development (SFD), represented by its former director, the late Mr Abdul Karim Ismail al-Arhabi, took a decisive initiative that saved the mosque from that major threat. This was done by persuading the country's leadership to stop this intervention and launch a conscious and sensitive restoration process that respected the status of the mosque and the aesthetic and archaeological values stored in its building, and followed the highest conservation standards befitting the importance of this exceptional monument. The Kuwaiti institution Arab Fund for Economic and Social Development (AFESD) was then persuaded to finance the restoration program. The Arab Fund, represented by its former General Manager and Chairman of its Board of Directors, Mr Abdul Latif Yousef al-Hamad, accepted financing the restoration program with a number of grants, requesting that the honour of financing this program becomes exclusively to the Arab Fund, which was done.

Then, the practical steps began when the Republican Decree No. 354 of the year 2001 was issued to form the Board of Trustees of the Great Mosque to oversee and ensure the administrative and institutional independence of the restoration program management. This was a necessity in order to avoid overlapping powers between several bodies with intertwined jurisdictions that also lack the necessary technical and administrative capacity.

In parallel with that, the Cultural Heritage Unit (CHU) at SFD, through specialized local consultants, initiated several studies, the most prominent of which were:

- A diagnostic study of the areas of damage.
- A study of the historical milestones of the mosque's building from the available sources.
- A comprehensive architectural documentation by specialized cadre from Ṣan'ā' University, which provided a necessary basis for restoration planning.

This was followed by the CHU attracting some of the best, relevant, international, Arab and local technical advisors and experts to lead and implement the training, documentation and restoration as follows:

- Ms Marylène Barret, a restoration expert from the Ecole Nationale des Sciences Géographiques (Paris) was appointed to carry out a three-dimensional (photogrammetric) architectural documentation of the mosque and its surroundings, including the documentation of the painted wooden ceilings, as well as the decorations and frescoes, wherever found, using the latest technologies available in this field.
- Professor Ronald Lewcock was appointed to provide general technical advice and guidance for the restoration program. Professor Lewcock is a Professor of Architecture at Cambridge University (UK), Professor of Architecture at the Institute of Technology in Georgia (USA), and Professor of Architecture supervising master's and doctoral theses in the Aga Khan Program at the Massachusetts Institute of Technology (MIT) in Boston (USA). He is also a distinguished lecturer at a number of universities in Australia and South Africa. Professor Lewcock is a restoration specialist, an international conservation planner, and an author of a number of books on Yemen, especially on Shibam Hadramawt and the Old City of Ṣan'ā'. The most important of which is *Ṣan'ā': An Arabian Islamic City* (London 1983) which he wrote in partnership with his colleague R.B. Serjeant.
- The late engineer Isam Awwad was selected as the head of the work team. He is a distinguished architect and conservation specialist, and was the supervisor of the restoration work of the Dome of the Rock in al-Quds al-Sharif. His selection came through a competition with a number of other international consultants.
- Archeologist Chris Edens, former director of the Yemeni American Institute, was appointed as the head of the project's archaeological team. He led the largest and most complex archaeological documentation process ever carried out at the Great Mosque through which the most important stages of the mosque's building and foundation were identified. As a result, valuable evidence and information on the development of this monument were obtained for the first time.
- Then came the major practical step was taken when the Istituto Veneto per i Beni

Culturali (Venice, Italy) was appointed to oversee the practical restoration project. The selection of this institute was based on an analysis of the offers obtained by the SFD's management. A trusted partner, the Istituto was eager to reduce the costs and put them within their actual limits, it also offered to implement the restoration work on a very reasonable basis. The work was based on a deep scientific and diagnostic analysis. The Istituto's team was also keen to transfer technical expertise through theoretical and practical training in different domains. The Italian team trained more than 80 Yemeni trainees in addition to sending the most distinguished ones to Italy during the years of work for further training in the fields of wood restoration, stucco decoration restoration, stone restoration, and other fields. Under the leadership of its director, Architect Renzo Ravagnan, the Istituto and its advisors attended to their supervisory duties with sincerity, perseverance and love until before the outbreak of war in early 2015.

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Finally, by reaching this stage and after our long journey – even not concluded – in the restoration work, we can only express our deep thanks to the Istituto Veneto, its Director Mr Renzo Ravagnan and its distinguished technical team. SFD appreciates all the efforts they made and the high professionalism with which they carried out the various restoration activities for many years. This work has saved, in the first place, precious cultural elements that have been restored in accordance with the highest international standards. Additionally, these efforts have produced qualified professionals who can now continue the work and implement future restoration and maintenance projects either within the Great Mosque in Ṣan‘ā’ or on any other cultural landmark of the same level of architectural, artistic and historical importance.

Furthermore, we would like to thank the general technical supervisor of the restoration work, Professor Ronald Lewcock, and the head of the work team, the late engineer, Mr Isam Awwad (may his soul rests in peace). We also thank Mr Christopher Edens, the head of the archaeological team, and his assistant, Ms Bakiye Yukmen Edens. We also express our deep gratitude to Ms Marylène Barret for her kind efforts and great services in addition to Mr Yves Egels, Mr Daniel Schelstraete and Ms Raphaële Héno, the experts from the National Institute of Geographical Sciences in Paris. Also, thanks to all our colleagues at the CHU, including the field team members, specialists, engineers, consultants, technicians and administrators. We thank everyone (entities or individuals) who contributed or participated, in any way, in the success and support of the restoration project activities from entities or individuals.

Finally, we extend our gratitude to the members of the Board of Trustees; Mr Faraj

Bin Ghanem, Mr Abdul Karim al-Iryani, Qadhi Ali Abu al-Rijal, Qadhi Ismail al-Akwa' (may their souls rest in peace), Qadhi Ahmad Abdul Razzaq al-Rugiahi, we do not forget praise the late Mr Abdul Karim Ismail al-Arhabi who was in charge of the launch and success of this exceptional project and the members of the Board of Trustees who passed away after providing valuable support for this achievement.

Abdullah Ali al-Dailami
Managing Director
Social Fund for Development

INTRODUCTION

Restoration of the Great Mosque of Ṣan‘ā’, in Yemen

From 2006 to 2015, the Istituto Veneto per i Beni Culturali,[1] at the request of the Social Fund for Development[2] on the recommendation of the former Chief Architect and Conservator at the Esplanade of Mosques in Jerusalem, Isam Awwad, restored two important monuments in the Republic of Yemen, the Great Mosque (al-Jāmi‘ al-Kabīr) of Ṣan‘ā’ and the mosque and madrasa al-Ashrafiyya of Ta‘izz.

This volume, product of the studies and work on and in al-Jāmi‘ al-Kabīr, contains a number of articles by experts who, in addition to reconstructing the history of the mosque, reporting on their assessments of the quality and dating of its decorations, reading and interpreting the Koranic inscriptions carved into the wood planks that line the walls, also examine and report on the works done to safeguard it from the structural and esthetic standpoint.

Among other things, it contains a detailed report of the restoration of the wood ceiling (occupying an area of more than 3,000 sq.mt. with about 5,200 coffers, all carved and painted) done by the IVBC over a period of ten years. In 2015, sadly, due to the conflict ongoing in the country and related safety concerns, we were forced to interrupt our activity when we had almost completed the work. By that time our Yemeni students were, however, able to complete it, with the guidance of their instructors from Italy, thanks to modern communications technology.

Alongside the works of restoration, in fact, we took care to train young local workers, by agreement with the Social Fund, providing courses in restoration, during which strict theoretical teachings were flanked by works on site, according to the ever-fruitful practice of training on the work site, along with periodical updates through seminars with Italian specialists in the different sectors. Indeed, the training was our first priority because, in addition to the goal of conservation, we wanted to develop capable local expertise so as to ensure constant expert maintenance of the artistic heritage of their country. In 2014, a group of these students, including two women, came to Italy for a period of specialization at the Institute. Now there would be about eighty young workers employed in the two mosques, if they had not been forced to give up the work on account of the war.

The work plan was based on the most advanced concept of conservation, the product of a consolidated culture in the field of restoration, consisting basically of the maximum respect for the historic memory: maintaining the original pieces, repairing them when necessary rather than replacing them, adding only what is necessary for the stability and understanding of the work, without altering it, using reversible techniques compatible with the existing materials. The balance between conservation and adaptation to the needs of enjoyment is not always an easy one to achieve, so the actions implemented, especially on a magnificent monument spanning more than a thousand years, require care and attention to the balance and harmony of the whole. A work of art is unique by definition. The Great Mosque of Ṣan‘ā’, with its messages that extend beyond the limitations of place and time, in addition to being a religious relic of inestimable value, contains within it the history and culture of the people who built it and, as such, becomes itself the sum of the value added in terms of historical evidence that should be preserved and kept legible for the generations to come.

We believe that in these years there has been a fundamental sharing of technical, scientific and practical knowledge and that we have succeeded in providing an operating method and culture of conservation, involving young disciples, already in possession of diplomas or university degrees, with whom we have established relations of mentorship. In this way we have built deep human relations, based on trust, with our institutional interlocutors, with whom we shared, in addition to the ethical, cultural and social motivations, the concrete and complex problems that constantly arise in our work. We wanted this to be an example of an ideal project based on solid values and in which the economic aspects become secondary. We wanted to take all the time necessary to achieve the best possible results, based on the principles of good restoration set down in Italy already in the Sixties of the past century, not on the basis of bidding downward, as is too often the tendency nowadays. If architect Awwad wanted the work to be done by a school-worksite, it was because his fundamental goal was the human and cultural growth of the participants in building a professional legacy to spend in the safeguard of all of Ṣan‘ā’.

The exchange between people and cultures that differ from what they are used to certainly benefited both parties: the Yemeni apprentices were able to take advantage of a valuable training and work opportunity; we Italians were able to spend time in a very special place, laying the foundations for a qualified, lasting exchange that will be able to overcome the bitterness of current events. The result was a stronger professional culture and expansion of the intellectual horizons that had positive effects on the personalities of the individuals involved, as they grasped the essence and shared the principles of the Institute's action: knowledge, respect, skill and love of beauty.

The convinced participation of the Yemeni students in the cultural project, the application in learning and passion for the work, satisfied our goals of fostering a collective awareness of the need to take care of the natural as well as the built landscape, the inalienable right of all people. We wanted to contribute to make them and their population proud of their history and the marvels they have achieved, and that their ancestors were able to build through the centuries.

We wanted the commitment to finding the best and most long-lasting results and the entire process of study involved to inspire the students and give them a method to apply in the future as well.

The Great Mosque, al-Jāmi‘ al-Kabīr, though absolutely unique from the architectural and artistic standpoint, is a harmoniously structure erected at the center of the walled city of Ṣan‘ā’, among the tower-houses with their façades framed by ornate friezes, with their windows decorated in translucent alabaster and colored glass, enclosed in lacy borders of plaster, earthen houses standing as high as nine floors, built with incredibly ancient and still admirable technology.

The emergencies concerning the state of conservation of the ancient city of Ṣan‘ā’ were serious even before the political crisis threw it into the abyss of war: from the dislocation of much of the city's most wealthy residents to newer homes, to the lack of maintenance of the splendid tower-houses, from the use of inadequate construction methods and non-traditional materials for restructuring to the inclusion of modern infrastructures without adequate attention to maintenance of the typical buildings.

Currently, while so many houses are losing their stability, vast numbers have fallen under the bombing. To reverse this situation, which could degenerate into an irreversible alteration of the urban fabric, a team of emergency workers has been created, thanks to the Social Fund, to monitor the state of preservation of the houses. Adequate financing is still necessary to carry out basic structural work to prevent the more unstable buildings from collapsing. This would set off a virtuous cycle, creating a pool of qualified, reliable and recognized experts who could operate as consultants and educators for similar projects in other old cities throughout the country.

The works would also require the consultation and participation of small teams of artisans and local workers (*usta*), so as to secure the buildings with techniques and methods respectful of their material integrity. In this way, the Yemeni builders, final custodians of a tradition that spans more than a thousand years and is now at real risk of extinction, would obtain recognition of the value to be handed down for the preservation of their unique knowledge and skills.

Yemen is a country of ancient traditions that, despite the many vicissitudes of its history, has succeeded in maintaining its identity and preserving the architectural and artistic treasure it possesses, as well as the original techniques with which they were built.

The terrible humanitarian emergency that has stricken the Yemeni people is destroying even the historical, architectural and cultural memory, so the international community must work to save this precious beauty for mankind.

We cannot fail to express our gratitude to the Social Fund for the important initiative linked to the safeguard of this urban heritage.

It is thanks to all those who have participated in any way to this gratifying undertaking, in the realization of which they had contributed their experience and expertise with enthusiasm and passion. They have all believed in the value of this collective work and have taken responsibility for it, succeeding to create a balanced, harmonious environment.

Renzo Ravagnan
Director
Istituto Veneto per i Beni Culturali

1. The Istituto Veneto per i Beni Culturali (IVBC - the Veneto Cultural Heritage Institute) is a non-profit organization accredited by the Veneto Region. Since 1996, it has been holding courses of professional training for young restoration workers. Its educational activity extends over a three-year period that includes the acquisition of theoretical knowledge and practical training, disposing of worksites that have become a reference for several significant locations in the area. Through its worksite schools, in Venice and the rest of Italy, and also abroad, it has carried out many restorations of public buildings or buildings in use by the public; for years it has been cooperating with institutions engaged in the safeguard and valorization of historic and artistic properties, such as the Direzione regionale Musei Veneto, and with the committees for the safeguard of Venice, particularly *Save Venice* and *Venice in Peril*. The commitment to preserve the cultural heritage has led the Institute to operate in other countries as well, particularly in the Holy Land and in Yemen.

2. The Social Fund for Development (SFD) is a non-profit organization that operates in Yemen. It was established to contribute to the attainment of the goals of the national plants of social and economic development for the reduction of poverty. The SFD supports development by improving the access to basic services, increasing economic opportunities and reducing the vulnerability of the poor, as well as providing professional training at the national and local level.

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The restoration of the Great mosque has been made possible thanks to the support and dedication of many individuals.

We are truly thankful to all of those who participated in this venture bringing along their enthusiasm, commitment and expertise. Everyone strongly believed in the importance of this collective work and felt strongly responsible for it. This contributed to the establishment of an ideal working environment, which in turn, ensured works were finalised on time. This is an achievement we all shall be proud of.

A very special thanks goes to Isam Awwad, who passed away far too soon. His friendship and teachings though are still very much alive in me.

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Section 1

THE GREAT MOSQUE IN ṢAN‘Ā’

Section 1 - Chapter 1

EARLY ISLAMIC ARCHITECTURE IN YEMEN

RONALD LEWCOCK

If the Sassanian occupation of the Yemen after c. 574 was marked by the erection of major buildings, they have not survived. The corbelled wooden "dome" construction in front of the *miḥrāb* of the Great Mosque in Ṣan'ā' is of Sassanian type and it is possible that it was copied from one in the Sassanian governor's palace in Ṣan'ā'. That such palaces, or at least their audience halls, may have been built in the Yemen is strongly suggested by the close approximation of some of the mosques, e.g. Shibām-Kawkabān, to the Sassanian *apadana* in its traditional old-fashioned, Achaemenid form.[1] Finally, some columns, capitals and decorated panels found in Yemen betray Sassanian influence, but it is difficult to be certain that they date from the period of Sassanian occupation rather than the early Islamic period.

Al-Hamdānī, quoted by al-Rāzī (d. 460 h./1068), wrote in the early 10th century that there were four mosques in the Yemen dating from the days of the Prophet Muḥammad; they were, apparently in order of construction, al-Janad near Ta'izz, the Great Mosque in Ṣan'ā', the Jabbānah near Ṣan'ā', and the mosque of Farwah ibn Musayk near Ṣan'ā'.[2] All four are standing in some form today.

The mosque at al-Janad near Ta'izz was originally erected by one of the Companions of the Prophet Muḥammad, Mu'ādh ibn Jabal; his building, "a pretty mosque", was the centre of a pilgrimage regarded as "equivalent to a visit to the holy places of Mecca, or even to the rites of pilgrimage. The custom of annually resorting to it grew, until at length the practice was regarded as one of the religious ceremonies attending the pilgrimage to Mecca".[3] The mosque was rebuilt by the Nubian slave Ḥusayn ibn Salāmah, Wazir of Zabīd, c. 981–1011.[4]

A more ancient survival is the second of the Yemeni mosques, the Great Mosque in

1 Cf. K.A.C. Creswell, *Short Accounts of Early Muslim Architecture*, London 1958, p. 158.
2 Cf. al-Rāzī, *Tārīkh Ṣan'ā'*, Damascus 1974, pp. 232-233.
3 'Umārah al-Ḥakamī, *Yaman*, trans. H.C. Kay, London 1892, p. 10.
4 H.C. Kay, *op. cit.*, pp. 9-10.

Ṣan'ā'. It was originally built by another Companion of the Prophet, probably Farwah ibn Musayk.[5] The early Islamic sources stress that the mosque was laid out on the instruction of the Prophet, and that he indicated the site and precise limits of the building. If this is so, it must always have been a very large building, for the western wall still lies over the western marker, a stone outcrop in the garden of the palace of Ghumdān (called in the texts the garden of Badhān, the last Persian governor). Although the eastern side of the mosque was later moved in order to enlarge it, the original size can hardly have been less than 55 metres. Beyond the northern *qiblah* wall there was built the large tomb of an early "prophet"[6] – possibly following the tradition of building tombs against the outer walls of the pre-Islamic temple enclosures in Yemen. Until archaeological excavation is undertaken, we cannot be sure that any of the surviving mosque dates back to this original foundation. On the other hand, with such dimensions we can be certain that it originally had a courtyard, and therefore must have resembled to some extent pre- Islamic temples which were still in ruins in the same area.

The character of the original mosque cannot be truly ascertained, as it was "constructed and enlarged" at the orders of the Umayyad Caliph al-Walīd c. 707 A.D. His governor enlarged it "from where its *qiblah* was to the place where its *qiblah* is today" (written in the mid-eleventh century A.D. by al-Rāzī).[7] The rebuilding of al-Walīd was probably responsible for the general external appearance of the mosque as it now remains. The first mosque had been smaller; the prophet's tomb to the north of the mosque was demolished, perhaps only partially at first, to make way for the moving of the *qiblah* wall and the whole of the prayer hall further north, more than doubling the size of the courtyard. It seems reasonable to suppose that the western and southern walls remain in their original positions.

Internally the al-Walīd mosque had a *miḥrāb,* an early recorded instance of one in a mosque,[8] and it had inscriptions and wonderful workmanship in plaster.[9] The roof of the mosque was carried on arcades, supported mainly on columns and capitals of indigenous South Arabian style, indiscriminately mixed together. The use of arcades in this mosque is probably to be explained by the exposure of Ṣan'ā' during the previous centuries to Byzantine and Sassanian arcaded structural systems. The great palace of Ghumdān, which had stood alongside the mosque, had been destroyed on the orders of the Caliph 'Uthmān c. 632, and no doubt formed a quarry for a good deal of the stonework, pre-Islamic inscriptions and architectural elements now to be found in the mosque. It is an old tradition that the door by which the Imam entered the mosque

5 Ibn Rustah, *Kitāb al-A'lāq*, before 903 A.D., ed. de Goeje in Bibliotheca Geographorum Arabicorum, Leiden 1982; description of Ṣan'ā' trans. by R.B. Serjeant, in R.B. Serjeant and R. Lewcock (eds), *Ṣan'ā', an Arabian Islamic City*, London 1983; al-Rāzī, *Tārīkh Ṣan'ā'*, and al-Hamdānī, *al-Iklīl*, VIII, p. 43.

6 Ibn Rustah, *Kitāb al-A'lāq*, VII.

7 al-Rāzī, *Tārīkh Ṣan'ā'*, p. 214.

8 Cf. *Encycl. Islam*, article "Mamar", III, p. 231.

9 Al-Rāzī, *Tārīkh Ṣan'ā'*, p. 214.

through the *qiblah* wall had been rescued from Ghumdān and was built into the mosque at this time. It is plated with metal (now painted), the lower panels having pairs of arches in relief and the upper inscriptions in ancient South Arabian script. Kufic inscriptions in the outside walls recording the work done on the mosque by the Umayyad Caliphs were defaced when the ʿAbbasids seized power.[10]

The Great Mosque was among the mosques repaired on the order of the ʿAbbasid Caliph in 753–754, according to the inscription preserved in the courtyard. The finest of the Christian capitals and shafts were probably moved into the mosque at this time, as the cathedral was being demolished, and incorporated in places which improved the old work, one indeed next to the *miḥrāb*.

In 911–912 it was recorded that there was a minaret on the Great Mosque.[11] It is not known when this was built, but it seems to date from the eighth or ninth century,[12] there were minarets built as part of al-Walīd's mosque in Medina c. 707.

In 875–76 the mosque was severely damaged in a great flood, and had to be extensively repaired.[13] It was probably at this time that the ceiling which resembles that of the mosque of Shibām-Kawkabān began to be erected.[14] Later the mosque was reputedly deliberately flooded by a leader of the Ismailis in 911-12; he allowed the water to remain "until the freshness of the decoration in the ceiling was lost". This must have caused considerable damage to the structure, and may have directly resulted in the need, probably within a century, to lower the ceiling and replace it by one of a plainer design, preserving only four bays of the higher ceiling at the western end, into which the surviving wooden fragments were gathered.[15]

The eastern arm was completely rebuilt in a new position to the east of the old one, thus widening the courtyard, according to a seventeenth century authority,[16] by Queen Arwā bint Aḥmad in 1130–31. The mutilated eighth century inscriptions were built back into place on the outside of the rebuilt eastern wall, which also retained its original stone building technique. Arwā raised the height of the entire eastern ceiling, introducing splendidly carved beams and ceiling panels with an endless variety of fine decoration. At the same time the ceiling of the northern prayer hall, crudely reconstructed in the tenth or eleventh century, was painted with decoration of matching type. The western ceiling was raised to match the eastern, and given similar painted decoration.

10 Deduced by G.R. Smith from the style of the calligraphy and the lack of a likelihood that any other reason for the mutilation of the inscriptions, which are certainly earlier than the tenth century, could exist.

11 Al-Janadī, *Sulūk*, trans. Kay, p. 200. The eastern minaret seems the older of the two, on structural grounds.

12 H. Scott, *In the High Yemen*, London 1942, records that both minarets were built in 878, but he does not give his reference. Their structure and shape are different, the eastern being of brick and square, the western of stone and cylindrical internally.

13 Al-Rāzī, *Tārīkh Ṣanʿāʾ*.

14 Al-Janadī, *Sulūk*. al-Hajarī, *Masājid Ṣanʿāʾ*.

15 al-Janadī, *Sulūk*, p. 200. al-Janadī asserted that traces of the water-level in the mosque could be perceived to his day (c. 732 h./1331).

16 Sayyid Yaḥyā b. al-Ḥusayn, *Anbāʾ al-zamān*.

The minarets were rebuilt or repaired in 1206/07, according to the inscriptions on them, and the domed treasury for mosque records in the courtyard was built during the first Ottoman occupation in 1603. It is not known whether anything existed on that site beforehand, although there was probably an earlier treasury there, raised above a fountain, of the type that al-Walīd provided in the other mosques he rebuilt.

The great Mosque in Ṣan'ā' is thus a building composed of work from many periods, but essentially dating from the eighth and ninth centuries.

One remarkable feature of the Great Mosque remains to be discussed, which was already mentioned above. This is the wooden construction of the ceiling in front of the *miḥrāb*, that is, in front of the centre of the *qiblah* wall. Two small squares formed by beams flank both sides of a large central square which takes up the full width of one bay. On the beams further beams are laid diagonally, then others above them, to form polygons, and from these rise wooden corbelled polygons, each progressively smaller until the "domes" end in alabaster top lights, now blackened with age and plastered over externally. Such a construction was built in Persia over important halls from Achaemenid times onwards, and the use of it to construct roof lights may have been imported into Yemen during the Sassanian occupation of the country immediately prior to the Islamic period.[17]

The old Jabbānah in Ṣan'ā' was a place for open-air prayer to mark the two festivals of the Muslim year. The Prophet Muḥammad laid down that such places should be outside the town, and the one at Ṣan'ā' was sited to the north of the city wall. It was a stone enclosure with a paved court and a *miḥrāb* built into the surrounding wall. The latter was rebuilt at various periods, particularly in 1015/16,[18] and in the early twentieth century it was doubled in size by moving the southern wall; at the same time the *miḥrāb* was redesigned.

The mosque of Farwah b. Musayk al-Murādī was a small mosque built by the Companion of that name while he was supervising the construction of the Jabbānah. It was extensively rebuilt by the Ottoman Ḥasan Pasha in 1588, and agian in 1972, leaving little to indicate the original form of the mosque.[19]

The finest early mosque in the Yemen, and at the moment that most perfectly preserved, is the mosque of Shibām-Kawkabān, which gives an impression of the original appearance and character of a great Southern Arabian mosque in the ninth century A.D.[20]

17 For further discussion on this problem se R.B. Serjeant and R. Lewcock (eds), *Ṣan'ā'*.

18 See translation of the inscription by G.R. Smith in R.B. Serjeant and R.B. Lewcock (eds), *Ṣan'ā'*.

19 Al-Hajarī, *Masājid Ṣan'ā'*, p. 89.

20 For a detailed description of this mosque, see R.B. Lewcock and G.R. Smith. "Two Early Mosques in the Yemen – A Preliminary Report", in *Art and Archaeology Research Papers*, London, 1973, IV, pp. 117-130.

Section 1 - Chapter 2

FOUNDATIONS OF THE GREAT MOSQUE IN ṢAN'Ā'

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The archaeological component of the Great Mosque of Ṣan'ā' Restoration Project has among its goals assessment of the structural integrity of the building's underground portions. The following report summarizes in this regard results of below-ground investigations carried out between 2006 and 2016. The report is based largely on visual inspection of structural elements exposed by archaeological excavations. As will become evident, many structural locations in the Mosque present signs of past interventions (repairs or re-buildings), or of additions or remodelings which imposed additional loads on older structures. For this reason, even visual assessment of integrity requires at least basic historical analysis of the structures in question.

This report is divided into eight numbered sections. The first three sections make a brief introduction to the archaeological investigations in the Mosque and their results. The next four sections each focuses on a set of major structural elements of the Mosque. These elements are the Mosque's exterior walls, the two minarets, the arcading pillars in the Mosque's four *riwāq* (halls), and the libraries and related structures which front on the southern end of the courtyard. Each section opens with a general description of the relevant structural element. The description focuses on foundations but also considers above-ground portions of structures. The section then considers the history of structural elements, with attention given particularly to loads added to structures. The presentation here draws on the results but not details of stratigraphic analysis of floors and other deposits inside the Mosque. Each section ends with discussion of observed or potential structural problems. The report concludes with a summary of these observation, and bibliography of cited sources. The report does not make recommendations for remedial or preventative actions.

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1. Archaeology program

The archaeology team[1] has the twin goals of documenting the history of the Great Mosque and its immediate surroundings, and of assessing the Mosque's structural integrity. The team's program involves three basic activities – making excavations within and around the Mosque, making the roof openings for repair of ceiling beams, and documenting architectural features exposed by plaster-stripping. The archaeological investigations started in 2006 and continued with minimal interruption until 2016 when the regional situation forced suspension of the Mosque intervention.

This report draws primarily on the results of excavations made inside and around the Mosque. During the ten years of its activities, the archaeology team made 68 individual excavations plus a dozen small probes inside the Mosque, and six excavations outside it. In order to avoid damaging the Mosque, each excavation was typically only 3-4 sq. m. in area but many reached 3-5m in depth. The excavation program followed the schedule of the ceiling restoration team, to minimize the area closed off in the Mosque at any one time. As a result, excavations are not evenly distributed throughout the Mosque. Instead, they are concentrated in the northwestern, northeastern, and southeastern corners of the building, with additional excavations north of the west minaret and in the courtyard. Suspension of the intervention occurred just as the team was preparing excavations in the southwestern corner of the Mosque and at additional points in the courtyard.

Excavations inside the Mosque document more than sixty floors, plus occasional layers of fill, laid one upon the other in a sequence that is 0.6-1.8m deep across the roofed portions of the building. Many excavations also uncover architectural elements – walls, pillar bases and foundations, blocked doorways, chunks of decorated plaster, etc. – that belong to earlier versions of the Mosque, or to buildings older than the Mosque. The stratigraphic relationships between the floor sequence and architectural elements exposed in each excavation establish a relative chronology of construction events and structural modifications at that point in the Mosque. Some of the floors and fills are distinctive enough to establish stratigraphic correlations between different excavations. Such correlations are strong within a given area of the Mosque, but they are less definite across different parts of the Mosque. Even so, these correlations form a coherent framework for describing the structural history of the Mosque as a whole. Absolute dating of individual events in this history is more difficult to establish. Inscriptions in the Mosque and textual sources can help here, but these sources are not always decisive.

1 The present authors are the team leader and assistant team leader of the restoration project's archaeology component. The team members are ʿAbd al-ʿAzīz Saʿīd al-Qubaybī, Aḥmad ʿAlī al-Rawdī, Musliḥ ʿAlī al-Qubātī, Bashīr Sulṭān, Burhān Mahdī ʿAbdallāh, ʿIṣām ʿAlī, Mukhtār ʿAlī ʿAbd al-Rabb, Muṣṭafā Qāsim Aḥmad, and Mājid Ṭāhā al-Majayī. We are deeply grateful to all members of the archaeology team, and to all other members of the restoration project, whose hard work created the results reported here.

2. Outline of the structural history of the Mosque

The following summary of the Mosque's history is based on the results of uncompleted research. Understanding of certain points in this history may well change if excavations again become possible in the future and new information is obtained.

2.1 Pre-Islamic structures

The Mosque covers multiple periods of pre-Islamic building at this location. Pre-Islamic building remains are most dense below the southeastern portions of the Mosque (the eastern half of the south *riwāq* and southern end of the east *riwāq*), where excavations uncovered a stratified succession of architecture. The earliest of this architecture, which is documented in several spots, includes the corner of a finely-made wall and a roughly made wall with a row of storage jars set against it, at elevation 5.4-6.4m (see Section 3 for definition of 'elevation'). Just above this level are the remains of a large building or buildings which burned. In addition to walls, these remains include fine stone pavements (at elevation 6.5m) and a *qaḍāḍ*-lined basin. These remains are near the traditional location of Qaṣr Ghumdān, and may in fact belong to it. The pottery associated with these two architectural levels strongly suggests a 2nd-3rd century CE date. This date fits nicely with the tradition ascribing construction of Qaṣr Ghumdān to the Himyarite king Ilsharah Yahdib, ca. mid-3rd century CE (see Khoury 1993).

A stratified accumulation of collapsed wall stones and colluvial soil plus plastered or compacted surfaces with little architecture separates these earlier buildings from two later phases of architecture. The earlier of these phases consists of mud brick structures without foundations, and associated floors at elevation 7.6-7.5m. The second of these two phases is a group of parallel wall-like foundations with tops at elevation 8.1-7.9m, and probably associated floors at the same elevations. The latter walls and floors appear directly below floors of the *ẓullah* that is firmly associated with the "Umayyad Mosque" (section 2.3), and they are possibly remains of the first Mosque.

Pre-Islamic architectural remains are less dense below other parts of the Mosque to the north and west. In general, these remains probably represent an open fabric of more ordinary structures of stone and mud brick. A stone-lined well set within a formal well-head appears below the southeast corner of the north *riwāq*; a *qaḍāḍ*-lined channel set on a stone wall runs northward from the well-head. The location of the well suggests that this structure is al-Karāmah, the well of Qaṣr Ghumdān, which al-Rāzī (1984) states was opposite the first door of the Mosque. On the other hand, excavation against the west wall of the Mosque next to the Mulamlamah marker failed to find any rock that might correspond to *ḥajar al-Mulamlamah* which tradition says marked the west side of the original Mosque.

Despite common speculation among scholars today (e.g. discussion in Costa 1994), none of the pre-Islamic buildings can be identified as a temple, nor are any of them systematically incorporated into construction of the Mosque. Even so, the Mosque appears to continue an already ancient structural tradition. With one exception, alignment of the pre-Islamic architecture is parallel to or orthogonal to (within several degrees) the lateral walls of the Mosque. The exception is the last phase of architecture described above, when the group of parallel walls faced geographical north (i.e. they run obliquely through the south *riwāq*).

2.2 The first Mosque

According to historical tradition (e.g. al-Rāzī 1984), the Mosque was first built by order of the Prophet Muḥammad in the year 6/627. This first mosque is thought to have been in a southern part of Mosque's footprint today (e.g. Lewcock *et al.* 1983). However, the archaeological investigations have not definitively identified this building. As mentioned above (section 2.1), excavations did uncover some ribbon foundations and floors beneath the south *riwāq* that might belong to this first Mosque, but nothing associated with these remains indicates that they belong to a religious building.[2]

2.3 The "Umayyad Mosque"

The earliest Mosque identified with certainty is a rectangular structure, about 62m long and 52m wide. The north and west walls of this structure were in the same position as those of the Mosque today, while its east wall ran along the line of the inner pillars of the present east *riwāq*, and its south wall ran between the north faces of the two minarets. Structures at the southern corners of the buildings occupied the positions of the Mosque's two minarets today; these structures were probably early versions of the minarets (or *ṣawma'ah*), but their size and height remain unclear. The north *riwāq* was at least 5 aisles deep, and the two lateral *riwāq* were probably each three aisles deep. The existence of a south *riwāq* remains undetermined. The initial floor of the building was 1.5-1.8m below the present floor of the Mosque. This building almost certainly is the work ordered by the Umayyad caliph al-Walīd b. 'Abd al-Malik b. Marwān (86-96/705-715) as reported in al-Rāzī (1984).

At the same time or slightly later, a covered structure, perhaps a portico or *ẓullah*, was built against the outside face of the south wall, in the area now occupied by the Mosque's south *riwāq*. This structure had relatively small square pillars of plaster and stone, which have no structural relationship to the south *riwāq*, and no exterior walls have been identified for this southern appendage.

2 If these elements do belong to the first Mosque, then the *qiblah* would probably been oriented to geographical north, as expected in a mosque of this date (see King 1995 for discussion).

2.4 Construction of the present south *riwāq*

The south *riwāq* was built as an enlargement of the Umayyad Mosque, over the truncated remains of the *ẓullah*. The enlargement required demolition of the south wall of the Umayyad Mosque and construction of the present south wall, together with extensions of the early east wall and the west wall south of the two minaret structures. This south *riwāq* was at least four aisles deep. The floor of the new *riwāq* was 1.3m below the present tile surface of the south *riwāq*. This enlargement is not reported in the available historical sources, but it probably occurred during the 2nd/8th century.[3]

At some time after the enlargement, perhaps during the first half of the 3rd/9th century, the existing east *riwāq* was remodeled, and at this time the south *riwāq* was reduced to three aisles. Around the same time many or all of the columns in the south *riwāq* were renovated.

2.5 Construction of the present west and east *riwāq*

Construction of the Mosque's present east *riwāq* was the second enlargement of the "Umayyad Mosque". The enlargement involved demolition of the then-existing east *riwāq* together with the east wall of the "Umayyad Mosque", and then construction of the Mosque's present east wall plus the adjacent portions of the north and south walls, and the cylindrical columns and the brick arcades of the present east *riwāq*. The floor of the new east *riwāq* lay 60cm below the present tile floor. This final enlargement of the Mosque can be dated with some confidence to the 3rd/9th century.[4]

At approximately the same time the west *riwāq* was completely re-built, using the same type of cylindrical piers and brick arcading as found in the new east *riwāq*. The initial floor of the remodeled west *riwāq* was 90cm below the present tile surface.

2.6 Later remodeling

Subsequent changes to the Mosque were largely adjustments to individual structures inside the building.

The north wall was remodeled, probably in the early 6th/early 12th century when

3 An inscription in the Mosque (now fixed into the north façade of the eastern library staircase; see Fig. 6) states that the Abbasid governor ʿAlī b. al-Rabīʿ made repairs to local mosques in 136/754 AD. This work possibly included enlargement of the Great Mosque.

4 The existing east *riwāq* is often said to be the work of al-Sayyidah al-Ḥurrah bint Aḥmad al-Ṣulayḥī (Queen Arwā), who died in 532/1138. But all Yemeni historians writing before the 11th century/17th century attributed construction of the *riwāq* to the Yuʿfirids, and an inscription on wood below the ceiling names Muḥammad b. Yuʿfir and the date 270 *hijrī* (883-884 CE). The archaeological evidence – including numerous copper coins belonging to 3rd/9th century – firmly supports the Yuʿfirid alternative for the *riwāq* construction.

the three doorways now there were constructed, and the *miḥrāb* was moved to near its present location. The extant *miḥrāb* was made in the 7th/13th century.

The two minarets were rebuilt in Ayyubid times (late 6th-early 7th/late 12th-early 13th century), and they still retain the appearance probably created at that time.

Many pillars of the north and south *riwāq* were replaced, sometimes more than once, after the 3rd/9th century. The replacements seem to have occurred as repair of individual pillars, not as part of a general building program.

The extant domed structure within the central courtyard was built in the early 11th/17th century by an Ottoman governor. This structure is eccentrically located within the current configuration of the courtyard, but this location was at the center of the courtyard in the "Umayyad Mosque". Very likely earlier structures existed at this location, but no excavations have been made to test this probability.

In terms of visual impact and the use of interior space, the most significant alteration was construction of the libraries above the southern end of the courtyard and then extension of the south *riwāq* into the space below the libraries, during the interval 1344-1386/1925-1966).

3. Terminology used in this report

Definition of terminology and conventions used in the report are needed before turning to the substance of the report.

The *qiblah* in Ṣan'ā' is north-northwest (326°), and the Mosque itself is oriented approximately in this direction. For sake of simplicity, the *qiblah* direction is here designated simply as north, and the other cardinal directions are used in a corresponding way.

Reference to the Mosque's four *riwāq* reflects the Mosque's historical development rather than functional divisions. Thus, for example, the north (*qiblah*) *riwāq* might functionally extend from west to east walls, but historically and structurally the northeast corner of the building belongs to the east *riwāq*. The direction of arcading and of the primary beams of ceilings is an above-ground reflection of the historical *riwāq*. In keeping with these distinctions, the exterior walls of the Mosque are not simply named for the cardinal directions. Historically speaking, the eastern portions of the northern and southern walls were created together with the Mosque's east wall as part of the east *riwāq*. This historical distinction is visible today as vertical joints in the exterior faces of the northern and southern walls – these joints mark older northeast and southeast corners of the Mosque. Similarly, the exterior walls along the south and west sides of the south *riwāq* belong together in time, as the southward enlargement of the "Umayyad Mosque". The east and south walls of the latter building are today stubs below the surface of the present Mosque, but both walls retain structural roles in the building's above-ground portions.

The vertical position of structural elements presents other issues. Interior floors of the Mosque today vary in elevation by 35cm or more; outside the Mosque, today's street surfaces lie more than half a meter above the interior floor at the southeast corner of the Mosque, but about 75cm below the interior floor at the northwest corner of the building. Depths below present surfaces are relevant to many situations, but position relative to a standard horizontal plane is generally important. The latter, here called ‘grade’, is keyed to the 10m benchmark of the French photogrammetric plan of the Mosque.

The following list summarizes the basic referential terminology used in this report.

north *riwāq*	five aisles deep, extending from the east *riwāq* to the west side of the Mosque, with brick arcades running east-west
east *riwāq*	three aisles deep, extending the full north-south length of the Mosque, with brick arcades running north-south
south *riwāq*	four aisles deep today, extending from the east *riwāq* to the west side of the Mosque, south of the two minarets, with brick arcades running east-west; the fourth (innermost) aisle of the south *riwāq* is a recent addition below the 14th/20th century library structures, and this aisle is here considered to be a space separate from the south *riwāq* proper
west *riwāq*	three aisles deep, extending between the north and south *riwāq*, with brick arcades running north-south
aisle	aisles in each *riwāq* are linear spaces framed by the pillars of adjacent pairs of arcades; aisles are numbered from the exterior wall (first aisle/outer aisle) toward the central courtyard (third, fourth or fifth aisle/inner aisle)
pillar location	each pillar is designated by its location on a theoretical grid, in which the x-axis is given letters (“A” at the west, “O” at the east), and the y-axis is given numbers (“1” in the north, “18” in the south (thus the pillar nearest the northwest corner of the Mosque is pillar A1, that nearest the southeast corner is pillar O18)
east wall	the full length of the present eastern wall of the Mosque plus those portions of walls on the Mosque’s north and south ends which enclose the east *riwāq*; the latter portions of the east wall articulate with the north and south walls as a vertical joint on the exterior but not interior face of the walls
north wall	the Mosque’s present northern wall from the northwest corner of the building up to the exterior joint with the east wall
west wall	the Mosque’s present western wall from the northwest corner of the building to and including the footprint of the west minaret
south wall	the Mosque’s present south wall west of the exterior joint with the east wall plus those portions of the western wall south of the west minaret

early south wall	the south wall of the "Umayyad Mosque", running between the north faces of the two minarets, before construction of the present south *riwāq*
early east wall	the Mosque's east wall before construction of its present east *riwāq*, extending between the vertical joints still evident in the exteriors of the north and south walls (the eastern wall of the "Umayyad Mosque" plus the eastern wall of the south *riwāq*)[5]
grade	10.0m on the French photogrammetric plan; the present interior surfaces are at grade in the southern end of the east *riwāq* and in the southeastern corner of the courtyard, but drop to 10-15cm or more below grade to the west and north
elevation	reported with respect to grade
depth	below grade or present floor, as specified, and usually rounded to the nearest ten centimeters when cited.

Historical dates are given both *hijrī* and the common era, in that order and separated by a slash.

4. Exterior walls

The following descriptions and observations are based on 27 archaeological excavations at the present Mosque walls. The excavations are distributed as follows:

	interior face	exterior face	total
north wall	8	3	11
east wall	6	2	8
south wall	3	0	3
west wall	5	2	7
total	22	7	29*

* an excavation at the exterior joint between the north and east walls, and one at the corresponding location on the interior face of the wall, are each counted twice

The Mosque's exterior walls present facing stones set in regular courses. These stones are well dressed and squared stones are used for exposed portions (e.g. the exterior faces) of walls, but less well-shaped blocks appear in hidden (e.g. plaster-covered) faces. The two

5 The early east wall was constructed in two phases, the portion south of the east minaret being later, and built together with the present south wall. This historical detail has no evident bearing on the structural issues addressed in this report.

faces enclose a core of smaller irregular stones and clayey earth. Although they present a broadly homogeneous appearance, the walls do vary in detail. Wall thickness at grade ranges from 1.3m to 2.0m,[6] with significant variation occurring within same wall. Judging by excavated examples, the facing blocks comprise 70-90cm of this thickness. The walls variably rise 6-8m above the street level today – the east wall is around 8m high, while the others are 6-7m high. The individual facing blocks also vary in size. Some blocks are 1.3-1.5m long and 50-60cm high, while others are only 20cm long and 25cm high. In general, lower courses are formed of larger blocks than higher courses, the interior face is formed of smaller blocks than the exterior face, and blocks of the east wall are smaller than those elsewhere in all positions.

The walls rise as smooth continuations from rubble-core foundations that are faced variably with dressed blocks set in regular courses (north and west walls), with a mix of dressed roughly shaped blocks in courses increasingly irregular with depth (south wall), or with roughly shaped stones arranged in irregular courses (east wall). The foundations were built into trenches cut to a variable depth for this purpose (an example is shown in Fig. 1). At their tops, the trenches are 1.0-1.5m wider than the wall face, but they typically narrow to 10-20cm at the bottom of the cut. At the southern end of the east wall, a wider gap between foundation and trench is filled with a 40cm-wide buttressing of coarse rubble. The narrowness of the trench in its lower portions enhances the lateral stability of the foundations.

4.1 North wall

The north wall is the thinnest of the Mosque's present walls: at its eastern end the wall is 1.5m wide, but at its western end it is only 1.3m wide; most of the tapering occurring west of the central doorway. The *miḥrāb* in the north wall is a meter deep, but it is not accommodated by an exterior projection; here the wall thickness is reduced to around 50cm. Three doorways are placed in the wall. The central doorway (the "*imām*'s doorway") is framed by a shallow arched surround, while the two lateral doorways are flush with the exterior face of the wall (see Figs 2-3). The latter two doorways are blocked up with stone at the exterior side, and the resulting space is today used for storage.

4.1.1 Structural characteristics of the north wall

The north wall was first built as part of the "Umayyad Mosque." Foundations for the wall extend to elevation 5.5-5.9m, around 4 meters below the present Mosque floor (see Fig. 1). On its interior face the foundation widens by 50-60cm, and rests upon a bed of rubble. On its exterior face the foundation widens at least 20cm. The facing stones used for the

6 The wall thicknesses given here and elsewhere are estimated from the French photogrammetry map (scale 1:100).

foundations are all well-dressed and squared blocks, laid in regular coursing. The transition from foundation to wall is marked only by a tighter fit of facing stones.

Interior wall plaster is continuous down to elevation 8.0-7.7m (1.8-2.1m below the present floor). The bottom of the plaster covers a horizontal slot built into the wall, and a similar slot appears in the exterior face of the wall at the same elevation (Fig. 1). These slots are 10-12cm high and 20 deep. Regularly coursed facing stones frame the top and bottom of the slot, and the stones and earth of the wall's rubble core form its inner side. Although they are now empty, the slots once contained wooden beams that formed two continuous bands which were tied together by additional beams through the thickness of the wall, creating a horizontal latticed frame.[7] The earliest floor of the Mosque ran up to the wall plaster just above the beam slot at elevation 8.0-7.9m. In other words, the foundations are 2.1-2.4m deep with respect to the original floor of the *riwāq*.

Excavations at the *miḥrāb* show that this location was originally a doorway, with an exterior entry staircase. If the "Umayyad Mosque" had a niched *miḥrāb*, that structure was not located at the middle of the *qiblah* wall; but very possibly the building did not have a *miḥrāb* (see Khoury 1998 for discussion of the history of the *miḥrāb*). A *miḥrāb* was later built into the space of the original doorway (probably Abbasid or Yu'firid, 2nd-3rd/8th-9th centuries), and subsequently rebuilt into its present position,[8] along with the present imam's doorway and the other two doorways now existing in the north wall. These innovations involved extensive rebuilding of the wall's exterior face, using very large facing stones (blocks in lower courses are up to 77-86cm long and 77-84cm high, and blocks in higher courses are commonly a meter or more long and 40 cm high) down to 1.4-1.5m below grade (evident in Figs 1-3). This remodeling, which probably occurred in the 6th/12th century, extended to one or at most two courses above the wood beam slot in the original wall, and left untouched the original foundations (Fig. 3, see also Fig. 5).[9] The original wall plaster is uninterrupted to a level below the first floor of the north *riwāq* (Fig. 4), implying that the interior face of the north wall was not been rebuilt or deeply repaired.

4.1.2 Structural issues

The general condition of the north wall foundations is good. Nevertheless, three issues, two of them inter-related, do exist.

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7 The wall plaster over the interior slot often has impressions of wood grain on its interior face, and at several points holes still exist into the thickness of the wall. Exactly the same structural features have been observed in the east wall of the "Umayyad Mosque", where decayed wood is still extant.

8 This relocated *miḥrāb* is lower in the wall than is the *miḥrāb* of today; construction of the latter truncated the former. The present *miḥrāb* bears a date of 665/1267.

9 This statement is based on one excavation at the east expansion joint and excavations at two of the three doorways, but without a 'control' excavation at a segment of the wall without a doorway. In other words, the rebuilding may have primarily affected portions of the wall around the doorways, rather than the entire length of the wall, most likely early in the 6th century AH (cf. the inscription over the central doorway, dated 513/1119).

4.1.2.1 Lateral deformation

Re-building the exterior face of the north wall left the wood beam slot in place. The wood has completely decayed, allowing the facing stones of the course above the slot to pivot downward and collapse into the slot (evident in Figs 1, 3-4, 6). This movement probably introduced buckling of the exterior wall face, similar to the buckling also evident in the west wall (see section 4.2.2) for the west wall. The 6th/12th century re-building of the exterior face of the wall probably corrected much of the deformation that existed at that time. However, some deformation is still evident in the re-built courses.

The re-building followed the traditional technique of setting facing stones at a slight angle, with their bottom set 1-2cm back from the course below and their top leaning outward by a similar amount, to produce an approximately vertical wall. However, in places the lowest 3-4 courses of the rebuilt wall lean outward cumulatively by 5-6cm over 1.3-1.8m of height (3-4% off vertical), before becoming more or less vertical at elevation 10.1-10.3.

This slight but noticeable outward lean is possibly an intentional feature of construction. But more likely it reflects continuing deformation due to slow collapse of facing stones into the wood beam slot. The low revetment along the exterior of the Mosque's north wall is the most recent version of a structure which first appeared after the 6th/12th century re-building (see section 4.1.2.3), perhaps in part as a measure to buttress the wall against lateral deformation.

In some locations the collapsing facing blocks have completely closed the beam slot, and these areas are now relatively stable. But in other locations (e.g. just east of the imam's doorway) the collapsing facing blocks have not completely closed the beam slot, and leave open the possibility of additional distortion of the coursing above them in the future.

Collapse of facing stones into the interior beam slot has not been observed to occur to the same degree.

4.1.2.2 Central doorway foundations

The central doorway in the *qiblah* wall sits within a masonry surround which projects 30cm from the wall proper (Fig. 6). The doorway structure is 2.7m wide, and its stonework extends 1.5m below the entryway itself (60-70cm below the current street level). The doorway is not an original feature of the north wall: its stonework bonds with that of the rebuilt north wall and, like the latter, its lowest course incorporates large blocks (the block at the bottom of its east corner is 77cm wide, 58cm high and over 31cm deep).

The doorway structure suffers from several structural weaknesses.

At its bottom, the doorway structure sits above stone rubble of an earlier retaining wall with deep foundations, and it cuts into remains of a plaster structure belonging to the same retaining wall. However, the stone rubble of the earlier retaining wall lies 25-30cm below the bottom of the doorway structure, with loosely packed earth and plaster rubble plus two *qaḍāḍ* surfaces separating the two structures (Fig. 7). In other words, the doorway structure lacks deep foundations specific to it.

The bottom of the doorway structure sits about 40cm above the wood beam slot in the north wall, with a single course of blocks separating the structure from the beam slot (Fig. 4). Immediately east of the doorway, these blocks are partially collapsed into the beam slot (see section 4.1.2.1).

Whereas the lower portions of the doorway structure's sides rise vertically (examined only at the structure's east side), the lowest four courses of the structure's outer (north) face lean slightly outward – cumulatively by 6cm in 1.8m of height – before becoming vertical at about 30cm above grade. This outward lean closely matches the same feature evident in the north wall itself (see section 4.1.2.1).

This outward lean probably reflects the combined effects of the doorway structure's lack of deep foundations plus the continuing collapse of facing stones into the wood slot beneath the structure. The wood slot here is still partially open, and additional movement of the facing stones above it remains possible.

4.1.2.3 Moisture

Moisture rising up the interior faces of walls is an obvious problem at many points around Mosque. The moisture deteriorates wall plaster and also the *miḥrāb* in the north wall, and crystallizing salts promotes desquamation of wall facing stones. The Mosque's floor lies as much as 70cm below street level in the building's southern and southeastern sections of the building, but as much as 75cm above street level in its northern and northwestern sections. Moisture damage to wall plaster is evident in both situations, suggesting that multiple factors contribute to the problem.

The revetment (*bughlah*) along the outer face of the north wall is an obvious contributing factor at the north side of the Mosque. The *bughlah* today is constructed as a skin of stone blocks and cement over a core of stones and earth, and rises against the north wall more than a meter above street level, and ca. 20-50cm above the present level of the floor in the Mosque's interior (Fig. 1 and 6).[10] The sharply sloping surface of the *bughlah* does deflect water away from the Mosque, but the structure's stone and cement skin also retains moisture against the *qiblah* wall and encourages its movement through the wall and into the Mosque. The Mosque's tile floor is also laid in cement, leaving the wall plaster as the conduit of moisture.

Cement of the *bughlah* most probably exacerbated but did not initiate the moisture problem, as suggested by two separate excavation findings.

Excavations at three points along the north wall exterior reveal the remains of at least three, perhaps four, previous revetments in the same location. The earlier revetments

10 The *bughlah* is higher relative to the interior floor at the east end of the north wall: the interior floor is fairly horizontal, whereas the street outside drops some 30cm from east to west.

were constructed of stone blocks laid in clay-rich earth, and enclosing a core of stone and earth. *Quṭrah* coated the masonry of the north wall (visible in Fig. 3) and adhered to stones immediately adjacent to the wall, but this cement-like material was not otherwise incorporated (or preserved) in the structures. The earliest of these previous revetments appears at 1.1m below the present *bughlah*, some 40-60cm below the present street level, and 1.2m below the present floor level of the Mosque's interior; *quṭrah* on the *qiblah* wall extended slightly deeper. Pottery from street deposits adjacent to the earlier revetments indicates that these revetments date to the past three or more centuries.

Excavations against the interior face of the north wall exposed a 70cm-wide trench dug 1.7m deep along the wall (but leaving the wall plaster in place) and then filled with loosely packed rough stones and gravel (Fig. 1). This feature may have been a sort of dry-well intended to allow moisture to drain away from the wall plaster. The feature seems to run the entire length of the Mosque's north wall; it definitely does not extend into the east *riwāq*, however. Its stratigraphic position suggests that the feature was inserted around the time the *miḥrāb* was shifted to its present position.

The existence of earlier revetments, and in particular the application of *quṭrah* to the north wall exterior, plus construction of a possible dry-well against the north wall interior, suggest that moisture here has long been a concern.

4.2 West wall

The wall along the western side of the Mosque is 1.4m wide at its north end, and widens to 1.8m towards the west minaret. It has three doorways today. The northern doorway was rebuilt with a concrete lintel as part of the 1970s "renovations". the central doorway had a domed portico that was removed for construction of the Awqaf Library in 1404/1984, and the southern door was remodeled in conjunction with construction of ablution facilities. The marker for the Mulamlamah is just south of the central doorway.

The northern section of the wall, from the west minaret to the northwest corner of the building, originated with the "Umayyad Mosque," whereas the southern section from the minaret to the southwest corner of the building belongs to the south *riwāq* expansion. Only the west wall proper – i.e. the wall from the west minaret to the northwest corner of the Mosque – is discussed here, based on information from two excavations at the exterior face of the wall and five excavations at its interior face.

4.2.1 Structural characteristics of the west wall

The west wall was built at the same time as the north wall, and is very similar to the latter in character. The corner formed by the north and west walls has not been examined for bonding below grade. The west wall foundation is bonded with the west minaret foundations (described in section 5.3.1.1)

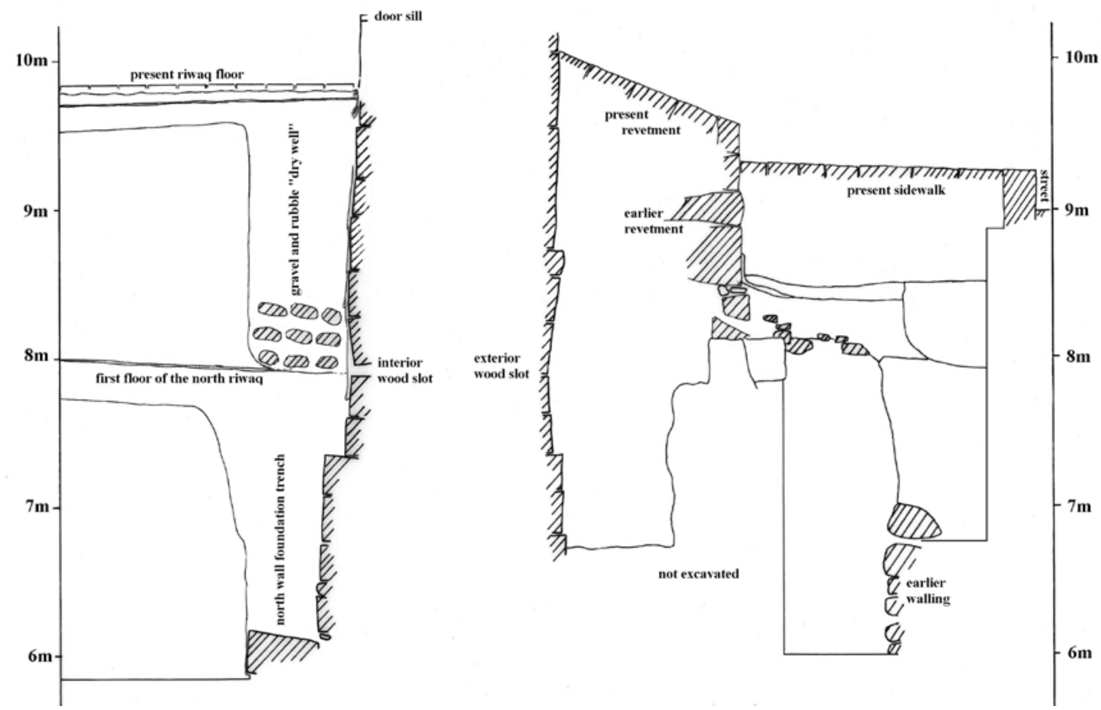

Fig. 1. Cross-section of the north wall at the western blocked doorway, with simplified stratigraphy (vertical scale with respect to grade).

Fig. 2. Exterior face of the north wall, the surround of the imam's doorway, and remains of the earlier formal entryway. Note the large size of the facing blocks of the wall.

Fig. 3. Exterior face of the north wall at the western doorway. Rubble of the *bughlah* is visible on the left side of the photograph, and *quṭrah* of the *bughlah* adheres to the facing stones of the wall. Note the much smaller size of facing stones at the bottom of the wall compared with upper (rebuilt) courses. The mostly closed wood slot is visible at the bottom of the scale (each bar is 5cm).

Fig. 4. Interior face of the north wall at the western doorway. The wall plaster visible at the top of the photograph is the original plaster of the north *riwāq* and it covers the wood slot. The wider footing of the foundation is visible at the bottom of the photograph.

Fig. 5. Detail of the north wall and bottom of the surround at the imam's doorway. The wood slot is visible near the bottom of the scale (each bar is 5cm). The plastered structure in front of and below the surround belongs to an earlier entry structure.

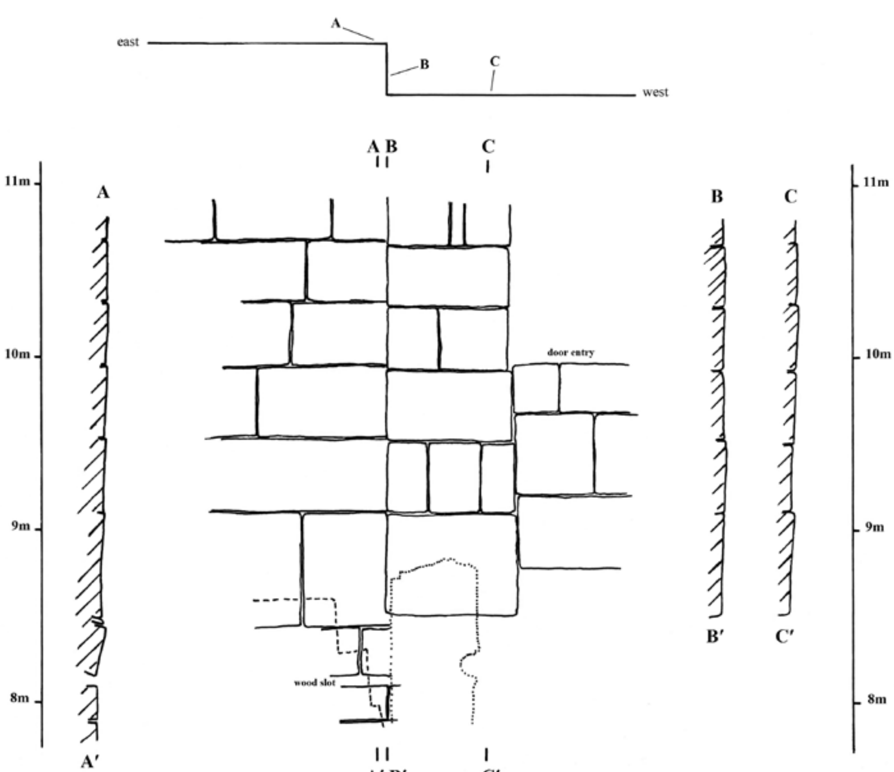

Fig. 6. Schematic cross-section of the north wall at the central doorway.

Fig. 7. Bottom of the surround at the imam's doorway, with the plastered remains of the earlier entry in front. The bottom of the surround sits upon an accumulation of plaster floors and stone rubble of the earlier entryway, but the surround has no foundations proper to it.

Foundations for the west wall were placed into a trench that cut into a gentle slope, so that the elevation of the bottom of the foundations is nearly a meter lower toward north end compared to south end (elevation 5.9m at a point between pillars A4 and A5, and elevation 6.8m at the west minaret respectively). The foundations sit on a wider bed of rubble (Fig. 8, see also Fig. 27), and they obliquely cross stubs of earlier walls at several points. The foundations near the west minaret are 5 courses deep below the horizontal wood slot, but they deepen to 7 courses below the wood slot toward the north end of the wall (Fig. 9). The foundations widen with depth by around 20-30cm on the interior face (Figs 8 and 27) and a little less on the exterior face.

Wall plastering on the interior face of the wall shows a continuous series of renewals of the original plaster; the latter extends to elevation 7.7m toward the north and to 8.1m at the south (near the west minaret). The continuity of plaster indicates that the interior face of the wall was never deeply rebuilt. The bottom of the wall plaster covers the wood slot, which also gently slopes to north, and the first floor of Mosque is at elevation 8.1m. In other words, the original foundation walls were variably 1.3-2.2m deep, but the depth and width of the rubble seating beneath the foundation wall has not been established.

4.2.2 West wall structural issues

The renovation work of 1973-4 included rebuilding a large section of the west wall and the western end of the north wall (see Costa 1994); this work apparently did not alter below-ground portions of the wall. The rebuilding left uncorrected deformation (buckling) of the exterior face of the west wall visible above grade in the area of the ablution facilities south of the west minaret, and excavations reveal similar, if not as pronounced, buckling at additional points further north along the west wall. Some deformation of the interior foundation is apparent in places (see Fig. 30), but it is much less common than on the exterior face of the wall.

The cause of this deformation is identical to that described above (section 2.1.2.1) for the north wall. The additional load imposed by the Awqāf Library on the exterior face of the west wall no doubt contributes to deformation of the wall between the central doorway and the west minaret.

4.3 South wall

The south wall of the Mosque is 1.5m wide at its west end and 1.8m wide at its east end. A single, centrally located doorway gives entry to the Mosque from this side. Foundations for the wall were exposed in three interior locations, all of which are east of the central doorway; the south wall west of the doorway and its western extension up to the west minaret have not been examined by excavation.

4.3.1 Structural characteristics of the south wall

South wall foundations extend deeper than elevation 4.5m. The foundations are faced with a mix of dressed blocks and rough stone laid in irregular courses; the mix is increasingly rough, and the coursing more irregular, with depth (Fig. 10). The foundations are significantly wider at their bottom than toward the top. The wall plaster is continuous to elevation 8.6, and the first riwāq floor is at this same elevation. In other words, the foundations are more than 4m deep with respect to the first floor of the *riwāq*.

The wall plaster covers a plastered slot inset into the wall at elevation 9.1, i.e. half a meter above the first *riwāq* floor. This slot seems to be confined to the eastern end of the south wall, where it joins a similar slot in the southern end of the early east wall. Construction of the present east *riwāq* involved demolition of the original southeast corner of the *riwāq*, and then extending the wall eastward. In contrast to the vertical joint on the exterior face, the interior faces of the wall show coursing of different heights that are irregularly bonded and reinforced with wood beams inserted at three positions.

Apart from alteration of the interior face at its eastern end when the present east *riwāq* was built, the south wall shows no evidence of deep rebuilding. The doorway in its present form was not original to the wall.[11] Rather, the doorway was most likely created during the 6th/12th century (judging by the style of the doorway and the Shiʿi formula of the inscription built into the wall above it), with subsequent modifications.

4.3.2 South wall structural issues

The three excavations made at the interior face of the south wall reveal no obvious structural problems. However, it should be remembered that the interior faces of the Mosque walls in general have few problems, and that no archaeological excavations have been made against the exterior face of the south wall.

Just as the imam's doorway in the north wall, the south doorway also sits within a projecting surround, to which a domed porch was later appended. As the south doorway has not been examined by excavation, the status of its foundations is not yet known. Because it is a secondary alteration, the doorway structure may not have deep foundations. However, the south wall seems not to have a wood frame at the top of the foundations, in the manner of the "Umayyad Mosque", and so escapes the danger of facing stones collapsing into the beam slot after the wood has decayed.[12]

4.4 East wall

The east wall runs the full length of the Mosque and turns to the west at each end to join the older north and south walls, enclosing the east *riwāq*. Vertical joints in the exterior facing stonework of the northern and southern walls of the Mosque show the ends of the east wall; the limits of the east wall are also visually evident in the broken coursing of facing stones and in the generally smaller size the facing stones used for the east wall. The east wall is the thickest of the Mosque's exterior walls, being 2.0m wide at its southeast corner and tapering to 1.7m at its northeast corner. Five doorways appear at regular intervals along the main stretch of the wall. These doorways are original to the wall.

The wall foundations are documented at two locations on its exterior face, and at six locations on its interior face.

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11 The level of the ceiling over the south *riwāq's* outer aisle is substantially higher than the ceiling over the second and third aisles. The brickwork of the *riwāq*'s outer arcade changes character in its upper portions, indicating that the outer aisle ceiling was raised above its original position. The outer arch of the south doorway rises nearly to the height of the ceiling over the outer aisle, and so must have been built after the ceiling was elevated.

12 A 1997 geophysical sondage against the south wall, 4-5m east of the existing doorway uncovered a feature reported to be a blocked doorway at 2.7m below the street level. Such a doorway has not been confirmed (it does not figure in Lamei-Mostafa 1997), and its existence seems doubtful.

4.4.1 East wall characteristics

The east wall foundations extend as deep as elevation 6.0m in places, but they are as shallow as elevation 7.1m in other places where the foundations rest upon earlier wall stubs. The foundations widen with depth on the interior face, by 25cm at its northern and southern "wings" and up to 90cm along its east side (Figs 11-12). The exterior face of the foundations is very nearly vertical down to a wider bottom course (Fig. 13). The great majority of the blocks that form the interior face of the foundations are roughly shaped (re-used dressed facing stones appear only occasionally), and these blocks are arranged in rough courses. In contrast, the exterior face is composed of well-formed blocks in regular courses, down to a wider seat of rougher stones (Fig. 13).

At the one doorway exposed in excavation (the southernmost doorway), a vertical joint in the interior facing of the foundation extends from the stone door jambs to near the bottom of the foundation. The foundation incorporates unusually large stones lateral to this joint, below the door jamb. This feature suggests sectional construction at the doorway, with reinforcement of the foundation below the sides of the doorway that also allows the position of the door sill to be set independent of the general coursing of the foundations.

Plaster covers the interior face of the walls down to elevation 9.4-9.3m (Fig. 11), where the first floor of the east *riwāq* also appears. Thus the foundations extended 2.3-3.4m below the original floor of the *riwāq*. A wood beam slot does not exist at the bottom of the wall plaster or at any other point in the foundations. However, three bands of wooden beams are set into the interior face of the wall, including the north and south "wings" of the wall above grade, at elevations 10.8m, 12.0m, and 14.0m. Wood bands do not appear in the exterior face of the east wall, either above or below street-level.

4.4.2 East wall problems

The five east doorways are identical in style, and they were constructed at the same time at the wall itself. While the four lateral doorways are flush with the exterior face of the wall, the central doorway in the east wall sits within a projection. The existence and condition of foundations for the projection have not been checked. But because the projection is an original feature of the wall, very likely it has a proper foundation.

In one location at the southern end of the east wall, a box-like void appears in the interior face of the foundations near its bottom. The void is 28-33cm high, and extends at least 1.8m in length and about 45cm into the body of the foundation. Mud packing smoothly surfaces the sides of the void, giving the impression that the void may originally have enclosed wood. The void obviously weakens the foundations at this point. However, the foundations here are about 90cm wider than the wall proper, and the upper portions of the foundations (higher than elevation 7.7m) lie entirely lateral to the void. This structural defect probably has minimal deleterious effect on the structural stability of the foundation.

Fig. 8. Interior face of the west wall near the west minaret. The wider course and the rubble bed at the bottom of foundations are in the center of the photograph. The plaster adhering to facing stones suggests that many of these stones were recycled from older structures.

Fig. 9. Interior face of the west wall near the north doorway. The wall plaster at the top of the photograph is the original plaster of the west *riwāq* and covers the wood slot in the wall.

Fig. 10. Interior face of the south wall, just east of the south entrance.
Note that the stones become less regular with depth.

Fig. 11. Interior face of the east wall near the northeast corner of the Mosque. The wider course of stones at the bottom of the foundation may belong to an earlier structure. The wall plaster is the original plaster of the east *riwāq* and its bottom corresponds to the initial floor of the east *riwāq*.

Fig. 12. Interior face of the east wall near the southeast corner of the Mosque. The wider courses at the bottom of the foundation are intended elements of the foundation design. Notice the irregular blocks used for the foundation facing.

Fig. 13. Exterior face of the east wall at the southeast corner of the Mosque. The facing blocks are well shaped and the coursing is very regular down to the rough stone seat. Note the rubble packing that fills the gap between the seat and the edge of the foundation trench.

5. Minarets

Excavations at the north sides of the two minarets show that these structures originally had nearly identical appearance and size, and that they were built at the same time together with the south wall of the "Umayyad Mosque". The minarets then followed divergent structural histories. The east minaret was enlarged in area or otherwise significantly altered at least twice, so that it achieved a 5.7m (N-S) by 5.6m (E-W) footprint at ground level. In contrast, the footprint of the west minaret, at 5.0m (N-S) by 3.9m (E-W, including the abutting arcade of the west *riwāq*), probably remains close to its original size. The minarets today rise about 33.4m and 31.7m above grade (the west minaret is slightly shorter than the east minaret), whereas the original structures were undoubtedly shorter by a significant but unknown amount. The two structures also differ significantly in specific structural details. Most notably, in the east minaret the central pier of the staircase is square, while that of the west minaret is circular. Despite the difference of size and structural detail, the present appearance of the two minarets very likely reflects Ayyubid work.

A major issue, therefore, is the structural relationship between the original foundations and the load of the minarets that now rise above them. In addition, construction of the present west and east *riwāq* arcading post-dated construction of the minarets, and involved both modifications to faces (especially at the corners) of each minaret, and the introduction of new loads by tying arcading and ceilings into the east side of each minaret.

The following descriptions focus on the foundations on the two minarets, and on the ways in which arcading and ceilings articulate with them. The divergent histories of the two minarets require a separate description for each of them.

5.1 East minaret

The east minaret presents the most visible structural problem in the Mosque. The entire structure above grade leans off-vertical to the west by about 1° (estimated). The structural sources of the lean are not immediately apparent, but archaeological results suggest that the history of the minaret is a significant contributing factor.

5.1.1 Structural history

Excavations at the east minaret have been carried out at the north, east and south sides of the structure. The eastern library staircase abuts the minaret on its west side, and no excavation has been undertaken there. The excavations show that the minaret was slightly enlarged to the west and significantly enlarged to the south, but that the structure retains its original foundations on its north and east sides.

5.1.1.1 Original structure

The original minaret structure sat outside the southeastern corner of the "Umayyad Mosque", the south wall of which joined the north face of the minaret structure and the east wall of which joined the structure's east face. Judging by its north face and by above-grade architectural details on its east face, the footprint of original minaret structure measured about 5.25m east-west (including the thickness of the "Umayyad Mosque" walls) and 4.75m north-south; the corresponding dimensions of the minaret today are 5.65m and 5.75m.

5.1.1.1.1 North face of the original structure

Excavations have exposed the surviving portions of the north face of the original minaret, and a more limit exposure of its foundations (Fig. 14). Additional details of foundations can be added from a nearby excavation at the early south wall.

The original structure was entered from the early east *riwāq* through a 71cm wide doorway with a plaster surround (Figs 14-16). A stone step led to the doorway from the first floor of the early east *riwāq* (at elevation 8.45m, 1.55m below the present courtyard pavement). The northwest corner of the structure was a shelf over which a series of successive recesses obliquely crossed. The shelf was about 45cm high and 88cm long, and its western end turned southward as the open corner of the minaret structure. The analogous feature at the west minaret features a series of three recesses which run up to a large engaged pillar. The engaged pillar drops onto the stub of the early south wall, and this relationship probably reflects the location of a doorway next to the minaret (see section 5.3.1.1). The same arrangement probably exists at the east minaret (the east library staircase blocks access here).

The foundations of the original minaret structure were exposed to elevation 6.7 (1.7m below the original floor of the early east *riwāq*), but only at the corner formed with the early east wall. (Figs 14, 17-18). The stonework uses the same squared and dressed facing blocks as found elsewhere in the "Umayyad Mosque". The coursing is bonded with the stonework of the early east wall, and slots for wooden beams appear in the wall and in the minaret structure at the same elevation (8.2m), just below the first floor of the early east *riwāq*. A continuous coat of wall plaster covered the slots. The early east wall foundations rest upon the earth and rubble core of a wall with facing stones set 80cm westward of the foundations; this wall possibly was built as part of the early east wall foundation, but more probably it belongs to an earlier structure (Fig. 15). The minaret foundation abuts and covers this wider structure. The lowest exposed foundation course projects about 50cm north of the course above it, and about 70cm beyond the face of the minaret (Fig. 15, profile A-A′). The excavation was too limited to identify the ground surface from which the construction pit was dug.

A nearby excavation at the exterior face of the early south wall adds information relevant to the north foundations of the original east minaret structure. The top of the early south wall stub, at elevation 8.1m, is probably the bottom of a wood beam slot. From here the foundations drop in six courses to elevation 6.5m; the bottom course projects 15-20cm beyond the course above it, but otherwise the foundation is vertical. This result suggests that the original minaret foundations may be only slightly deeper than recorded at the structure itself.

5.1.1.1.2 East face of the original structure

The east face of the minaret shows no obvious signs of deep rebuilding. Stonework of dressed facing blocks extends without structural interruption from the bottom of foundations at elevation 7.1m to the brickwork of arched niches at elevation 14.1m (Fig. 19). The stonework rises ca. 5° off vertical (inclined westward some 21cm between the present floor, which is at grade, and the plastered brickwork), and the facing blocks alternate white and black to form a checkerboard pattern in the middle and upper portions of the stonework. A beam slot does not appear in the lower portions of this stonework, in the manner found in the north face of the minaret, the early east wall and the early south wall. However, three courses of wood beams are set into the stonework above grade, in the manner evident in the present east wall of the Mosque. These differences open the possibility of remodeling.[13]

The bottom of the foundations here are two courses of roughly shaped blocks that project 40-50cm beyond the courses of dressed blocks above them. These wider courses are at elevations 7.1-7.8m. Limited probes below the basal courses (down to elevation 6.7m) encountered rough stones in line with the upper courses of the foundation facing, and these deeper stones may belong to previously existing walls.

The construction trench for the minaret foundations was dug from a ground surface at elevation 8.1m, which matches the ground surface at elevation 8.0m from which the trench for the early south wall was dug on the other side of the minaret. In other words, the original foundations of the minaret structure seem to have been only 1.6m or so deep.

5.1.1.2 Alterations of the east minaret – construction of the east *riwāq*

Construction of the south *riwāq* introduced an extension of the early east wall southward from the minaret, but it did not require major alterations to the minaret.[14] Construction of the east *riwāq*, on the other hand, involved removal of the early east wall and creation

13 The archivolt of additional niches projecting northward into the plaster of the east *riwāq* arcading implies that if the east face of the minaret was remodeled, this work must have occurred before construction of the present east *riwāq* (perhaps when the south *riwāq* was built, or as part of rebuilding the early east *riwāq*).

14 Initial construction of the south *riwāq* must have had a structural effect on the southern side of the east minaret, since the inner arcading of the initial south *riwāq* ran up to the southwest corner of the minaret, and the ceiling must have tied into the southern face of the minaret. However, no evidence is available regarding these alterations.

of north-south arcading that sprang from square pillars inserted into the new northeast and southeast corners of the minaret. In addition, ceiling beams of the new *riwāq* were inserted into the brickwork above the plastered niches in the east face of the minaret.

The inner arcade of the east *riwāq* articulates with the minaret in a different manner at each corner of the minaret. The arch immediately north of the minaret has a normal span, and drops directly to a spring formed by two courses of bricks set into the minaret stonework directly over the pillar M14, which lacks a capital. The joint between minaret and arcade is covered by plaster, leaving uncertain whether the arcading brickwork and minaret stonework simply abut, or are bonded. The footing for the pillar at the northeast corner remains unexamined, but presumably it sits directly upon the stonework of the original minaret and the stub of the early east wall.

The arch to the south has a narrow span, and springs from a pillar with capital at the southeast corner of the minaret (pillar M15). The arcading brickwork above the pillar abuts the plasterwork of the blind niches on the minaret's east face; the vertical joint here appears to mark the earlier southeast corner of the minaret structure. The pillar sits upon two courses of stone blocks, inserted over the stub of the early east wall in a slightly more northerly position than the present south face of minaret. The position of the pillar and of its footing at the minaret's southeast corner implies a southward enlargement of the minaret by 90cm.

On the minaret's north side, the original doorway and the corner niches were truncated to elevation 9.3-9.4m, the remainder of the doorway was blocked up, and courses of new stonework were set across the stub of the earlier structure. Only the lowest course of this new stonework survives today (Fig. 14: (a)). The north face of the remodeled minaret took a slightly more northerly orientation (at its west end, it sits 17cm north of the minaret's original northwest corner), and it projected 34cm west of the original corner.

5.1.1.3 Ayyubid alterations of the east minaret

The next alteration, evident in the north and south faces of the minaret, is marked by a course of stone blocks, the top of which appears at elevation 10.0-10.1m (i.e. visible above Mosque surfaces today). On the north, this course involves a second westward enlargement of the minaret by an additional 10cm (Fig. 14: (b)), and a very slight northward change of its orientation. On the south, the alteration course sits upon a new foundation of roughly shaped stones in irregular courses which project beyond the minaret face in a stepped fashion (Fig. 20). This foundation, set in *quṭrah*, is inserted into a cut made from elevation 9.7 (only 25cm below the present floor of the south *riwāq*), and sits upon earlier structures. At the southeast corner of the minaret, this foundation abuts earlier minaret courses set onto the early east wall, and sits on the stub of a pre-Islamic wall at elevation 7.8m (this older wall continues to elevation 6.2m); at its west end the foundation extends more than half meter beyond the southwest corner of the minaret, and sit on the stub of another earlier wall at elevation 7.1m (the excavation exposed only the top of this older wall).

Brickwork sits directly upon this stone course. For most part, the brickwork is identical to that found in decorated portions of the minaret shaft, which includes an inscription that names Tughtakin b. Ayyub. The association of brickwork and stone coursing suggests that the deep foundations at the minaret's south side belong to construction of the Ayyubid minaret that largely still exists today.[15] At the minaret's southeast corner, brickwork of the minaret and of the east *riwāq* arcade is not bonded, and forms two abutting structures. The two brick structures are in fact separated by a crack which begins at the top of the pillar capital at the southeast corner, and widens to 13cm at the level of the eastern library. This crack is a result of the minaret's visible lean away from vertical.

5.1.1.4 Later alterations of the east minaret

The presumptively Ayyubid brickwork is replaced by a band of recent stonework around the north face (Fig. 14: (c)), west face, and portion of the south face of the minaret. This stonework extends to about 3m above the present Mosque surfaces. A small zone of similar stonework also appears at the minaret's southeast corner, where it rises only 2m above the floor of the Mosque. The stonework encloses the minaret's present north (courtyard) doorway, which may have been cut when the stonework was inserted. This stonework is probably related to construction of the eastern library (see section 7.1.1). It sits upon the same foundation course as the Ayyubid brickwork, but it also projects slightly beyond these basalt blocks. At the southwest corner of the minaret, the stonework also covers (by 10cm to the west and 2cm to the south) a flat pave of the "Ottoman courtyard" (see section 7.2.1); this pave abuts the southwest corner of the Ayyubid foundation course.

5.2 Structural problems in the east minaret

The excavations thus indicate at least two episodes of enlargement plus minor realignment of the minaret in the 3rd/9th and early 7th/13th centuries, and an additional episode of more superficial remodeling in the 14th/20th century.[16] The two major episodes involved foundation work on the south and, inferentially, west sides of the structure, and adjustment of the relationship between the structure and other architectural elements both above and below ground. The result is a complex structure, assessment of which is hindered by limited access to the interior and west side of the minaret. The following points may be highlighted.

15 Some caution is required here, however. The lowest 1.4m of brickwork on the south face of the Mosque, directly upon the stone foundation course, differs in character (size of bricks, nature of mortar, and lack of grooved joints between bricks) from the brickwork higher in the minaret shaft. The difference may reflect a post-Ayyubid repair of brickwork or it may indicate a pre-Ayyubid date for the foundation course. The latter possibility is less likely, given the high stratigraphic position of the related construction trench.

16 Historians report various episodes of maintenance, e.g. repairs following a lightning strike in 1056/1646 (al-Qāsim 2008: 469, al-Wazīr 1985: 118), and repair of cracks during the 1300s / 1880s (al-Ḥajarī 2006: 32-33). These actions appear not to have affected the foundations.

5.2.1 New loads on old foundations at the east minaret

The minaret's foundations visually appear to be in good condition – those exposed on the north and east sides retain regular coursing of dressed blocks, while those to the south are rougher in appearance but deeper and probably stronger. The beam slot on the north face does pose the possibility of structural distortion here (see section 4.1.2.1 for this problem in the north wall), but the slot remains in good condition, with at most minor buckling evident (see Fig. 15: profile A-A′; Fig. 21). In addition, a new wood beam was inserted into the exposed slot before the excavation there was in-filled in 2008. The unexamined west face of the original structure probably does not have a wooden beam slot, give its absence on the east face.

The minaret's original foundations were built for a smaller and probably lower structure. But these foundations were not altered on the minaret's north and east sides when the structure was re-built to a greater height. Moreover, the inner arcade of the east *riwāq* ties into the northeast and southeast corners of the minaret, and the ceiling beams in this portion of the east *riwāq* are inserted into brickwork of the minaret's east face. These modifications introduce loads for which the eastern foundations of the minaret were not designed. Assessing the actual and potential impacts of these additional loads and lateral forces is complex, and involves additional unknown factors, e.g. whether the minaret sits over deep foundations placed within the facade of older stonework that forms the minaret's east face. In his "foundation inscription" dated 603/1206, Wardashār claims to have built the minarets from its foundation to its top. This claim is demonstrably hyperbolic: the south foundations probably belong to the Ayyubid intervention, but the north and east foundations clearly do not. Even so, the Ayyubid work probably inserted new interior foundations, specifically for the massive central pier around which the staircase winds. But these foundations have not been examined, nor have their articulation with older foundations been assessed.

5.2.2 Insufficiencies on the west side of the east minaret

With its two evident enlargements, the minaret's north face was rebuilt along a slightly more northerly line (the upper stonework at the northwest corner overhangs the original corner by 17cm to the north) and extended to the west by nearly half a meter. The northward projection of the minaret's face rests upon a foundation ribbon for pillars, which was inserted when the early east *riwāq* was rebuilt (probably 3rd/9th century). The foundation is a 1m-wide structure of rubble that runs northward from the original minaret. The southern end of the foundation is fitted into the space between the doorway and the northwest corner of the original minaret, so that rubble of the foundation fills the recessed shelf at this corner (see Figs 14, 16, and 22). A narrow lateral probe, about 30cm deep along the western side of the shelf and below the stonework of the expanded minaret shows that the west edge of the newly inserted pillar foundation aligns with the western face of the recessed shelf, and furthermore that the northwest corner of the enlarged minaret rested directly upon the succession of *riwāq* floors (Fig. 22).

In other words, the western façade of the expanded minaret seems to lack proper foundations, at least at the northwest corner of the structure. The early south wall does run up to the original minaret structure, but as indicated above (section 5.1.1.1) a doorway probably existed at this point, and the evidence a little distance away suggests that the top of the wall stub is probably at elevation 8.1m. This evidence in turn suggests that around a meter of floors and fill separates the bottom of the new northwest corner of the minaret from the early south wall stub.

The structural implications of this finding depend partly on whether other portions of the expanded minaret do have proper foundations, and partly on the extent and depth of foundation work inside the minaret. But at very least the northwest corner lacks support, and this factor doubtless contributes to the westerly lean of the minaret. Above-grade cracking observable in the recent stonework of the minaret's north face (section 5.1.2.3), at a point above the minaret's original northwest corner, suggests that differential subsidence continues around this point.

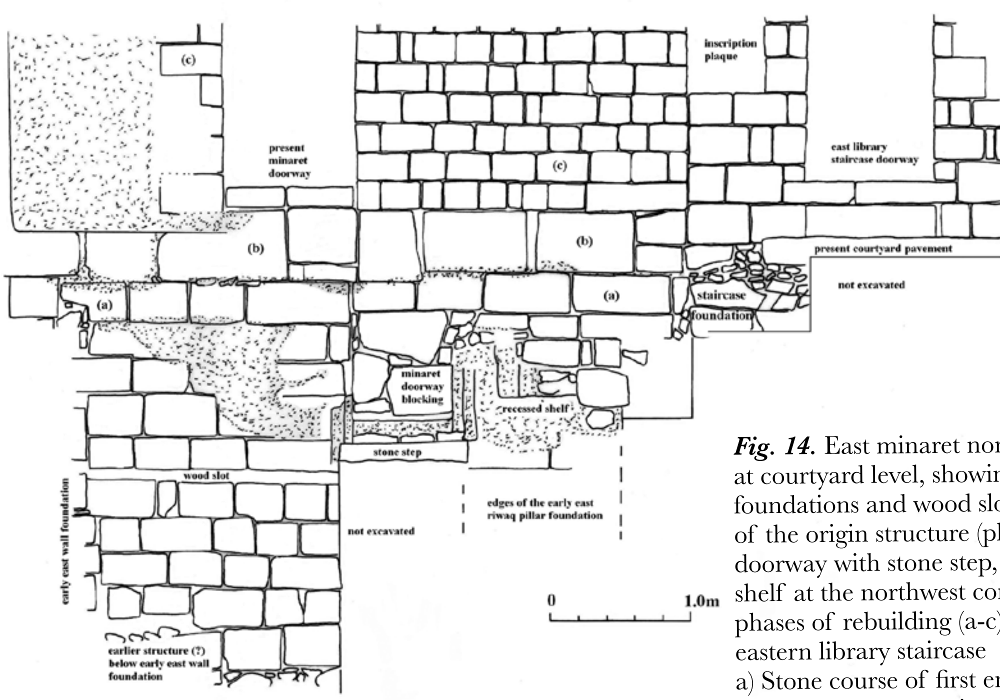

Fig. 14. East minaret north elevation at courtyard level, showing original foundations and wood slot, elements of the origin structure (plaster-framed doorway with stone step, recessed shelf at the northwest corner), three phases of rebuilding (a-c) and the eastern library staircase
a) Stone course of first enlargement of the minaret, associated with construction of the present east *riwāq*
b) Stone course of the second enlargement of the minaret, probably Ayyubid period
c) Stonework of apparent recent date.

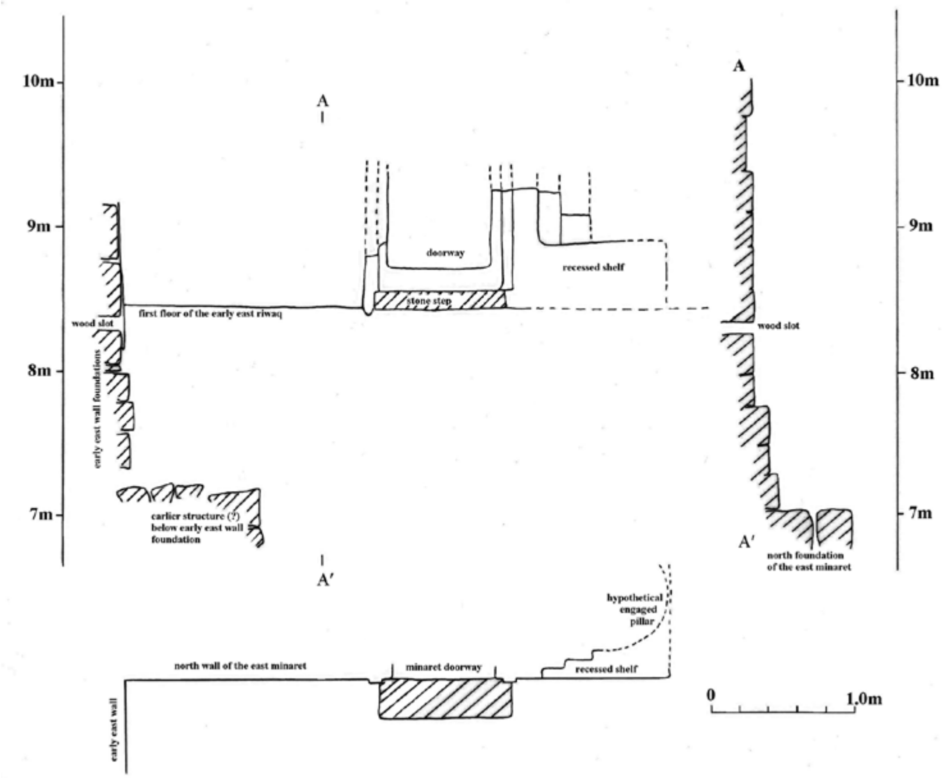

Fig. 15. East minaret - north face of the original structure elevation and plan, with details of the wood slot and foundation coursing in profile (A-A′), with the adjacent early east wall foundation in profile.

Fig. 16. Original doorway, stone step and recessed shelf at the northwest corner of the east minaret. The stones visible in the lower right corner of the photograph belong to the north-south pillar foundation that was inserted when the early east *riwāq* was renewed. The stone blocking within the minaret doorway belongs to the same episode of renewal.

Fig. 17. Oblique view of the corner formed by the east minaret (along the right side of the photograph) and the early south wall of the Mosque (along the top of the photograph).
The original wall plaster has been largely removed, revealing the wood slot. Note the very wide seat at the bottom of the early east wall foundation (perhaps the stub of an earlier wall), the progressive widening of the minaret foundation, and the mass of roughly shaped stones lateral to the bottom of the minaret foundation.

Fig. 18. Vertical view of the corner formed by the east minaret (along the top of the photograph) and the early south wall of the Mosque (along the left side of the photograph). Note the very wide seat at the bottom of the early east wall foundation (perhaps the stub of an earlier wall), the progressive widening of the minaret foundation, and the mass of roughly shaped stones lateral to the bottom of the minaret foundation.

Fig. 19. Foundations below the east face of the east minaret, upon the wider rough stone seat. The wall visible at the bottom of the photograph is the stub of an earlier wall above which the minaret foundation sits.

Fig. 20. Foundations below the south face of the east minaret, sitting upon the stub of an earlier wall. Remains of the early south wall (wall plaster and foundations) are visible on the right side of the photograph.

Fig. 21. Detail of the wood slot in the north face of the east minaret, below the original doorway (after removal of the stone step).

Fig. 22. Detail of the horizontal probe below the present northwest corner of the east minaret. The large stone on the left side of the photograph corresponds to the stone visible on the right side of Fig. 16. The plaster visible below this stone is the west side of the recessed shelf. Behind the scale is visible the stack of floors upon which the northwest corner of the enlarged minaret sits.

5.3 West minaret

The west minaret is both shorter and smaller in footprint than the east minaret. The two also structurally differ. Whereas the east minaret is free-standing but with loads introduced from *riwāq* arcading and the eastern library, the west minaret is partially incorporated into the west wall. At roof-level the minaret measures 4.1m to a side, and the western 80-90cm of the structure rises from the west wall of the Mosque (Fig. 23). Brickwork of the outer arcade of the west *riwāq* runs along the east side of the minaret over pillars A14 and A15. The brickwork is not directly tied into the corners of the minarets, while pillar A14 sits on stonework of the minaret's original northeast corner (see Figs 24-25). Furthermore, the interior staircase of the west minaret is a circular space around a circular pier, whereas the staircase of the east minaret is a rectilinear space around a square pier. Wardashār's foundation inscription appears on both minarets, but the differences of construction leave open the possibility that Ayyubid work on the west minaret was actually minimal.

5.3.1 West minaret structural history

Much less is known about the structural history of the west minaret, simply because excavations have been made only at the north face of the structure. The north face of the minaret presents stonework from its foundations to elevation 11.9m (2.1m above the present floor), from where plastered niches set into brickwork rises to the *riwāq* ceiling (Fig. 24). Wooden beams are set into the stonework at elevation 9.9m (just above the present floor) and at 11.6m. The upper portion of an arched doorway, now blocked up with brick, appears toward the northeastern corner. A compound pillar of re-used stone elements sits at the northeast corner; this pillar A14 abuts the north side of a probably engaged pillar belonging to the original structure, and these two elements together support the arcading that runs along the east side of the minaret.

5.3.1.1 Original north face of the west minaret

Excavations indicate that the north face of the origin west minaret presents a mirror-image of the east minaret (Fig. 26). The still partially visible arched doorway continues down to elevation 8.5m (1.3m below the present floor) to a plastered sill, in front of which is a stone step that sat on the first floor of the west *riwāq*, at elevation 8.1m (Fig. 25). The wall plaster that covered the stone face on each side of the door extended down to cover a wood beam slot at elevation 8.2m. A plastered shelf with recessed niches occupied the northeast corner; the shelf was positioned slightly higher than the nearby door sill. The stub of the early south wall appears at the minaret's northeast corner, with a stone step placed against the wall within the first floor of the *riwāq*. A plastered pillar, today encased in later brickwork and plaster, sits upon the rubble core of this wall, in a position at the south end of the recessed niches. The pillar definitely existed before construction of the west *riwāq*, and appears to belong to the original minaret structure, probably as an engaged pillar at a doorway through the early south wall.

The north foundations, faced with squared and dressed blocks, descend to elevation 6.8m (3.0m below the present floor), and widen by 5-10cm (Fig. 26: profile A-A′). The foundations sit upon a bed of rubble which both abuts and underlies the west wall foundations (the latter continue at least one course deeper; Fig. 27); the depth of the rubble bed has not been determined. The stonework of the minaret and west wall are bonded from the bottom of the foundations up to elevation 9.0m or higher, the wood slot in continuous between the two structures, and the original wall plaster uninterruptedly covers both structures at the level of the earliest floor. These considerations indicate that the original foundations were only 1.3m deep, plus the unknown depth of the rubble upon which they sit.

5.3.1.2 Later alterations of the west minaret

When the west *riwāq* was rebuilt using individual piling foundations for the pillars (see section 6.2), the engaged pillar and recessed shelf at the original northeast corner of the minaret were adapted to support arches of the *riwāq*'s outer arcade. However, the adapted engaged pillar is about half a meter south of the ideal position for this arcade of the new *riwāq*,[17] and the visible pillar A14 was inserted against the north side of the plaster pillar to accommodate the arcading. This pillar is composed of three parts – a lower shaft of basalt, an upper shaft (pre-Islamic) of limestone, and a capital of basalt. The reinforcing pillar A14 sits upon facing blocks at the join between the early south wall and the minaret's original northeast corner, with a semi-circular piling of rubble placed against the earlier structure as reinforcement (the same technique as found in the east *riwāq*; see section 6.2.2). The rubble piling here is not more than a meter deep (elevation 8.1-8.9). The inserted pillar establishes the northeast corner of the minaret today. Arcading brickwork above the 3-piece stone pillar appears to abut the then-existing brickwork of the plastered niches.

On the east side of the minaret, *riwāq* arcading runs north-south to a pillar at A15 near the minaret's southeast corner. Plaster-stripping has exposed only the capital and a tiny area of the shaft of this pillar, which appears to be an example of the plastered rough stone piers characteristic of the west *riwāq* (see section 6.2.1), and so probably sits on a circular piling foundation set against the southeast corner of the minaret foundation. The arcading arch is in-filled with rough stonework which forms the minaret's present east face. The stonework extends about 35cm south of pier A15, to form the minaret's southeast corner. Plaster stripping at this corner shows the stonework to be about 63-64cm

17 The arch here is 18cm wider than the parallel arch of the *riwāq*'s middle arcade; the decorated stucco capital of the engaged pillar lies an additional 37cm further south. In other words, the pillar is about half a meter out of position with respect to the west *riwāq* arcading.

thick, and to abut the plastered brickwork of an earlier east face of the minaret. The same brickwork forms the minaret's present south face.

The original wall plaster of the north face was removed down to elevation 8.8m, probably in connection with rebuilding of west *riwāq*. This event may simply be a comprehensive replastering of the *riwāq*, but it may reflect a partial re-building of the minaret's north face. Stonework of the minaret on its north side is not bonded to the upper portions of the west wall – here the west wall abuts the minaret stonework and plastered niches from around today's floor level (elevation 9.8) or lower (plaster was not removed from the corner from floor level to about a meter below the floor).

The extent of re-building undertaken for the Ayyubid minaret remains uncertain. The minaret at roof level is smaller than its dimensions at floor level (Fig. 23). This tapering is only 10-20 cm on the east and south sides, but the north side is set back by 50-60cm relative to its position at floor level. This difference suggests that re-building left the older north side as a façade, and that the north foundations of the Ayyubid minaret were created within the footprint of the older structure. If this supposition is correct, the Ayyubid foundations have not been examined.

These above-ground observations, added to those from excavations at the north face, identify multiple structural elements belonging to several still poorly understood phases of the minaret's history. Excavation firmly identifies the stratigraphic position of the original minaret structure, and of the arcading brickwork and pillars of the present west *riwāq*. But stratigraphic position remains uncertain for the plastered brickwork of the minaret's south and east faces, and for the minaret's southeast corner and the stone in-filling of the arcading arch along its east face. Judging by above-ground spatial relationships, the plastered brickwork evident at the southeast corner of the minaret belongs to the Ayyubid work, which would imply that the stone in-filling (which contains Wardashār's foundation inscription) beneath the arcading brickwork is later in date. Additional excavation is needed to check and flesh-out this chronology.

5.3.2 West minaret assessment

Pending the results of archaeological excavations at the minaret's east face and at its southeast corner, the following points may be made about the condition of the minaret.

Stonework of the minaret's north face, including foundations, is in good condition, apart from several examples of stones cracked or broken into two pieces which are still in place. Some cracking and slippage of plaster work is apparent in the plastered brick niches in the north face. This cracking reflects the lack of bonding with the west wall here, but probably does not indicate more serious structural problems above grade. However, the two courses above the original wood beam slot have shifted out of place, closing half of the slot (see sections 4.1.2.1 and 4.2.2 for this problem). This movement has caused a limited buckling of the wall face above these courses (Fig. 26: profile A-A′).

Foundations on the minaret's north side are shallow – only 1.3m in five courses below the beam slot – and sit upon a bed of rubble, the depth and extent of which is undetermined (Fig. 27). When the minaret was rebuilt to a greater height, these foundations were not altered or strengthened, at least on their exterior face. However, if the possibility is correct, that the north face of the minaret at grade is a 50cm thick skin of older stone work set in front of the minaret tower, then the original foundation does not directly bear the load of the Ayyubid minaret. So the unanswered critical issue is whether foundations were deepened or otherwise strengthened inside the minaret's footprint when it was built higher.

The outer arcade of the west *riwāq* appears to have a minor structural relationship with the minaret. Pillar A15 at the minaret's southeast corner seems independent of the minaret and built for purpose with its own foundation. The compound pillar A14 at the northeast corner rests partly on the original minaret foundations and partly on the remains of the early south wall. The foundations of the latter have not been examined at its west end, but they are probably similar to those at the east end of the same wall (see Section 5.1.1.1.1) and so they are probably as deep as the minaret foundations. At both corners the load of the arcading is carried mainly by these pillars and their foundations, with little lateral force applied to the minaret structure.

In summary, relatively little is presently known about the foundations of the west minaret. Addition excavations are needed at the minaret's east and south faces to understand more clearly minaret's structural elements and their history, to identify the structural relationships among them, and to understand the distribution of loads on older elements of the minaret.

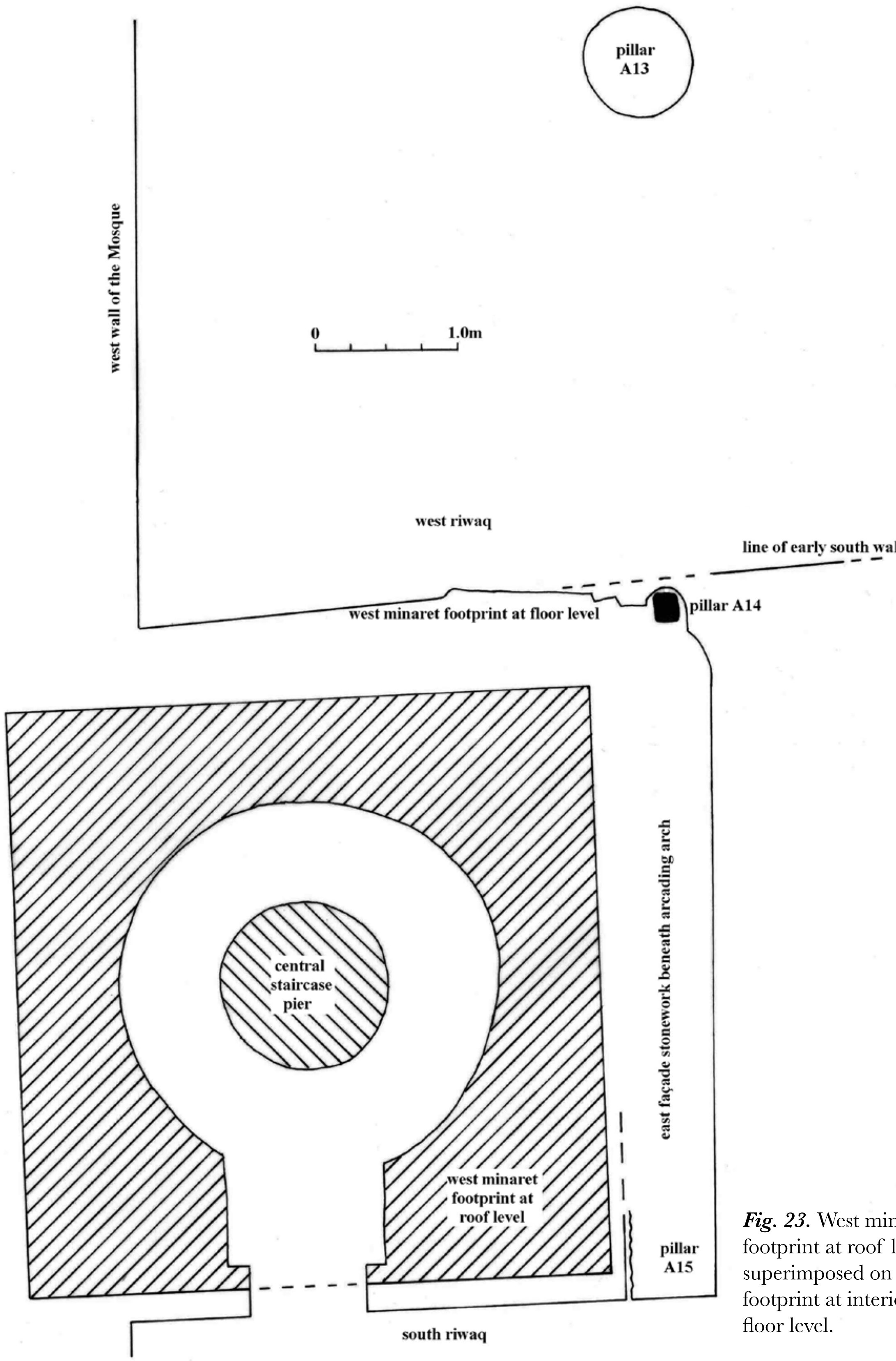

Fig. 23. West minaret footprint at roof level superimposed on its footprint at interior floor level.

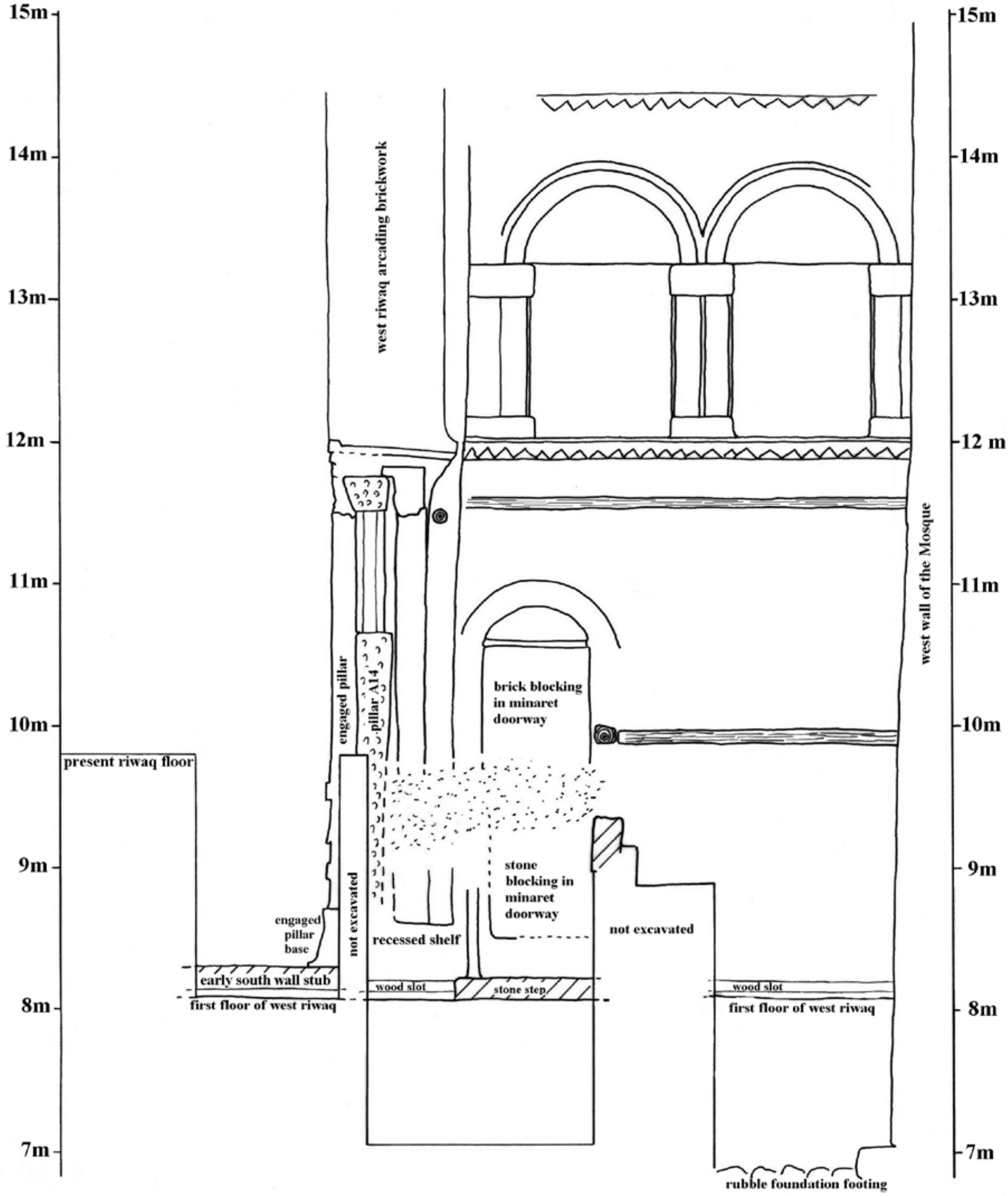

Fig. 23. West minaret north elevation at *riwāq* floor level, showing the relationships between elements of the original structure (recessed shelf, doorway, step, engaged pillar and the early south wall) with the present pillar A14 and arcading brickwork.

Fig. 25. The original northeast corner of the west minaret. The original step is partially covered by a later higher step (made necessary by raising the level of the door sill as the level of floors rose). The group of stones in the upper right corner of the photograph is blocking in the doorway. The vertical stone at the left side of the photograph is the bottom of pillar A14, set upon the exposed stone of the recessed shelf. The group of rough stones in the lower left is the rubble buttress for pillar A14.

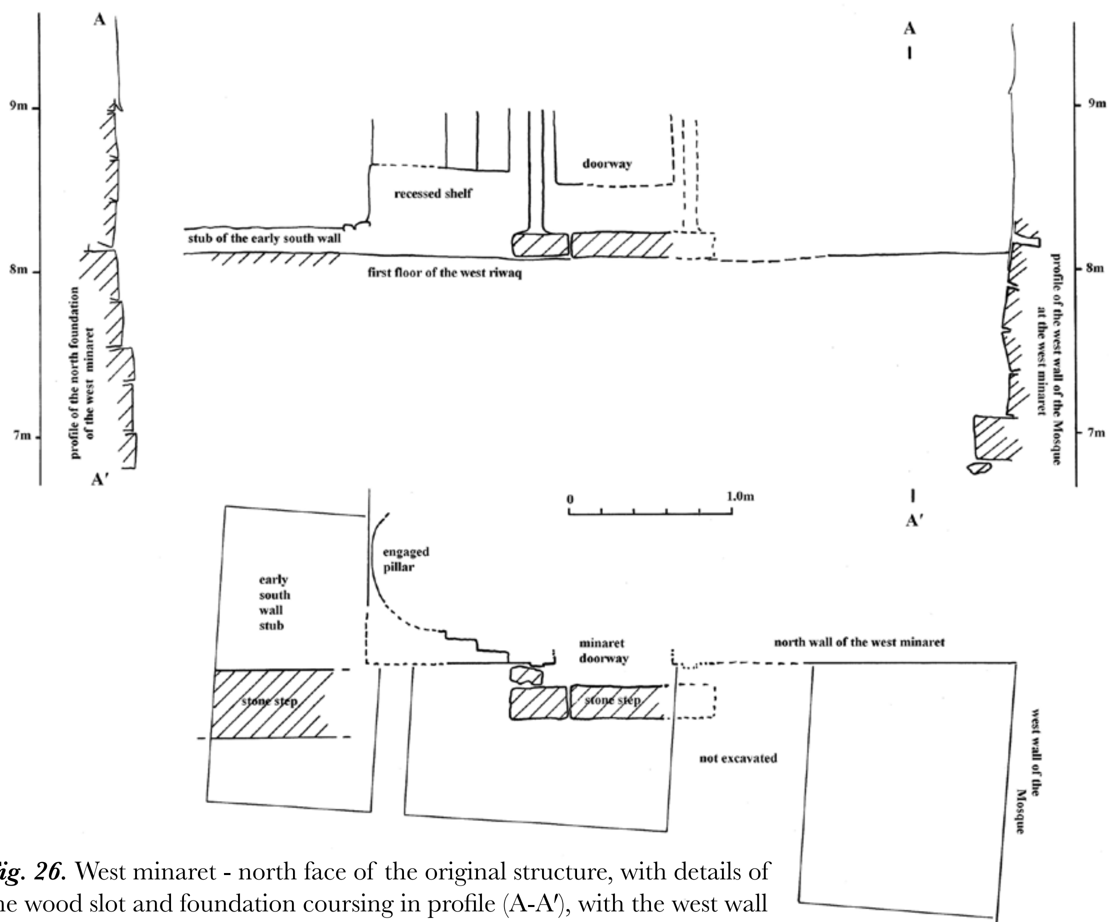

Fig. 26. West minaret - north face of the original structure, with details of the wood slot and foundation coursing in profile (A-A′), with the west wall foundation in profile; note that details of the northeast corner are largely hidden by the rubble piling inserted to reinforce the pillar A14 foundation.

Fig. 27. The corner formed by the foundation for the north face of the west minaret (to the left) and the foundation for the west wall of the Mosque (to the top). Note the bed of rubble that abuts and underlies these foundations.

6. Arcading pillars

The following observations are based on excavations at multiple pillars themselves, plus other excavations which exposed portions of pillar foundations; most but not all excavations at pillars also exposed pillar foundations. To date, the *riwāq* have been examined at different intensities, as follows.

	foundations at pillars	foundations away from pillars	total
north *riwāq*	6	5	11
east *riwāq*	7*	2	9
south *riwāq*	9	5	14
west *riwāq*	6*	0	6
total	28	12	40

* including pillars incorporated into the fabric of the minarets

These numbers indicate that the west *riwāq* has received significantly less attention than elsewhere. In addition, the numbers are somewhat deceptive. Four of the seven excavations at pillars in the east *riwāq* occur along the inner arcade, where the pillars use the stub of the early east wall as their basic foundation. Moreover, two of the six excavations at pillars in the north *riwāq* did not expose remains of early bases at these positions. Even so, the work provides a reasonably firm basis for the following description of construction techniques and of pillar histories, and for identifying potential structural problems.

Two different foundation systems appear beneath the Mosque's pillars. Pillars of the north and south *riwāq* sit upon continuous wall-like ribbon foundations which run beneath the corresponding arcade, whereas pillars of the east and west *riwāq* stand upon individual circular foundations. The following discussion looks in turn at these two forms of foundations.

6.1 Pillars in the north and south *riwāq*

The pillars in the north and south *riwāq* are heterogeneous in character. Many of them are re-used pre-Islamic pillars, some of them are piers of the same kind found in the two lateral *riwāq* (see section 6.2.1), and a few are multiple drum pillars; the pillars around all four sides of the courtyard[18] are re-cycled, often pre-Islamic architectural elements. This heterogeneity reflects the complex histories of the north and south *riwāq*. Probably none of the extant pillars in the north and south *riwāq* are original to these spaces.[19]

	north *riwāq*	south *riwāq*	total
pre-Islamic spolia	32	15	47
block-and-plaster pier	16	6	22
multiple short drums	0	3	3
total	48	24	72

NB: The inner arcades of both *riwāq* s are excluded from the table, as the form of these pillars seems specific to the courtyard (before creation of the fourth aisle below the libraries in the case of the south *riwāq*).

6.1.1 History of the north and south *riwāq* pillars

The original pillars of the north and south *riwāq* were piers of large rough blocks encased in plaster, similar to those now characteristic of the east and west *riwāq*. Stubs of the original piers were incorporated into later pillars at some locations; at others the original pier was

18 For the south *riwāq* these are the pillars of the 3rd arcade, which bordered on the courtyard reached before construction of the library buildings in the 14th/20th century.

19 Rough stone and plaster piers occur within both the north and the south *riwāq*, but these piers seem not to be original – excavation at two of them, A3 in the north *riwāq* and I17 in the south *riwāq*, shows that they also were erected upon a secondary base. In addition, a rough stone and plaster pier was erected at L17 probably in the 3rd century/9th century and was subsequently replaced by a pillar composed of multiple drums.

entirely removed (described below). The piers rest on bases which are stone blocks with finely finished plaster covering their upper portions; these bases are about 70-80cm to a side, and 25-30cm high. In the south *riwāq* the bases sit in turn on stone plinths, which seem to be composed of several roughly dressed blocks and which measure approximately 80-90cm to a side and 40-50cm in height. The bases or plinths are fixed with rough plaster and clay to the foundations.

The foundations are continuous wall-like ribbons that run east-west below each arcade of the north and south *riwāq* (Figs 28 and 29). The foundations are formed of mixed dressed blocks and roughly shaped stones laid with mud mortar in irregular courses, and set into narrow trenches. At their tops, the foundation ribbons are 1.0-1.1m wide, and they widen only slightly with depth. The foundations are 2.2-3.0m deep from top to bottom. In the north *riwāq* the tops of foundations walls appear at elevation 7.8-7.9m (1.9-2.0m below the present floor), and the first related floor is at elevation 8.0-8.1 (1.7-1.8m below the present floor). In the south *riwāq* the tops of the foundations are at elevation 8.0-8.1m (1.8-1.9m below the present floor), and the first floor of the *riwāq* is at elevation 8.5-8.8m (1.3-1.4m below the present floor). The greater distance between foundation and first floor in the south *riwāq* perhaps reflects the looser surfaces of the *ẓullah* that lies beneath this space (see section 2.3).

At all of the examined locations in the south *riwāq* the original piers were replaced before construction of the present east *riwāq* perhaps as a comprehensive remodeling of the *riwāq*, whereas in the north *riwāq* the replacements seem to have occurred at different times. The original piers were removed completely or reduced to a stub. New bases were inserted, either directly upon the original base, directly onto the stub of the original pier, or into a bed of gravelly *quṭrah* that covered the stub of the original pier. The examined pillars in both *riwāq* in fact present a succession of as many as three bases superimposed upon the original plastered base, or the stub of the original pillar, plus the present pillar itself (Figs 30-36).

These alterations left unchanged the foundations of the original pier, including the original base and plinth. They also left largely untouched the original brickwork of the arcading in the two *riwāq*.[20] A layer of 3-5 juxtaposed wood beams (roughly squared, 15-20 x 10-15cm in cross-section) appears between pillar capital and arcading brickwork at many pillars in both north and south *riwāq*. The beams are placed perpendicular to the arcading; a second layer of beams occasionally appears, above this first layer, aligned with the arcading. The beams are part of the rebuilt pillars, and most likely are remains of scaffolding inserted to support the arcading brickwork while pillars were being renovated, and then sawn through at the brickwork. These beams exist today at locations with stone pillar shafts, but they seem to be absent from the block-and-plaster piers in the two *riwāq*.

20 The arcading brickwork of the two *riwāq* is very similar, but the bricks used in the north *riwāq* are larger (averaging 30 x 30cm) than those of the south *riwāq* (24 x 24cm).

6.1.2 Structural problems of pillars in the north and south *riwāq*

The successions of multiple bases and pillar stubs reflect individual history of alteration at each pillar, and also possibly (according to stratigraphic evidence now in hand) one occasion in which all pillars in the south *riwāq* were simultaneous altered as a general renewal program. The complicated structural history of north and south *riwāq* result in several interrelated concerns. The following points pertain primarily to the east end of the south *riwāq*, where the archaeological work has been dense enough to identify general as well as specific problems. Similar concerns very likely also apply to the north *riwāq* but the excavations there has not been dense enough to confirm them.

6.1.2.1 Pier stubs

Multiple rejuvenation of pillars and pillar bases created a 1.3-1.7m high stack of directly superimposed structures (including the original plinth at the bottom of the series), set upon the wall-like foundation structure. In some of the exposed examples the stack consists entirely of stone bases. These compound structures appear to be structurally stable. But in most examples (four of six in the north *riwāq*, three of six in the south *riwāq*) include stubs of cylindrical piers within the stack. The three stubs identified in the south *riwāq* are 8-17cm tall at pillars K16 (Fig. 30c), K17 (Fig. 30d), and L17 (Fig. 35), whereas the pier stubs exposed in the north *riwāq* can be up to 65-80cm high at pillars E1 (Fig. 31), F1, C2, L3 (Fig. 30a and 32), and B4 (Fig. 30b and 33). In these cases, particularly in the north *riwāq*, the nature of the pier and the condition of the surviving stub may affect the stability of bases, and also the present pillar, above the stub. None of the examined stubs show signs of structural weaknesses, but unexamined stubs no doubt also exist.

6.1.2.2 Eccentric positioning over bases

Pillar bases have a general tendency to become smaller through time, and they sometimes were placed off-center with respect to base(s) below (e.g. Fig. 30d), as were the pillars upon them. The cylindrical piers that occur today within the north and south *riwāq* have a diameter of approximately 80cm. In several examined cases, such piers project several centimeters beyond the bases upon which they sit. Most likely this effect is simply facing plaster that encloses the stone core of the pier, without any structural detriment. But it remains possible that such piers sit slightly off-center over their bases, which might introduce instability.

6.1.2.3 Wood beams

As described above (section 6.2.1), a layer of wooden beams separate pillar capitals from arcading brickwork at many locations in the north and south *riwāq*. In general the beams are in good condition, but in a few cases (e.g. at I16, see section 6.1.2.5 below) the wood is somewhat decayed. This problem is probably most common along the 3rd arcade of the south *riwāq*, which once formed the southern edge of the central courtyard. The same problem may exist along the 5th arcade of the north *riwāq*, but none of these locations have been examined.

6.1.2.4 Arcading deformation

The arcading of the south *riwāq* today visibly leans southward off vertical at multiple points, particularly in the *riwāq*'s eastern half. Arcading and ribbon foundations presumably were built in the same vertical plane, but distortion of arcading brickwork shifted the load to one side of foundation centerlines. Attempts to keep pillars centered beneath the load they carry must have contributed to the repeated rejuvenation of pillars and their bases. As one result of this process, many pillars in the south *riwāq* today sit at or near the southern edge of their foundation walls. The vertical profile of arcading brickwork-pillar-foundation at pillar I17 (Fig. 37) illustrates this effect.

Another response to the problem was insertion of secondary transverse arches to buttress the main arcading. In the north *riwāq*, five secondary arches extend the inner arcade of the west *riwāq* from A5 to the north wall, and single transverse arches are present between B1 and C1 and the north wall. In the south *riwāq*, single transverse arches were placed between pillars H18 and I18 and the south wall.[21]

Some of the arches in south *riwāq* arcading were rebuilt in 2012, to repair major cracking evident in them. However, these repairs did not correct the lateral deformation of these arcades. The north *riwāq* once featured an analogous northward lateral deformation of arcading brickwork, but this problem was largely corrected at some past time by extensive re-building of portions of the arcades.

6.1.2.5 Additional loads

Distortion of arcading brickwork and its position over pillars is perhaps most severe at pillar I16, in the third (inner) arcade of the south *riwāq*. This position forms the east side of the partially demolished *miḥrāb* of the south *riwāq*; it is also below the southwest corner of the eastern library and the southeast corner of the western library (see section 7.2.2). In its present form (Fig. 38), pillar I16 is a compound structure of three distinct parts.

(a) The original structure is represented by a square (about 35 by 34cm) stone pillar with

21 It may be noted that holes in the arcading brickwork of the north and south *riwāq* indicate the existence of tie-beams, now cut, along the arches of arcades and also between arcades. Wood still remains in these holes in some places.

a tapering square stone capital.[22] A group of wood beams run north-south over the capital; the north ends of the beams are much deteriorated. Arcading brickwork rests directly upon the beams. The arcade is now heavily distorted: the arcading brickwork leans southward well away from vertical, and the center-line of the arcading at its bottom is shifted about 10cm southward with respect to the center-line of the pillar (even taking into account the removal of brickwork described below). The now partially demolished *miḥrāb*, within the arcading arch immediately west of I16, was built against plaster of the arch and projects from the plaster. The added weight of this structure perhaps accentuated distortion of the arch.

The stone arch that carries the west wall of eastern library 2 (see section 7.1.1 below) springs from two stone blocks placed over the north end of the wood beams. To accommodate these blocks, the builders of the library arch chopped away 10-15cm of arcading brickwork. The arch takes a segmental form – it spans 3.25m but rises only 1.35m above its southern spring – and so exerts additional lateral thrust on the bottom of the arcading brickwork.

(b) A buttress inserted against the south side of the *riwāq* pillar directly supports southern portions of the arcade brickwork. The buttress is built in two sections. The lower section of coursed stone (also 1.4m high) is set against the original pillar and capital, with a stone slab and wood beam then fitted beneath the wood beams that cover the original capital. The latter two elements project 18cm to the south, as the bottom of the buttress's upper section, which consists of 1.4m of stonework and then an additional meter of brickwork placed against the existing plaster face of the arcade. The buttress appears to be a relatively recent introduction, built probably at the same time as the arch on the opposite side of the *riwāq* pillar, over which sits the west wall of the east library. The buttress foundations have not been examined.

(c) The stone pier beneath the southeast corner of the western library sits northwest of the *riwāq* pillar. The pier measures 48 x 61cm in basal cross-section, but its upper section is narrower to accommodate the inner arcade brickwork (see section 7.2.2 for the pier's foundations). The pier is structurally independent of the *riwāq* pillar and the arcading brickwork, but it appears to lack a deep foundation (section 7.2.2).

The south buttress appears to play an essential structural role, both supporting the brickwork of the *riwāq* arcading and resisting the lateral thrust of the eastern library. Foundations for other elements of the eastern library are generally light – examination and assessment of the buttress's foundations are strongly recommended.

6.2 Pillars in the east and west *riwāq*

Two types of pillars appear in the east and west *riwāq*. Both adopt a similar type of foundation, but with differences that reflect the structural history of the building.

22 Excavation in pillar I16 exposed the northeast side of the pillar only to depth 90cm. The top of the pillar foundation wall was exposed at depth 2.1m in a nearby excavation, so an additional 1.2m of bases and pillar stubs remain undocumented at pillar I16.

Fig. 28. The ribbon foundation between pillars B3 and C3 in the north *riwāq*. The foundation cuts through a pre-Islamic wall visible at the left side of the excavation.

Fig. 29. The ribbon foundation between pillars H16 and I16 in the south *riwāq*. The foundation is draped over the stub of a pre-Islamic wall (visible at the bottom of the photograph).

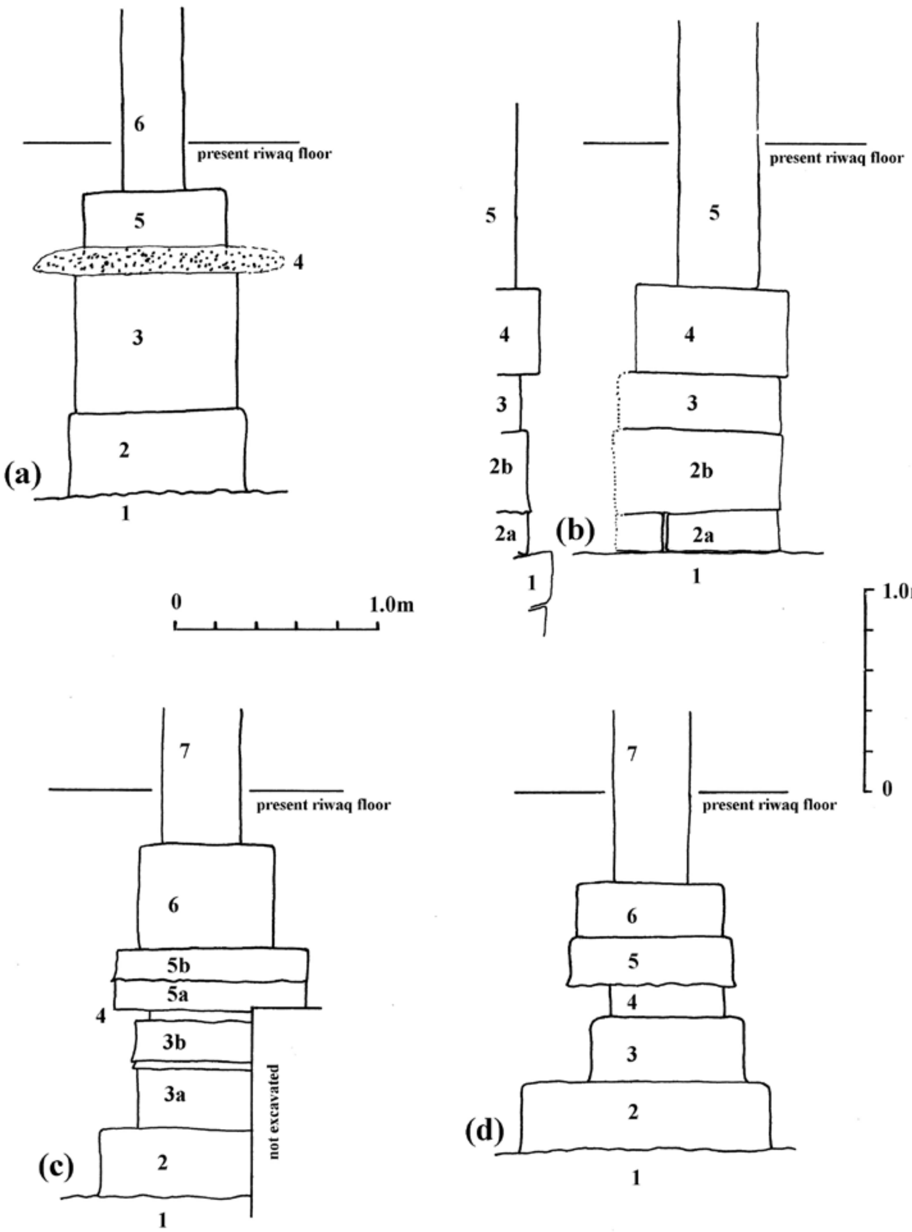

Fig. 30. Examples of rebuilt pillars in the north and south *riwāq*:
a) Pillar L3 (north *riwāq*): 1- ribbon foundation; 2- plastered stone block(s) base; 3- stub of original pier; 4- bed of *quṭrah*; 5- plastered single (?) block base; 6- present pillar (adapted pre-Islamic pillar)
b) Pillar B4 (north *riwāq*): 1- ribbon foundation; 2a- unplastered multi-block base; 2b- finely plastered upper section of the multi-block base; 3- stub of the original pier; 4- unplastered single (?) block base; 5- present pillar
c) Pillar K16 (south *riwāq*): 1- ribbon foundation; 2- roughly plastered stone plinth; 3a- roughly plastered stone block(s) base; 3b- finely plastered upper section of the base; 4- stub of the original pier; 5a- unplastered multi-block base; 5b- finely plastered upper portion of the multi-block base; 6- single block (limestone) base; 7- present pillar (adapted pre-Islamic pillar)
d) Pillar K17 (south *riwāq*): 1- ribbon foundation; 2- stone plinth; 3- finely plastered block(s) base; 4- stub of the original pier; 5- finely plastered single block (?) base; 6- finely plastered multi-block base; 7- present pillar (adapted pre-Islamic lintel with inscription).

Fig. 31. Pillar E1 in the north *riwāq*. The ribbon foundation is visible at the bottom of the photograph. The original pier, with multiple replasterings, sits on a large plastered base. The present pillar is also a pier, established on a bed of large rough stones embedded upon the stub of the original pier.

Fig. 32. Pillar L3 in the north *riwāq*. The original plinth and pier are covered by a second stone base set in *quṭrah*, with the present pillar (a recycled pre-Islamic pillar set up-side down) on the secondary base.

Fig. 33. Pillar B4 in the north *riwāq*. The foundation, plinth and original pier are visible in the lower half of the stack (see Fig. 30b). A large stone base sits upon the low stub of the pier, and the present pillar is a re-used architectural element (perhaps a lintel) fixed to the secondary base.

Fig. 34. Pillar K17 in the south *riwāq*. The pillar stack consists of (from bottom to top) the foundation ribbon, the original plinth, the original base, two secondary bases, and the present pillar (a lintel with a South Arabian inscription, see Fig. 30d). At the bottom of the photography is visible a ribbon foundation and the stub of a square pillar belonging to the *ẓullah* (see Section 2.3).

Fig. 35. Pillar L17 in the south *riwāq*. The pillar stack visible in the upper left corner of the excavation consists of (from bottom to top) the foundation ribbon, the original plinth, the original base, the low stub of the original pier, a narrow secondary stone base, and a wider secondary stone base framed in brick; the present pillar (not visible in the photograph) is a multiple drum pillar of relatively recent date. The square base and walling along the left side of the excavation belong to the *ẓullah* (see Section 2.3), whereas the wider wall below these two structures antedates the Mosque.

Fig. 36. Pillar J18 in the south *riwāq*. The pillar stack consists of (from bottom to top) the ribbon foundation, the original plinth, the original base (with two coats of plaster), a stack of three secondary bases, and the present pillar (multiple drums). Note that the top of the foundation trench (visible in the section to the right of the foundation ribbon) is cut from a level above the top of the plinth.

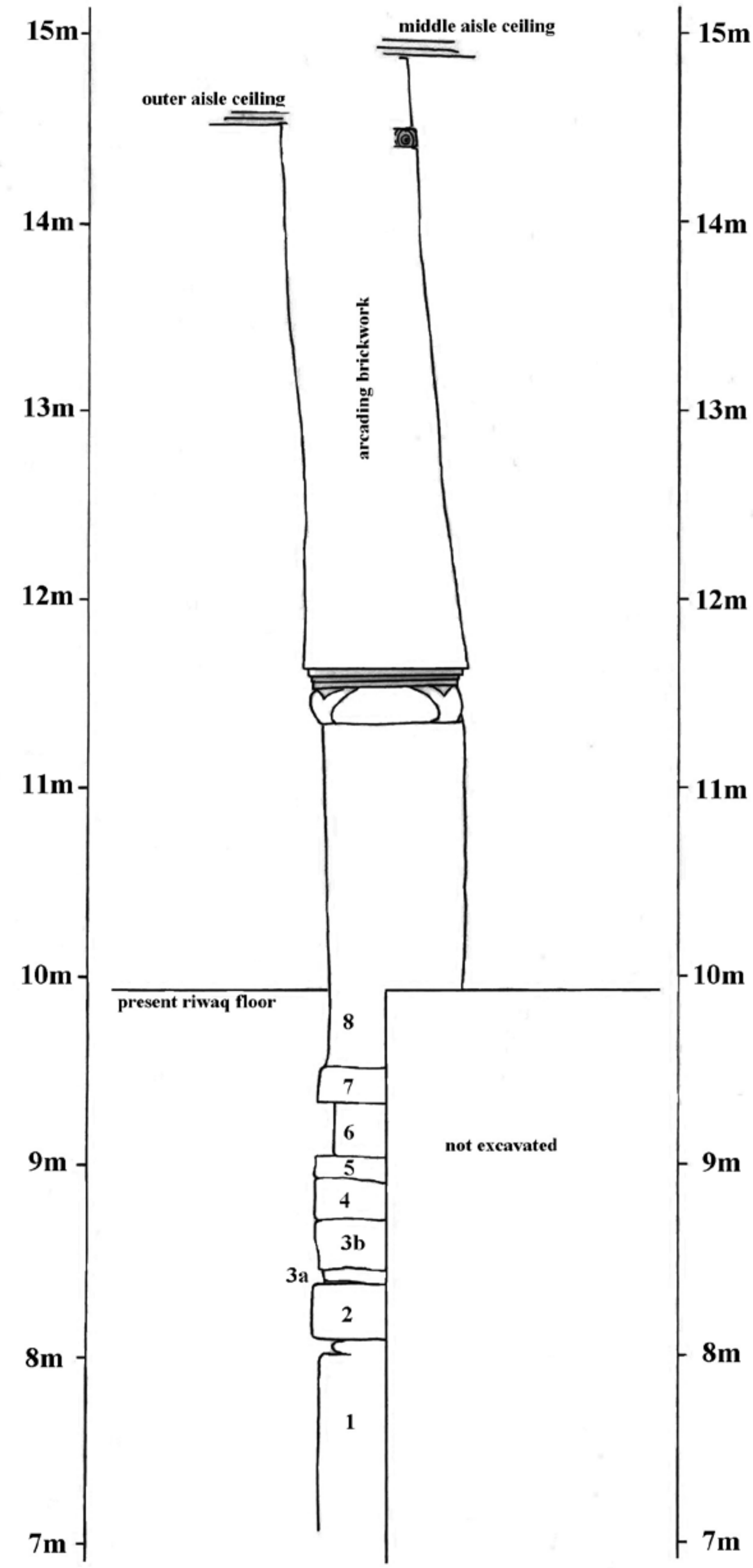

Fig. 37. Profile of pillar I17 (south *riwāq*), showing southward shift of the arcading load with respect to the pillar foundation;
1 - ribbon foundation;
2 - roughly plastered multi-block plinth;
3a - roughly plastered bock(s) base;
3b - finely plastered upper portion of the base;
4 - unplastered single block base;
5 - stub of a pier;
6 - finely plastered base;
7 - plastered brick base;
8 - present rough stone and plaster pier.

Fig. 38. Pillar I16 in the south *riwāq*, from the west. The vertical stonework on the left half of the compound pillar is the pier supporting the southeast corner of the western library (section 6.1.2.5(c)) while the stonework on the right half is the buttress with the wood beams separating its two parts (section 6.1.2.5(b)). The plaster visible between these two components covers the arcading brickwork. The original pillar is not visible from this side.

6.2.1 Outer and middle arcades of the east and west *riwāq*

Pillars of the outer and central arcades of both *riwāq* are cylindrical "piers" about 80cm in diameter. The piers are constructed of irregular stone blocks encased in plaster, and set upon a block-like base (Fig. 39). The bases are roughly dressed rectilinear blocks of stone that are approximately 80cm by 80cm in area, and around 30cm high.

The base of each pier in the outer and central aisles is fixed into a bed of clayey earth that covers the top of a roughly cylindrical stone "piling" (Figs 39-41). The pilings are constructed mostly of unshaped stones, although recycled facing stones of walls were sometimes also used (Fig. 39). These stones were dropped haphazardly into a deep cylindrical pit. Most of the stones are up to 30-40cm in longest dimension. Although empty spaces frequently appear between stones, the sides of the pit stabilize the structure. Pilings are typically 2.6-2.8m across (estimated). In the west *riwāq*, the tops of pilings appear at elevation 8.7-8.8m (1.0m below the present floor) and the first floor associated with the pillar bases at elevation 8.9m (90cm below the present floor; in the east *riwāq* the respective positions are 9.1-9.2m (80-90cm below the present floor) and 9.3-9.4m (50-60cm below the present floor).

The east and west *riwāq* do differ in one important detail. The original west *riwāq* of the "Umayyad Mosque" contained pillars (no longer extant) that rested on east-west ribbon foundations of the kind also present in the north and south *riwāq* (see 6.1.1 above). The foundation pilings of the rebuilt *riwāq* drop down through nearly a meter of accumulated *riwāq* floors onto the earlier ribbon foundations (Fig. 40). The west *riwāq* pillar foundations thus combine structures of two different ages. Although the risk of instability prevented excavation to the bottom of any combined pillar structure in the west *riwāq*, bottoms of the combined foundations are probably around elevation 5.5m (4.3m below the present floor).

In contrast, the east *riwāq* was an enlargement built over an area of streets and buildings that lay outside the "Umayyad Mosque". Here the piling foundations do not incorporate earlier pillar foundation, although some of them probably do sit upon remains of earlier buildings. These pilings extend at least 3.3m below their tops.[23]

Investigations at eight of these piers (three in the east *riwāq*, five in the west *riwāq*) found no evidence for major reconstruction or replacement. Many pillars do show major re-plastering events which sometimes shifted the center-line of the pier by 2-3cm, but without changing the load-bearing stone elements of the pier. In other words, the piers visible today within the east and west *riwāq* seem to be the original structures within these two spaces. The piers, bases and pilings (foundations) are all generally in good condition.

6.2.2 Inner arcade of the east and west *riwāq*

The pillars along the boundaries of the central courtyard are stone shafts with capitals and bases; very often these are pre-Islamic in origin. The pillars on the west side of the courtyard form the entire length of the inner arcade of the west *riwāq*, while those on the east side of the courtyard form the central section of the inner arcade of the east *riwāq*. The north and south ends of the latter arcade are piers of the same type found in the outer and central arcades of these *riwāq* (section 6.2.1).

The inner arcade of the east *riwāq* runs above the stub of the early east wall of the Mosque, and the pillars of this arcade use the wall stub as foundation. The top of the stub is at elevation 9.2-8.9m (60-100cm below the present floor). The early east wall and east *riwāq* arcading are not identical in orientation, and the arcade runs obliquely along the wall stub. As a result the piers at the southern end of the arcade are positioned near the east face of the wall stub while those at the north end of the arcade are near the west face of the wall stub (the base for pier M1 is 5cm from the west face of the wall; see Fig. 41).

The pillars and piers of the inner arcade sit upon roughly dressed rectilinear bases (seemingly single blocks), which are fixed to the underlying foundations by a 3-6cm thick bed of clayey earth. The foundations are pilings of rubble draped over and against the stub of the early east wall. In some instances (e.g. M1, M9 (Fig. 42), M17, M18) facing blocks of the

23 The corners of nearby excavations exposed a small section of foundation pilings for pillars N3 and N17 in the east *riwāq*. In the west *riwāq* larger portions of foundation pilings were exposed to shallower depths at pillars A7, A10 and B11. Their individual nature entails that deep exposure of pilings would remove the earth buttressing around part of the foundation and so risk its collapse; no attempt has been made to expose the full depth of any piling.

early east wall have been rearranged to support directly the pillar base, with the addition of a rubble buttressing against the side of the wall stub. In other cases (e.g. M5 (Fig. 43), M16) the piling covers the wall stub, incorporating displaced facing stones and continuing down the face of the wall stub. The same arrangement is evident at the northeast corner of the west minaret, where a shallow rubble buttress helps support pillar A14 (Fig. 44).

Despite the variation in detail, the early east wall forms the basic foundation for these piers and pillars. The wall stub is 1.6m wide at the top, and widens with depth. Excavations at various points along the wall stub show that it is more than 2.4m deep north of east minaret, and over 2.7m deep south of the minaret. At all examined points the foundation remains in good condition.

No excavation has been made at a pillar of the inner aisle of the west *riwāq*. However, the foundations here are almost certainly circular rubble pilings draped over earlier ribbon foundations of the kind described above (section 6.2.1).

7. Other recent structures

Several structures built during the 1340s/1920s through 1380s/1960s front on the southern side of the courtyard. These structures include the two libraries and the two staircases. Results of excavations and limited probes indicate that some of these structures lack purpose-built foundations.

Fig. 39. Upper portion of the foundation piling, the base and pier at pillar A7 in the west *riwāq*. Note the recycling of dressed facing stones in the piling.

Fig. 40. Top of the foundation piling and the base at pillar A13 in the west *riwāq*. Note the top of a ribbon foundation of the original west *riwāq* in the lower part of the photograph. The stone and brick structure at the right of the photograph belongs to a relatively recent chamber probably associated with the tomb of the prophet Ḥanẓalah b. Ṣafwān (traditionally thought to be below the west minaret).

Fig. 41. Top of the foundation piling at pillar N1 (bottom of the photograph) and the base of pillar M1 set upon the stub of the early east wall (top of the photograph) in the east *riwāq*. The wood slot in the exterior face of the early east wall is visible.

Fig. 42. Pillar M9 in the east *riwāq* (east edge of the courtyard). The pillar base sits directly on rearranged blocks of the early east wall stub, and is buttressed by the rubble piling set against the early east wall stub. The pillar itself is a recycled pre-Islamic (Axumite-style) pillar.
The stonewall set against the pillar is the present courtyard edging wall.

Fig. 43. Top of the foundation piling and the base of pillar M5 in the east *riwāq* (northeast corner of the courtyard). The structure visible at the bottom of the photograph is a doorway through the early east wall, the inner face of which is below the second step up to the doorway. The board visible in the right side of the photograph covers a large pre-Islamic well (see Section 2.1).

Fig. 44. Shallow buttressing piling set against the northeast corner of the west minaret, to buttress pillar A14.

Most of the pillars and piers at the base of the library structures fall within the regular grid of the Mosque's pillars, and the Project designations will be used in referring to these. The two middle pillars of the eastern library 2 do not fit into this grid, however. They are here referred to as pillar J15E (=east pillar) and pillar J15W (=west pillar).

7.1 The historical and architectural situation

Before the 1340s/1920s, the 3rd (inner) arcade of the south *riwāq* fronted on the courtyard, which extended up to the east *riwāq* south of the east minaret. Over much of its history the courtyard surface was packed earth and gravel but, according to historical sources (e.g. al-Qāsim 1968: 792), it was paved with stone around 1000/600 by the Ottoman governor Sinān. Sinān's pavement is said to have survived until 1388/1968, when the courtyard was resurfaced with its present pavement (al-Marwanī 1988: 43), shortly after the south *riwāq* had been enlarged to four aisles (see section 7.1.3, below). Portions of this "Ottoman pavement" survive today beneath the new fourth aisle.

7.1.1 Eastern library

The eastern library presents two structural parts, built in succession above the southeastern corner of the courtyard. The earlier eastern library 1 was built into the space between the east minaret and the 3rd arcade of the south *riwāq*, around or shortly after 1344/1925, when Imām Yaḥyā issued a decree establishing his library at the Mosque (cited in Messick 1992: 119-20; see also al-Wāsiʿī 1984: 338). The wooden floor of this structure was fitted into the existing brickwork of the arcade and the east minaret. An 'L'-shaped curtain wall was built down to the courtyard to support the northwest corner of the library structure.[24] This wall is a skin of dressed stone blocks over brick, with a total thickness around 40cm. The long leg of the 'L' abuts the west face of the east minaret about 50cm from the southwest corner of the minaret, while the short leg of the 'L' is a stone pier. A single window (with porthole above) appears in the upper portions of the wall, and a smaller aperture appears in its lower sections. The upper window today serves as the entrance to the library from the eastern staircase.

The eastern library 2 was constructed as a westward enlargement of the library in 1355 (al-Ḥajarī 2006: 33) and/or 1356 (the date on the foundation inscription), i.e. 1937-1938. The construction involved removing most of the library 1's original western side, and building the extension to the west. The floor of the extension was strung between the existing brickwork of the 3rd arcade to the south and a new stone façade to the north and west. The north wall of the extended library runs above three sharply pointed arches which sit upon two slender pillars (at J15W and J15E) and a pier at each corner (at positions I15 and K15), while the west wall rises over a segmental arch that springs from pillar I16 of the south *riwāq* (see section 6.1.2.5). Three windows (again with portholes above) pierce the north wall, and two windows the west wall. The south wall is brick, erected over the third (inner) arcade of the south *riwāq*.

7.1.2 Western library and western staircase

The western library was built in 1379-1380 / 1959-1961 at the instruction of Imām Aḥmad (al-Marwanī 1988: 41). This structure abuts Imām Yaḥyā's Library, the facades of the two structures forming a continuous line, albeit in different heights, arching and decorative styles. The western library also differs in construction technique. Its south wall is again brick, erected above the inner arcade of the south *riwāq*. However, the library floor and also the bookshelves along the south wall are carried by structures independent of the arcading and pillars of the south *riwāq*. Seven rectangular stone piers are placed directly north of, and independent of, pillars C16-I16 of the 3rd arcade. A concrete beam runs over the stone piers. The piers continue upward as brick above the concrete beam, and shelving of the library is inserted into the niches between these brick piers. On the north, a row of seven stone piers (C15-I15) carry six round arches, over which rises the

24 Much of this wall is obscured today by later structures to the west and north. The short leg of the 'L' functions as the east pier of the Eastern Library 2, and this structure was probably remodeled when that section of the Library was built, but a largely obscured inscription near the roof-line indicates that the curtain wall originally did form a corner.

north wall of the library, in which appear five wide windows. The wood floor is strung between the concrete beam in the south and the stone wall in the north.

The western staircase is set against the brickwork of the inner arcade of the west *riwāq*. The staircase structure is a pair of inclined concrete beams which rise from the courtyard to a landing on the west side of the western library; the western beam abuts the brickwork of the 3rd aisle of the west *riwāq*. At their tops these beams rest on the horizontal concrete beam above the western two piers of the library. Lower portions of the staircase are enclosed by a rectangular stone structure leaves the middle section of the staircase open as a passage from the courtyard into the west *riwāq*. Four windows appear in the west wall of this enclosing structure, and one window in its north wall.

An in-line continuation of the staircase runs up to the Mosque roof, and a doorway from this section of the staircase gives access to three rooms built upon the south *riwāq* roof directly west of the staircase. The rooms are brick structures, the load of which is supported on one side by the western piers C15 and C16 of the western library plus the previously existing courtyard pillars C13 and C14, and on the other side by the previously existing pillars B16 of the south *riwāq* and by pillars B13, B14 and B15 of the west *riwāq*.

7.1.3 Eastern staircase

The east staircase is a rectangular structure fitted into the corner formed by the east minaret and eastern library 1. The structure is 4.48m long (on its west side) by 2.53m wide at ground level, but about 25cm narrower at its top because of the east minaret's lean. The staircase takes 1 1/2 turns around a central rectilinear pier to reach the library, and then continues up to its roof. A doorway at courtyard level and one window pierce the north wall of the structure, while three windows appear in its west wall. The staircase was built in 1386/1966, when the open spaces below the libraries were closed by wood doors and glass, and a cement *miḥrāb* was built into the space below the eastern arch of the western library (al-Marwanī 1988: 31-33, 40).

7.2 Structural questions

Most of the structural questions related to these modern structures concern their effects on older elements in the Mosque. These effects on the east minaret and the south *riwāq* arcading are considered above (see Section 5.1.1.4, 6.1.2.5). At the same time, these structures themselves do have some potential problems.

7.2.1 Eastern library

Investigations below the northwest corner of eastern library 1 (which also serves as the east pier for arches of eastern library 2) indicate that the stonework of pier K15 sits directly upon stone paves of the "Ottoman" courtyard surface (Fig. 45). The paves form a 20cm wide fringe along the south side of the pier; deeper into the south *riwāq* the paves have been removed, apparently when the modern tile floor was installed.

The west pier I15 and the two pillars of eastern library 2 arcade are partially obscured by the plaster that holds the frames of windows and doorways along the courtyard. Excavations at the two pillars J15W and J15E show that these also rest directly upon pre-modern courtyard paves (Fig. 46). The western pier I15 has not been explored. These results indicate that the arcade below the north facade of eastern library 2 sits directly on pre-modern courtyard paves, without additional support.

The same structural situation exists below the 'new' stonework that now forms the southwest corner of the east minaret. The stones of this corner cover a flat stone that abuts the "Ayyubid foundation" course just below the current tile floor (see section 5.1.1.3).

In effect, the structural frame of the north façade of the eastern library appears not to have purpose-built foundations, but instead relies on the then existing courtyard pavement. Judging by its remains beneath the modern tile floor of the 4th aisle, the "Ottoman pavement" consisted of basalt paves that varied in size and proportion (many are long and narrow, up to 123 x 37cm; others are more nearly square, up to 73 x 57cm) set in a bed of a tough *quṭrah* 'cement'. The combined thickness of paving and *quṭrah* is 20-24cm.

In the line of the library façade, the "Ottoman pavement" rested directly on a 35-40cm thick accumulation of earlier coarse earth and gravel courtyard surfaces that are only moderately compacted. The courtyard surfaces in turn cover a 20cm thick sequence of compacted interior surfaces, below which runs the east-west ribbon foundation for the older 4th arcade of the south *riwāq*, about 80cm below the surface of the "Ottoman pavement". This buried structure provides only modest resistance to subsidence and compression below the paves of the earlier courtyard.

7.2.2 Western library

Small openings made at three of the 14 piers show that all three are provided with foundations of variable character.

The pier at I16 (the southeast corner of the western library) sits directly on a large stone block at 19cm below the present tile floor (Fig. 47). The block is an *in situ* remnant courtyard edging made of *qaḍāḍ* and/or stone structures which existed before the Ottoman pavement. The block is about 15cm thick, and rests upon earth and small gravel. In other words, pier I16 at the southeast corner of the western library appears to lack purpose-built foundations.

The pier at H16 sits on a wide irregularly shaped pad of concrete at 26cm below the present tile floor. The concrete pad is 18-22cm thick and covers a bed of large stones, which is more than 15cm thick (the bottom was not reached). The concrete pad extends 35-50cm beyond the edges of the pier, and it shows no signs of cracking.

The pier at H15 sits on two flat superimposed stones, about 20-35cm below the present tile floor. The lower of these slabs may be a re-used slab from the Ottoman courtyard pavement. The slabs rest upon a mass of rubble packed with earth and *quṭrah* “poured” into the foundation hole. This mass of rubble extends to at least 90cm below the present tile floor, and is not much wider than the pier itself (Fig. 48).

The three roof-level rooms built off the western library staircase are additional loads that are carried largely by previously existing pillars of the south and west *riwāq*. The foundations at these pillars have not been assessed.

7.2.3 Eastern staircase

Excavation at the northeast corner of the staircase exposed foundations of unshaped stones and rubble, from directly under present courtyard pavement to ca. 70cm below the pavement; an additional 30cm of non-compacted earth and scattered rubble lies beneath these stones in the foundation trench (see Fig. 14). The stones of the foundation project about 20cm beyond the north façade of the staircase. This result suggests that the staircase is supplied with relatively shallow, irregularly formed foundations, which might be a source of structural problems in the future. However, foundations of this character and size are fairly typical of construction in Ṣan‘ā’ (Lewcock and Serjeant 1983: 472). Moreover, a foundation wall for early east *riwāq* pillars runs north-south below the west side of the staircase, about 15-20cm below the staircase foundation. This coincidence provides additional stability to the staircase structure.

8. Summary

In the most general sense, and with one obvious exception, foundation of the various architectural components of the Great Mosque seems to be adequate and in good condition.

The exterior walls are in good shape, albeit with minor defects caused by the vacant wood slot in the north and west walls. The foundations are generally somewhat thicker than the walls they carry, and including the sections of wall now below ground or floor level they are 3-5.5m deep, i.e. one-third to one-half the height of the walls they support. Buckling of the north and west walls, caused at least in part by facing stones collapsing into wood slots, affects the exterior faces far more than the interior faces of these walls, and the west wall far more than the north wall. Buckling of the exterior face of the west wall was partially rectified by the 1970s “restoration,” but it persists in places near the west minaret. The added load of the Awqaf Library probably contributes to this problem.

The east minaret leans westward off-vertical, and this is most obvious structural problem in the Mosque. The minaret’s foundations vary in depth from at least 3-3.5m on the north and east sides of the structure, to at least 4m (including remains of earlier walling) on its south side. However, exploration at the northeast corner of the minaret

Fig. 45. Paves of the "Ottoman pavement" serving as foundation for the pier K15, which supports both the northwest corner of eastern library 1 and the northeast corner of eastern library 2.

Fig. 46. Paves of the "Ottoman pavement" serving as foundation for the pillar J15W, which supports pointed arches in the north façade below eastern library 2.

Fig. 47. Pier I16 sitting upon a block belonging to an earlier courtyard edging. This pier supports both the southwest corner of eastern library 2 and the southeast corner of the western library.
A pave of the "Ottoman pavement" is visible on the left side of the photograph.

Fig. 48. Pillar H15 sitting upon a piling of rubble and cement. The pillar supports arches in the north façade below the western library.

indicates that this corner lacks proper foundation, and the same may be true of the entire west side of the structure. The latter possibility urgently needs clarification by cautious excavation within the footprint of the eastern staircase. Just as urgently, probes inside the minaret would be very useful for understanding the interior aspects of the foundations, and also the nature of foundations for the central stairway pier. The loads introduced to the minaret by the east *riwāq* roofing system and by the eastern library 1 probably have a minor role in distorting the minaret, but these effects also need carefully to be assessed.

The west minaret is in good evident condition, but its foundations remain largely unexamined. Indeed, only the north foundation has been examined. This foundation plus buried portions of the minaret face is 3m deep, and apart from minor buckling caused by collapse of facing stones into a wood slot, the foundation is in good condition. However, this structure seems to have only an indirect role in supporting the tower.

The pillars of the east and west *riwāq* appear to have adequate individual foundations that retain their integrity, and the rough block-and-plaster pillars themselves are generally in good condition. The situation is different in the north *riwāq* and especially in the south *riwāq*. In these halls the ribbon foundations are deep and in good condition. But repeat renewal of pillars has created stacks of pillar bases and pillar stubs that support the existing pillars. In some cases these stacks introduced the possibility of instability. Off-center distortion of arcading in the south *riwāq* exacerbates the possible instability (the parallel problem in the north *riwāq* seems to have been fixed in the past by rebuilding sections of individual arches). The stability of pillar foundations must be assessed individually.

Foundations for the library structures are variable in quality. Foundations for the western library appear to be adequate, whereas those for the eastern library appear to be simply paves of the previous courtyard surface. These paves plus the "cement" in which they are laid are only 20-24cm thick, and they may be inadequate as long-term foundations for the eastern library.

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Section 1 - Chapter 3

THE ARCHITECTURAL DECORATIONS

RONALD LEWCOCK

The Great Mosque in Ṣan‘ā’ houses a vast area of very early wooden ceilings, most of which are painted and some carved. In few other parts of the Islamic world – or indeed in Europe – are there wooden ceilings from the early middle ages, and hardly any painted and carved decorations of such quality survive.[1]

The decoration in the Great Mosque is actually of three different kinds: stone mouldings and bas relief decoration on the some of the columns and capitals, plaster mouldings and bas relief decoration in some areas of the walls and *miḥrāb*s, and decoration in paint and bas relief on the wooden ceilings, on the *minbār* and *dikkah*, on one beam over the south door, and on the wooden "domes" over the *miḥrāb*. (The only addition to the above that should be noted are the bronze panels on the closed-up north door in the *qiblah* wall).

Prior to the building of the first of the succession of Great Mosques in Ṣan‘ā’, two foreign regimes had ruled there successively. The first foreign occupation resulted from the Ethiopian invasion, which established a Christian regime based on Axum in the early sixth century AD, and lasted approximately fifty years.

When the walls of the Great Mosque in Ṣan‘ā’ were built in the next century their construction was of a distinctly Ethiopian type. Also in the Ethiopian style are many of the columns shafts, bases and some of the surviving pieces of carved wood in the north and south halls of the mosque - but it seems that these are generally later imports into the Great Mosque, having been plundered from the cathedral and other buildings.

But there is a more significant legacy of the Ethiopian occupation. Historians record that the Byzantine emperor had sent in craftsmen from Constantinople to work on the cathedral in Ṣan‘ā’ c. 525 AD. As churches continued to be built in the Yemen and southern

1 In addition to frequent damages inflicted by fire and natural disasters such as earthquakes, wood constructions are also notoriously prone to deterioration by attack from woodworm and beetle, or through rot caused by dampness due to leaking roofs. Most wood ceilings have to be replaced within 300 years – often much less. But, at the time of the building of its early mosques, Yemen presented a unique situation. Because of the demolition of so many great temples and churches, supplies of ancient beams and ceiling timbers were readily available; it is not surprising that many of the carbon dates indicate that some of the wood was already four to eight hundred years old when it was reused – and therefore dry and free from resin which might attract termites or facilitate rotting. This was animportant factor in ensuring the ceilings of the Great Mosque their extraordinary survival.

Saudi Arabia, it is likely that the Byzantine style became deeply embedded in the work of the foreign and local craftsmen. This seems to be evidenced in the semi-circular arcading of the Great Mosque, in some of its early decoration and that of the early mosque of Shibam-Kawkaban, in the overall geometrical ordering of the mosques and often in the patterning.

One of the main Byzantine decorative legacies proved to be this preoccupation with geometry. Originating with Greek mathematics and becoming more and more important as time went on, geometrical relationships had earlier become central to the Ancient World in the study (and creation) of all the arts, from music to sculpture and architecture. In Christian Byzantium, if not before, geometrical proportioning and numerical relationships assumed a symbolic dimension (one which has been increasingly studied in recent scholarship). It is not certain to what an extent this symbolism of number and geometry was transferred to Islam – suffice it to say that a fascination with geometry and number relationships underlay a great deal of early Islamic design and decoration.

The second foreign regime began in Yemen in 575 AD, when the rule of the Christian Ethiopians was replaced by that of the Sassanians, a military occupation by a Zoroastrian state with its capital at Ctesiphon (near the later site of Baghad). Their rule lasted for another fifty years, before the conversion of the country to Islam.

Three of the surviving column shafts in the mosque are in a very late Sassanian style, suggesting that they – or at least one or two of them – might be survivals from the first Great Mosque. This would be likely to have been largely built by Persian-trained craftsmen or their descendants (the shafts resemble column shafts from another very early mosque, that of Wasit in Iraq, near Kufa. Alternatively, it is possible that the column shafts were taken from a public building or buildings built during the period of Persian rule, or even from other early mosques. A very similar shaft, now in the Museum, was found in the Saylah. Experts on the late Sassanian style date all of them to between the 6th and 7th c. AD. No parallels to them have been found in Ethiopia.

There is documentary evidence that the early Great Mosque(s) were richly decorated. (An imam in the 10th century had the decoration on the *qiblah* wall, which he thought excessive in the then mosque, removed). Early mosques in Persia and Afghanistan (the latter an old part of the Persian empire) give evidence of overall decoration of the walls in styles that are not very dissimilar from those on some of the column shafts in the Great Mosque (Fig. 1).

The wooden ceilings of the Great Mosque, which will be the main focus of the following discussion, were constructed using regularly spaced beams between arcades (as remains predominantly the case today in all the halls of the building) or alternate widely and closely spaced beams (the latter on either side of columns, as in the other early Yemeni mosque of Shibam-Kawkaban). In the former case, there were usually five or six square centralized ceiling panels or raised coffers between the beams; in the latter case larger square or rectangular ceiling panels of repetitive decoration were inserted in the wider spaces between the beams.

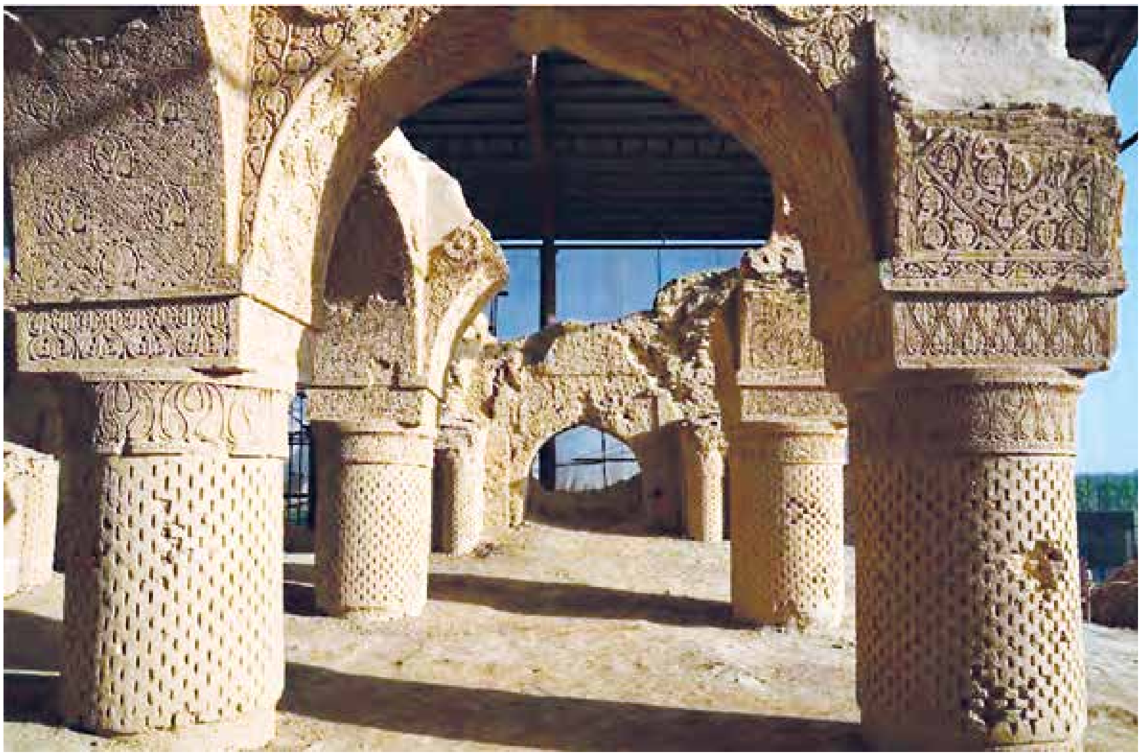

Fig 1. The Mosque of Balkh in Afghanistan. 2-3/8-9 c. AD.

All the ceilings were originally decorated with paint – often in bright colours. The lower faces of the beams were enriched with longitudinal patterns running from one end to the other. The patterns in adjacent rows of beams were often repeated to create a pleasing overall effect from below. To increase their richness, the patterns might be carved in the surface of the beam in low relief before they were painted. The sides of the beams were usually painted in running patterns. The flat ceiling panels in between them were generally each made up of a square frame containing a square field or one composed of triangles; in either case there was usually a square or circular central panel, in later styles this was carved in low relief before being painted in gold and rich colours. This system of ceiling construction was an ancient one, evidence for it surviving in stone copies of the ceilings like those of Baalbek and Palmyra (Fig. 2A-2B).

Painting on wooden ceilings of such an early date as those in the Great Mosque hardly survives anywhere in the world. So for comparisons of style we have generally had to resort here to comparisons with details of the stone carved ceilings – or with carved patterns or images in other hard materials, such as metals.

In the oldest ceilings, a considerable proportion of the surviving painting of the first levels of decoration is in a strongly Sassanian-influenced style. While it is possible that a few of these ceiling panels actually came from older buildings, it is also significant that the oldest quarter outside the ancient walled Qasr continued to be known as "the

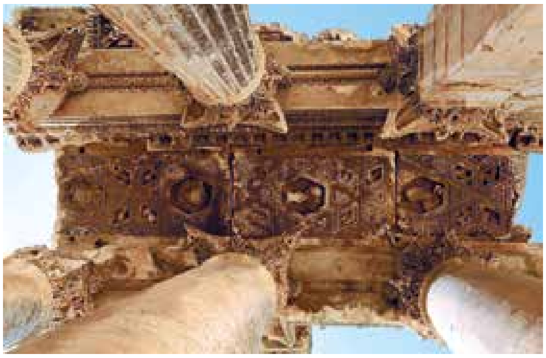

Fig. 2A Baalbek, Syria. Coffering on a fallen stone cornice of an entrance porch. 2nd c. AD.
2B Coffering, Arch of Titus, Rome. 2nd c. AD.

Persian Quarter" for several hundred years, suggesting a long persistence of Persian families of craftsmen and traders in the city. The predominance of Sassanian styles in the early decoration in the mosque may thus simply reflect the tradition of craftsmen continuing to use patterns of design that were handed down from father to son for many generations.

The ceiling decorations that have been revealed to date are (a) painted on flat surfaces and sometimes (b) carved in relief and then painted.

The decorative paintings on flat surfaces on ceilings and beams that have been revealed to date are of three main types:

(i) Floral, leaf and vine patterns.
(ii) Compositions of the above with pairs of birds wings and pearl necklaces.
(iii) Fantastic, geometrical, abstract and imaginary motifs, sometimes mixed with elements of the other types. This category also includes fish-scale and zigzag ornaments.
These are often ochre on red backgrounds, bright yellow and sky blue are also used.

In addition, a number of examples of another, completely different kind of painting have been found: This kind embraces line drawings of people, animals and birds. These are clearly not meant to be part of the decoration of the mosque, but are practice (?) drawings by the artists. They lie beneath later decorations or are on the sides or tops of beams or panels where they would not be seen.

During the cleaning process, at least four to five stages of decorative painting have, on average, been found (in some areas considerably less, only one or two layers, in a few areas even more layers). These may briefly be characterized as follows (Fig. 3).

The lowest, and oldest, paintings involve patterns of high quality related to Sassanian Persian coats of arms, resembling those characteristic of the decorations in the Dome of the Rock. They are drawn in black, with touches of other bright colours on white or red backgrounds. These patterns are paralleled by painted wooden panels and carved brackets, later reused in situ or moved into the four high bays on the western edge of the northern prayer hall.

Fig. 3. On the left some sample of lowest layer of painted decoration in the north prayer hall.
On the right: Sassanian relief decoration on silver cup 5th to 6th century.

The second layer is of high quality patterns, precisely drawn, brightly coloured, predominantly brown, scarlet, white and black against white, deep red, red or light red backgrounds although blue and ochre backgrounds are also seen (Fig. 6).

In some places these were later retouched, often incompetently or hurriedly. But occasionally the retouching was of high quality, in black lines of brushwork on a yellow ochre or blue background (Fig. 7).

Fig. 4. Central coffer motif. northern prayer hall, first (qiblah wall) aisle.
On the right Sassanian stucco relief from Ctesiphon, Mesopotamia. 5th-6th c. (Metropolitan Museum).

Fig. 5. Carved wooden brackets in one of the four raised ceiling bays on the western side of the northern prayer hall.
Inset: Sassanian stucco relief from Ctesiphon. Mesopotamia. 5th-7th c. AD (Berlin Museum).

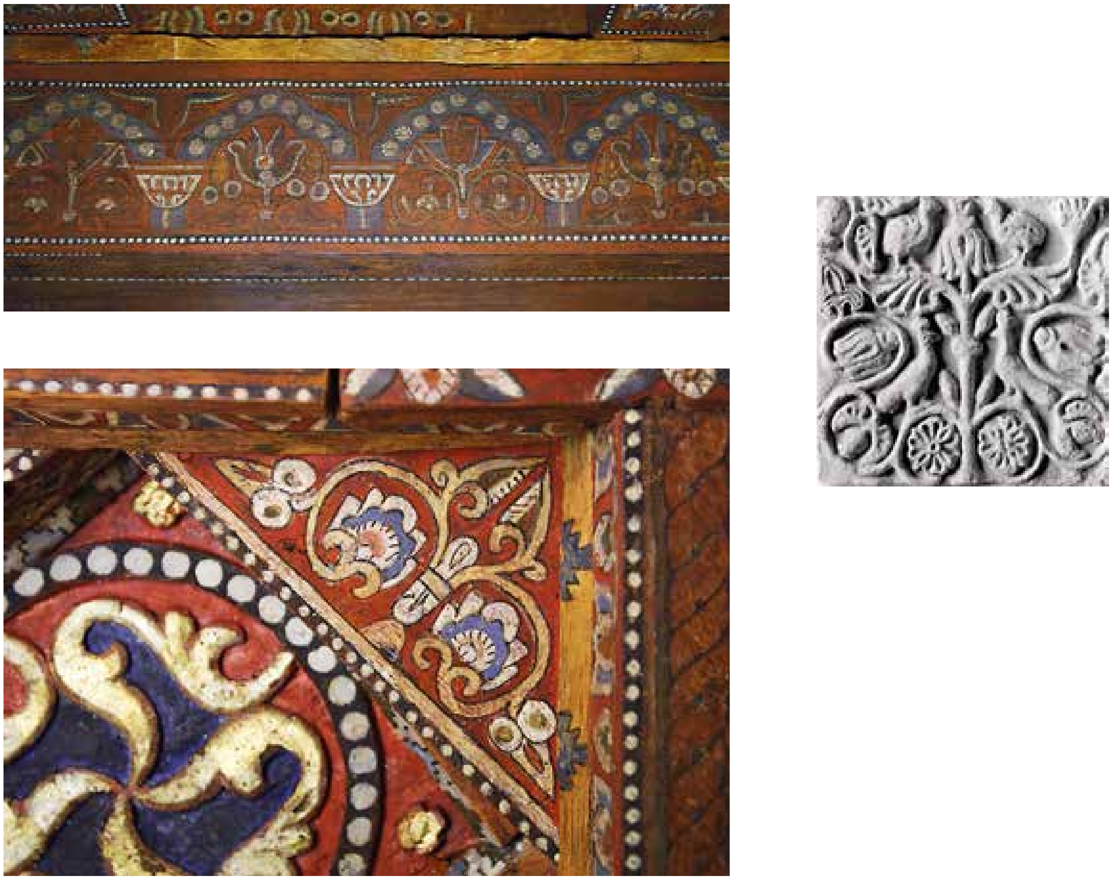

Fig. 6. Painted decoration on the side of a beam in the western prayer hall.
Inset right: Sassanian wall decoration with birds and vegetal design (Metropolitan Museum).

Fig. 7. Left: Typical painted decoration on coffers in the western prayer hall.
Right: Carved wooden decoration from the *minbar* of Great Mosque of Kairouan.

Fig. 8. Typical early Islamic painted decoration on the raised coffers in the first (qiblah wall) aisle of the northern prayer hall.
Inset right: Fragment of a Sassanian relief exhibited in the Metropolitan Museum, possibly 6th-8th c. AD.

Fig. 9. Painted drawings on the hidden part of a beam in the north prayer hall.
Inset right: Fragment of a Sassanian relief.

Fig. 10. Painted decoration on a beam in the northern prayer hall, first (qiblah wall) aisle.
Inset right: Fragment of a plaster wall mural, Samarra. 9th c. AD.

In other places, the motifs of the lowest two types of decoration was rather crudely copied by unskilled painters (Fig. 10).

By contrast, at some time, probably under the Yufirids in the 3rd to 4th/9th to 10th centuries, completely different, more conservative styles apparently began to dominate the decorative work in the Great Mosque. These closely resemble styles of ceilings introduced in several different phases in the Mosque of Shibam-Kawkaban, the original capital of the Yufirids. The styles were derived from Hellenistic Greece and Rome, via Byzantium. They were characterized by the use of elaborate geometrical patterns, predominantly based on circles and squares – which had become symbolic in meaning for the mono-theistic religions (Figs 11-12).

Fig. 11. Parts of early ceilings from two the four high north-western bays. Above: Part of a Roman mosaic floor (Conimbriga, Portugal).

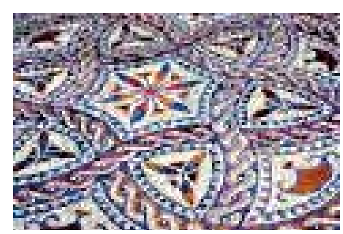

Fig. 12. Parts of early ceilings from two the four high north-western bays. Above: Part of a Roman mosaic floor (Palestine).

As mentioned above, the influence of classical traditions in Yemen would have been markedly reinforced by the presence of the Byzantine craftsmen sent from Constantinople to work on the Axumite cathedral in Ṣan‘ā’ (some of the descendants of those they trained may even have worked on the Mosque), but also by the familiarity with classical patterns in Ctesiphon, the capital of the Sassanians in Mesopotamia. So a taste for classical may also have been evident in the work of some of the skilled Persian-trained craftsmen in Ṣan‘ā’.

The most striking examples of these styles that survive in the fragments of earlier ceilings preserved in Great Mosque are in the four raised bays in the NW corner. Several of these, constructed, carved and painted, are illustrated here, with patterns which are compared with their ancestors from centuries before. (Floor patterns have to be used to illustrate precedent, as the undoubtedly widespread rich wooden ceilings of the Hellenistic and Roman empires are only today evidenced in a few copies made of them in stone.)

As noted above, this classical style is also present in the Great Mosque in the forms of the coffered ceilings that predominate throughout the mosque. Parallels may be seen in the stone coffering of temples from Palmyra and Baalbek in Syria (1st and 2nd c. AD respectively) and in some metalwork based on rectilinear geometry.

Returning to the floral and leaf motifs, another sophisticated layer of painted decoration overrides the first and second stages, and their crude repairs and copies, wherever repainting took place in the Great Mosque. This is in a simpler and purer style - frequently taking the form of curvilinear flowing floral patterns in ochre on blue or black backgrounds. Decorated inscriptions also make their appearance at.

The two successive styles of classical geometrical decoration are clearly seen in the mosque of the Yufirid's original centre, Shibam-Kawkaban. In its south hall, all the original fragments of the early style seem to have been gathered when the north hall was replaced with more splendid, finer ceiling as the dynasty became more affluent. Apparently the two ceilings are at least two generations apart in date.

Note: It is quite possible that the part of the Ṣan'ā' Great Mosque, for example, the commencement of the original eastern *riwāq* when it was built anew by the Yufirids, after the courtyard of the mosque was widened, did not have arcading, but was erected in apadana-type construction, the roof supported on tall columns, as in Shibam-Kawkaban – and with a similar paneled ceiling. Only after severe earthquake damage showed it to be a perilous kind of construction on that site would the whole structure then have been rebuilt with the present arcading – conforming to that of the older western *riwāq* this time.

(Again, this stage of the painting was occasionally crudely repainted – sometimes more than once – and even carelessly reproduced in places) (Figs 13-14).

During the Sulayhid and Ayyubid periods there were further developments in elaboration of the existing types of carved and painted decorations (Figs 15-16).

Finally, in many areas there are top coats of decoration overlaying the others. Some of these are of high quality in design and execution. Many others are rough and impromptu. Frequently they are executed in white cursive brush strokes on maroon backgrounds.

Preliminary observations on the dating of the painted decoration

In view of the difficulty of using the decorative motifs to obtain a precise dating for any of the layers of the painted surfaces (especially because in such a traditional society the same patterns continued to be used in the family crafts for generations) it might be

Fig. 13. Painted decoration on the side of a beam in the northern prayer hall, first (*qiblah* wall) aisle.
Inset above: Decoration on the inside rim of a bowl from Nishapur, Khurasan. Early 10th c. (Metropolitan Museum, NY.)

Fig. 14. Painted decoration on a beam in the second aisle of the northern prayer hall. Inset above: Three incised bricks from Nishapur, Kurasan; tentatively dated to 11th/12th c. AD. But the fine painted decoration here could well be earlier, as it also resembles decoration in al-Azhar mosque, Cairo, from the late 10th c. AD.

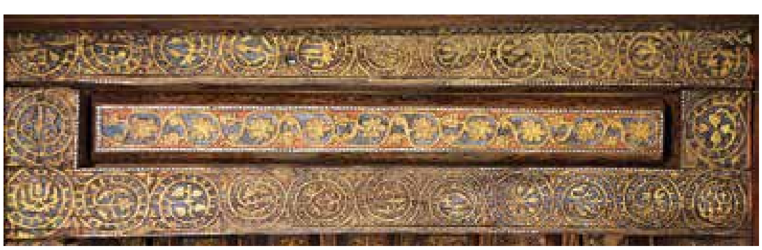

Fig. 15. Relief decoration in wood preserved in one of the four raised western bays of the northern prayer hall.

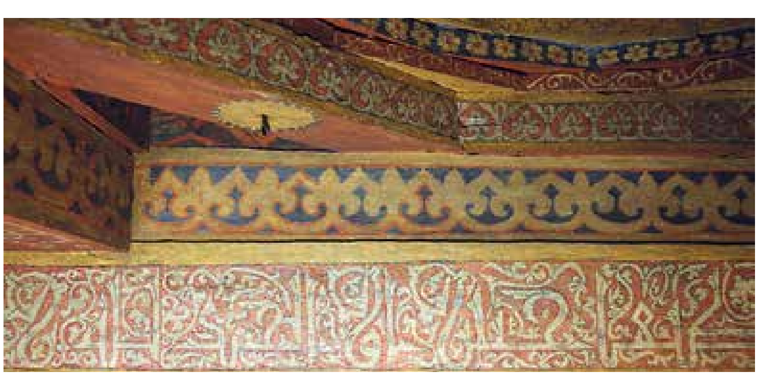

Fig. 16. Inscription on a beam in the second aisle of the northern prayer hall – characteristic of a number of inscriptions on beams painted and at about the same time.

Fig. 17. Carved and painted wooden panel in one of the four raised western ceiling bays in the northern prayer hall.
Inset above: Fragment of stucco decoration from the Qal'a of Beni Hammad, Algeria. C. 398 H./1007 AD.

relevant to ask first the question: is there any decoration that could possibly be from very early Islamic times in the Great Mosque? The immediate answer is: yes, there are a fairly large number of surfaces on which the lowest layer of decoration that has been revealed might be very early Islamic. But the difficulty here – since carbon dating is indicating that the wood was often older and was clearly re-used (see below) – lies in distinguishing what was pre-Islamic from what is early Islamic. A number of recent scholars have pointed out that pre-Islamic Hellenistic, Sassanian, and even Byzantine and Coptic Christian decorations appear to have been accepted in early mosques. This would be particularly likely to have occurred here in the case of Sassanian, as Ṣan'ā' was ruled by Persians immediately before the advent of Islam, and there must have been highly skilled craftsmen available who had been working with Persian motifs and decorations for several generations - some of the craftsmen originating in Persia. (There may also have been families of Christian craftsmen who had been working before the Persian occupation with Christian motifs under the Abyssinians).

The areas of the Great Mosque which appear to have some of the earliest Islamic styles of decoration on the lowest painted layer of beams and panels are (i) a fairly large number of the beams and panels in the north hall, (ii) some in the SE side of the south hall and (iii) a considerable number in the western *riwāq*, near the minaret and to the north side of it. Many of these decorations can be persuasively compared to early decorations in the Dome of the Rock in Jerusalem (but some are apparently even earlier in style) and some to decorations in the Omayyad Mosque in Damascus.

Others, possibly even earlier, may be identified as belonging to late or "post-" Sassanian styles closely resembling those on objects found in archaeological excavations and now exhibited in many museums in the Middle East, Persia and overseas.

Among the reused timbers there are also some that possibly have on them pre-Islamic decorations. Although there may be cases where these were meant to be exposed to be seen, or lie on the lowest faces but were repainted in Islamic times, in a number cases they were found intact on the hidden uppermost or vertical sides of the beams and panels, carried out within a hundred to three hundred years after the original painted layer. Many were executed in the late or "post-"Sassanian style, but the colours were stronger and the forms bolder. Drawing varied from rather crude to extremely skillful. In some cases geometrical patterns of considerable complexity were employed.

Other redecorations of parts of the mosque, sometimes overlaying the above, took place during Sulayhid times. Although Fatimid scholars who have been consulted are cautious about identifying them on the grounds of style, there seems enough difference between the earlier styles in Great Mosque and those which appear to show Fatimid influence for us to assume that they are Sulayhid or post-Sulayhid in date. This assumption seems confirmed by inscriptions referring to Queen Arwā on the inside and outside of the building.

Fig. 18. Central panel decoration of typical design from the coffers of the western prayer hall.
Inset: Ceiling panel between the corbels of Bab al-Futuh, Cairo. 480 H./1087 AD.

Upper layers are often cruder, and frequently reproduce patterns below in a very cursory manner. Nevertheless, a few of the final, uppermost layers of decoration are of high quality.

Wood and Stone carving and bas-reliefs

The decorations in stone and wood carving and in bas reliefs in wood range from those dependent on pre-Islamic floral, animal and vegetable designs to later patterns paralleling Samarran, late Abbasid, Fatimid and Seljuk work of the highest quality. A recurrent motif in the decoration under late Abbasid and Fatimid influence is the pine cone (Fig. 19).

Calligraphy

Almost all types of Islamic calligraphy known in the Middle East are represented in the Great Mosque. The most prominent inscriptions are those long inscriptions in bas relief

Fig. 19. General view of part of the ceiling in the eastern prayer hall, showing the square panels. Inset right: square panel from the facade of the Mausoleum of Samanid Ismail, Bukhara, end of 3rd / beginning of 10th c. AD.

of the Yufirids which run around many sides of the mosque under the ceiling. These were originally painted in ochre on a black background, with each character outlined in red. A narrow, continuous, painted castellation motif ran along the top of the inscription, coloured white on a skyblue background.

A second type of major bas-relief inscription occurs in the north and south halls below the ceilings, and dates from the Sulayhid period. This was executed in foliated Naskhi characters.

Painted calligraphy on the ceilings ranges from plain Kufic in style to the most elaborated form of later Kufic or Naskhi. It is usually painted in golden ochre on black, alternatively in black on a golden ochre background, or in white on a red or black background (Figs 14-15).

Radio-carbon dating

Dating of the decoration by radio-carbon techniques has so far proved inconclusive. Only a limited number of fragments of beams and panels have been analysed, and many of the dates obtained are some hundreds of years earlier than the likely date of the work done on the wood to execute the decorations. It therefore seems likely that much of the wood was reused, having been originally taken from ancient temples (or churches) and obtained from government wood stores. (This would also explain the apparent presence of pre-Islamic decorations, either at the lowest layer of paint work or in the basrelief patterning. Sometimes the wood was inverted, and the earlier decorations were hidden at the top or sides of the beams.)

Fig. 20. Preparatory drawing - and apparently unfinished painted decoration – of fine Sassanian style, on a beam in the third aisle south of the *qiblah* in the northern prayer hall.

In a few cases the radio-carbon date obtained appears to be too late for the style of the decoration. Action is being initiated to obtain a second radiocarbon date of the wood samples from another laboratory as a precaution for all the tests so far done.

Summary

From the above analyses of comparisons between decorations in the Great Mosque and those other parts of the Islamic world, some tentative conclusions may be drawn.

The finest early Islamic/pre-Islamic decorations uncovered are some fragments in the third aisle south of the *qiblah* in the northern prayer hall and in the western prayer hall.

In the same aisle there are more extensive sections of almost equally fine decoration, apparently also early Islamic/pre-Islamic, and others of the same period are found in the area to the north of the minaret in the western *riwāq*. (How much of this decoration is original to these locations may uncertain, however, as some appears to have been re- erected – and therefore possibly moved in position).

In addition, a number of fine early Islamic/pre-Islamic pieces of carved and painted decorated wood exist among those randomly gathered together in the four raised north-western ceiling bays.

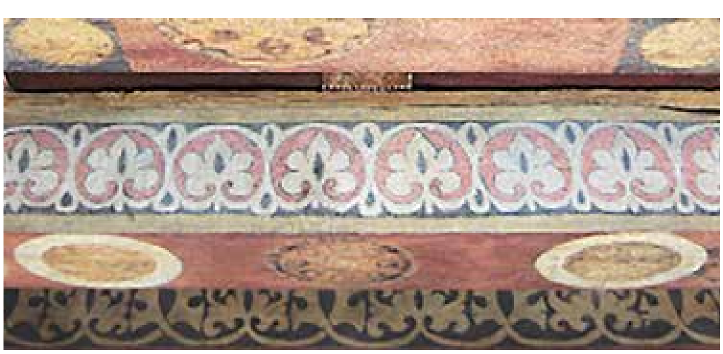

Fig. 21. Detail of painted decoration on a beam in the second aisle of the northern prayer hall. Inset above: luster-painted bowl. 4th/11th c. (Museum of Islamic Art, Cairo).

Apparently dating from the Abbasid period of the late 8th/early 9th centuries AD there are many panels and beams – as well as built-in fragments – in the northern three aisles of the northern prayer hall, and again in the four raised north-western ceilings.

From the Yufirid period of the late 9th/10th centuries AD dates a considerable amount of the painting and low relief wood decoration in the northern, the eastern, and the western prayer halls. Much of this is late Sassanian (but with a stronger influence of classical Hellenistic than is found in Islamic decoration further east), other areas are early Seljuk, not surprisingly, as these were the styles favoured in Baghdad and Samarra at this time and also in rich trading centres such as Nishapur.

Many of the above areas of decoration were retouched or painted over in succeding eras. It is clear that later craftsmen often respected the quality of the earlier work, and either retained it where they could – especially in central panels – or repainted or re-coloured it when it was faded.

Other craftsmen, less skilled, were employed to copy the Abbasid or Yufirid decorations – especially in the southern prayer hall. Some of this work seems to have been done in the period 287 to 390/900 to 1000, but much may be Sulayhid of the next century.

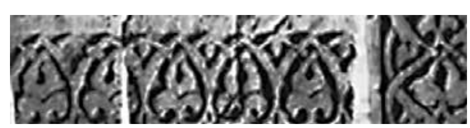

Fig. 22. Painted decoration on a beam in the *qiblah* wall aisle of the northern prayer hall.

On the facing boards below the Yufirid and Sulayhid inscriptions at the edges of the ceilings there are frequently zig-zag patterns; these seem to relate to late classical Mediterranean patterns, but it has not yet been proved that they are earlier than the 12th c. AD.

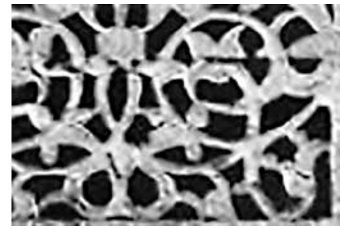

Fig. 23. One of the re-used fragments of painted decoration to be seen in some of the ceiling bays of the western prayer hall.
Inset above: pattern of the stone grillework from the Madrasa-Mausoleum of Salar and Sangar al-Gawli'. Cairo. 703 H./1303-4 AD.

High quality work after that date is rarer. But it is possible that some of it was removed or defaced. In the raised four north-western bays there are fragments of fine, late, painted decoration cut from larger panels.

Painted and carved inscriptions on the ceiling beams, some of them extremely fine, date variously from early to at least Ayyubid and Ottoman times.

Considerable repainting of the ceilings went on in later periods. This usually completely covered the earlier decorations with work of markedly inferior – frequently crude – quality.

Conclusion

The immense importance and value of the decorations in the Great Mosque in Ṣan'ā' to the history of Islamic religion and culture – and indeed world culture – cannot be overstated. The proposals for the environs of the mosque include the provision for a museum in which the many fragments that have been found hidden may be displayed – together with the archaeological finds. Part of the preparation of the maintenance plans for the mosque after the completion of the program of conservation is ensuring that every measure may be taken to ensure the permanent protection and preservation of the decorations of the mosque.

Section 1 - Chapter 4

CHRONOLOGICAL DEVELOPMENT OF THE DECORATIVE SCHEMES

RENZO RAVAGNAN, MAURIZIO MERLO, CRISTINA MURADORE

Introduction

The holistic intervention to the wooden ceiling of the Great Mosque of Ṣan'ā' included various investigations and analyses to deepen the knowledge of the artefact and to develop a conservation strategy. Stratigraphic (cross-sections) and chemical analyses on paint samples for the identification of the pigments and binders used, radiocarbon dating and the identification of the wooden support were therefore carried out. Samples were taken from different areas of the ceiling referable to a broad chronological period that spans from the 2nd century AD to the 11th century AD.

At the Centre for Dating and Diagnostics (CEDAD) of the University of Salento and at the Centre for Isotopic Research on Cultural and Environmental Heritage laboratory (CIRCE) in San Nicola La Strada (Caserta), radiocarbon dating campaigns were carried out on wood samples by means of Accelerator Mass Spectrometry (AMS). This necessary analysis was conducted to support the study of the style characteristics of the numerous decorative schemes, to determine the chronological development of the ceiling which had undergone, over the centuries, numerous restorations and/or reconstructions.

Being the product of the work of different craftsmen operating more or less invasively over the centuries, the decorative scheme of the coffered ceiling is in fact complex and composed of different styles with relevant differences also within small areas. To identify the original decorations from later additions, and their chronology, samples of wooden support were taken from representative areas of the four *riwāq*.[1]

Research on the historical context, along with archaeological studies and analysis, enabled an initial hypothesis to be drawn on the chronological development of the decorative schemes which will be presented below.

1 The *riwāq* is a portico or archway open on at least one side. It is an architectural stylistic element in Islamic architecture and Islamic Garden design. A *riwāq* often serves as a transitional space between indoor and outdoor spaces. In this case it is used to define the set of arcades of an entire sector.

Chronological development of the decorative schemes

The historical information and the archaeological excavations carried out in the most recent years determined that there were three significant stages, involving reconstructions or important renovations, considered to be the most significant for the development of the structure and the decorative schemes.

According to the historical tradition, it is believed that the first mosque was erected around the year 6 h./627 at the behest of the Prophet Muḥammad. However, recent archaeological investigations were not able to identify with certainty the outline of this first mosque. Elements which emerged from the excavations suggest that this first mosque might have been in the southern area of the current plan. But there is no unequivocable indication that these remains belonged to a religious building. Nonetheless, it is quite evident that this very small mosque had little correlation with the present one.

Consequently, the first significant historic moment for the construction of the mosque belongs to the later Umayyad era. During this period there was a massive increase in the Muslim population in Ṣan'ā', and it is reasonable to believe that a bigger mosque was built to replace the original building, but occupying a greater surface area in order to provide suitable space for more numerous worshippers.

Archaeological excavations were able to identify with certainty the plan of an ancient mosque relating to this historical moment, which is very similar to what we can see today. This ancient building is almost certainly the mosque built in 86-96 h./705-715 by order of the Umayyad caliph al-Walīd I 'Abd al-Malik ibn Marwān, as reported in al-Rāzī (1984).

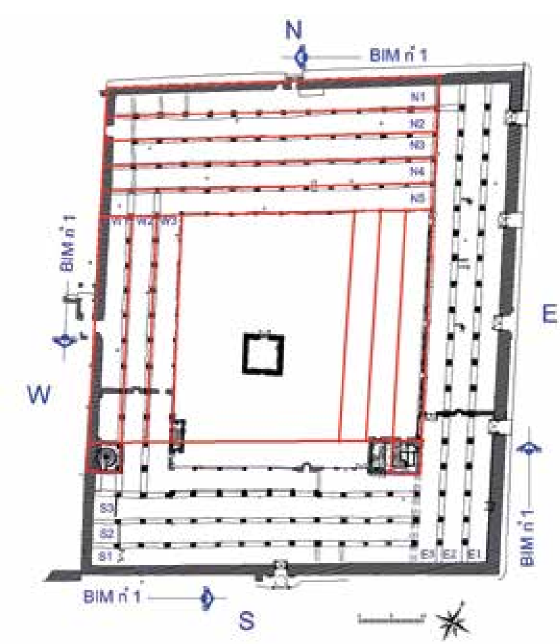

Fig. 1. Map of the current mosque with what must have been the mosque of the Umayyad period (in red).

This was a prosperous period for the caliphate and its territory, and there was certainly the desire to increase the prestige of the dynasty with the construction of one of the most important mosques in the kingdom. It appears that the ceiling of this mosque was very accurate in terms of materials and style and presented a harmonious composition in all three *riwāq*.

It is possible that the material used, being very precious wood, came from the demolition of other buildings, both civilian and/or religious. The style of the decorations and the frequent use of plant elements, such as the vine leaf and bunches of grapes, suggests they originate from Christian and/or Sassanid buildings, whose presence on Yemeni soil in the pre-Islamic period is more than confirmed.

However, it cannot be ruled out that the craftsmen were influenced by Mediterranean-Christian art and the decorations were especially made for the mosque or, as it is easier to think, readapted and completed from existing old decorations.

The main element built during this phase, which still survives today, is the general structure/plan of the aisles of the north and west *riwāq*, whose external walls will no longer change position or orientation but will only undergo modifications and/or extensions.

The second important historic moment sits during the second half of the 8th century. In 742 a powerful earthquake, which is said to have been felt as far as Constantinople, hit the area between Sa‘dah and Marib. The aftermath left the mosque of al-Walīd I badly damaged and caused the collapse of the ceiling. A reconstruction followed, with works probably lasted for a period of about 70 years. The reconstruction began under the rule of the second governor belonging to the Caliphal dynasty of the Abbasids, and continued with the new governor appointed by the Abbasid caliph al-Mahdī, established in 754 (as reported by Christopher Edens in Chapter 2). The reconstruction was completed by the Governor Muḥammad ibn Barmak, during one of the most prosperous periods for the city of Ṣan‘ā’ (186 h./802). In this period the south *riwāq* was built and, with significant successive extensions and interventions, its original structure still survives today. Due to the temporal proximity of this intervention with the earlier built *riwāq*, it is hypothesized that the ceiling of the south *riwāq* was built likewise using the same recycled material.

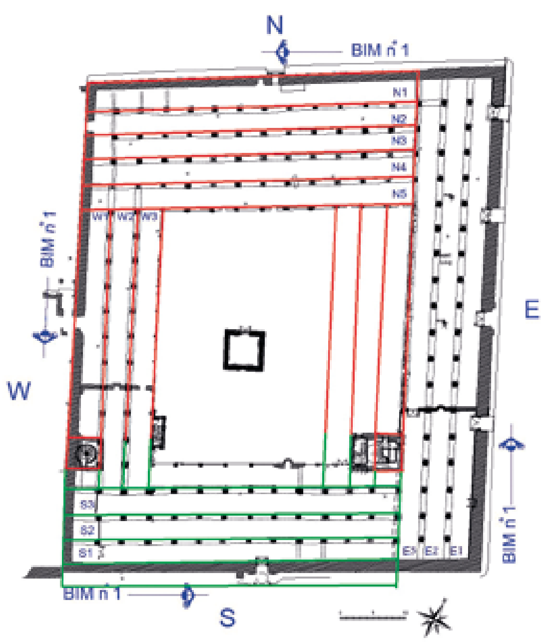

Fig. 2. Map of the current mosque with what must have been the mosque of Umayyad period (in red) and the areas built in the Abbasid period (in green).

The third important historic moment characterising the construction relates to the final enlargement of the Umayyad mosque, with the erection of the east *riwāq* in its current position and, probably at the same time, the complete reconstruction of the western *riwāq*.

Archaeological excavations have in fact highlighted interventions in the west wing, involving the replacement of the system of pillars using brick columns and arches of the same type as those still found nowadays in the new east *riwāq*. It is also plausible that, along with this extensive intervention, equally significant maintenance was also carried out on the coffered ceiling of both sectors in the 3rd century h./9th AD, perhaps following a flood that occurred in Ṣan‘ā’ in 265 h./875-876 AD. It was Muḥammad ibn Yu‘fir first and then his son Ibrāhīm ibn Muḥammad ibn Yu‘fir who undertook the reconstruction which ended in 879 AD, and documented in the inscription on a wooden panel, placed under the ceiling in the east *riwāq*, in which Muḥammad ibn Yu'fir and the date 270 h. are mentioned.

As a result of these constructive phases, the decorative scheme of the ceiling of the Great Mosque of Ṣan'ā' is rather complex and composed of different types of naturalistic and geometric motifs, even within the same *riwāq*. This confirms that today's decorative scheme is the product of multiple maintenances or refurbishments, as well as the efforts of various craftsmen who have worked here over the centuries.

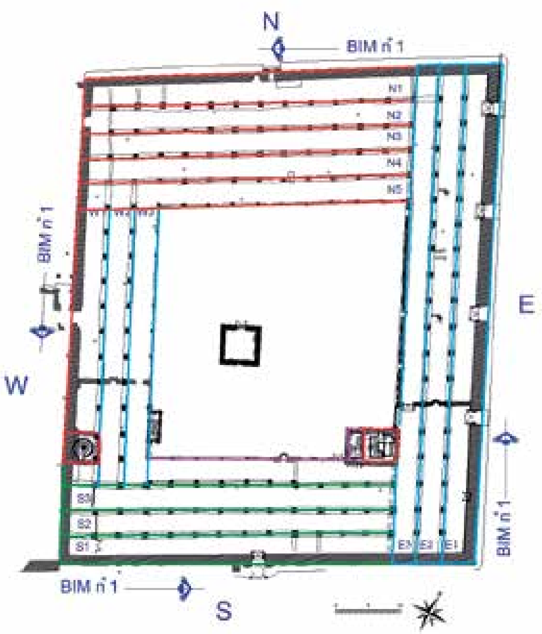

Fig. 3. The latest changes and enlargements (highlighted in blue) which brought the mosque plan to its present size.

However, it is still possible to identify the general scheme that helps to simplify the reading of the decorative scheme; the presence and the coexistence of two main types of decoration is clearly visible in both coffered panel and in the beams and sub-beams. In some areas the two decorations are superimposed (north and south *riwāq*), indicating the presence of a more recent repainting on top of an older paint scheme. In other areas traces of older painting (west *riwāq*) are hidden among the elements of the coffers, inside the masonry or under the boards that cover the beams and are no longer visible, while a different and slightly more modern decorative scheme remains visible.

We can therefore refer to the first paint scheme, the most ancient decoration, as a greasy tempera characterised by a thin layer of fine pigment particles, applied directly onto the wooden support without a ground preparation. The second paint scheme is a historicised repainting, also tempera, applied on a chalky preparation.

The latter is not always present in all *riwāq*, though it is the most recent paint scheme visible in the north and south *riwāq*, characterised mostly by the use of coarse material and an approximative execution in simple style that often takes the form of a curvilinear flow of floral motifs (white or ochre) on blue, black or red backgrounds. Unlike the first paint scheme, of which the execution in the workshop and subsequent installation on site is clear, the second paint scheme was painted on site. If the presence and coexistence of the two paint schemes is obvious in the north and south *riwāq*, a different situation is outlined for the east and west *riwāq*. Although we can talk of a second paint scheme, this however does not take the form of a superimposed paint.

Nowadays the north and south *riwāq* have many constructive and decorative elements of the coffers that unite them, whether it is the first or second paint scheme. In a different way, also the east and west *riwāq* show similarities. The stylistic study of the decorations allowed us to propose the basis for the first definition of the different phases of the mosque's decorative schemes. These were confirmed by both chemical analyses and radiocarbon dating, revealing perhaps the most important data for the understanding and knowledge of the development of the mosque.

North and south *riwāq*

If we believe that the age and chronology of the wooden ceiling follows, at least in general terms, the history of the construction of the Great Mosque, we expect the north and south *riwāq* to be the oldest. The radiocarbon analyses, summarized here in Table 1, seem to support and confirm this hypothesis.

SAMPLE CODE	LOCATION	CONVENTIONAL RADIOCARBON DATIND	CALIBRATE AGE INTERVALS	RELATIVE PROBABILITY	DATE
LTL3236A	S3T47a (south)	1346±45	610-780 AD	95.4%	22/07/2008
LTL3235A	N2T58a(north)	1688±45	230-440 AD	94.4%	30/07/2008
LTL5416A	N1DF37(north)	1758±40	130-390 AD	95.4%	19/11/2010

Table 1. List of the results of the analyses carried out on the samples taken in the north and south *riwāq*.

In both north and south *riwāq* the two paint schemes are visible as superimposed layers, with notable and significant analogies. It should be stressed here that the southern *riwāq* has undergone important structural changes over time, so the second paint scheme is not present in all its aisles. It is not present in the outermost aisle "S1" as the ceiling here was raised in the 12th century, and probably the coffers replaced; and it is not present in the innermost aisle adjacent to the courtyard. The latter being very recent and built in modern times to support the two libraries on the upper floor, its ceiling is composed of a combination of simple wooden planks. We will therefore refer only to aisles 2 and 3, the internal ones, as the original in terms of typological decorative system of the south ceiling, since only their decoration provides truthful and significant information for the purposes of our discussion.

The development of the decorative scheme, especially the earliest of both the north and south *riwāq*, seems quite homogeneous. However, there are exceptions with variations even within the same aisle, both for the type of decoration and for colours and materials. Sometimes, although rarely, discrepancies are also identified between the decorations on the coffers and those on the adjacent beams. The analysis of the first paint scheme is rather complicated because it is largely covered and hidden by the second. But we will provide our interpretation based on the visible elements discovered during different stages of restoration.

First paint scheme

The first paint scheme is present in the five aisles of the north *riwāq* and in the first three of the south *riwāq*. As validated by the chemical analyses, the first layer of paint is applied directly onto the wooden support without ground preparation. It is a fine draft with a dusty appearance and made with a limited palette (red, green, yellow, white and black). The hypothesis that the first decorative scheme was painted in the workshop is validated since the decoration extends into areas where the elements of the coffers overlap and in almost all the peripheral areas of the beams of the five aisles hidden by the masonry.

It is not equally clear whether the decorated ceiling was specifically made for the mosque. The most accredited hypothesis is that for a ceiling of such large-scale, in a region like Yemen where timber is rare and a very precious material, and considering also that coffered ceilings were not unusual in the Middle East, the decorated ceiling of the Great Mosque of Ṣan'ā' might have been recovered from the demolition of several other civil and religious buildings. This timber probably had decorations already in place and they were remodelled, adapted and integrated to form the new ceiling. This would explain the prevalence of a pre-Islamic style, to a lesser extent of Ethiopian Christian origin, but above all of Sassanid influence, whose artisan tradition persisted for a long time in Yemen.

This would also explain the presence of different types of early paint schemes. At first glance and based on the results of the scientific analyses, the first paint scheme appears as a single type of decoration. In reality, at least two main types, if not more, can be distinguished. What could create confusion is certainly the technique and the similarity of the materials used, in particular the dominant use of red in both cases. Scientific analyses have confirmed that the red, in the first paint scheme of both north and south *riwāq*, is cinnabar,[2] a very common pigment used for many centuries.

The first type of decoration, which we will call TYPE A, is basically of a floral type, very simple, not very elaborate, with a very limited palette and a predominant use of red and white colours and black outlines. Some parts of these decorations also have very bright shades of yellow and green. Scientific analyses[3] have shown that in the north and south *riwāq*, the colours of the first decorative schemes belonging to this typology are the same, confirming the idea that the decoration was performed in the same period of time. Cinnabar was identified for reds, the greens were obtained with a mixture of orpiment and indigotin, the yellows are mainly based on orpiment with or without traces of cinnabar, white lead was used for whites and lampblack for blacks.

The decoration just described above is the most widespread in the first decorative

2 See Section 4 - Chapter 2, "The painted surfaces of the al-Jami' al Kabir mosque in Ṣan'ā' - scientific analysis", by Arianna Gambirasi, sample Y-S4-2; see also Section 4 - Chapter 1, "Scientific investigations on the polychromy of the wooden ceiling of the Great Mosque of Ṣan'ā'", by Paolo Bensi, samples C37-N2C35b and C41-N2C35.

3 See Section 4 - Chapter 1.

scheme and for this reason it is considered the main form in the coffers, in both north and south *riwāq*.

Although rebuilt and raised with respect to the contiguous aisles, the first aisle of the southern *riwāq* presents the first decorative scheme completely exposed and without


Figs 4a and 4b. Complete example of the first decorative scheme and its detail.




Figs 5, 6, 7 and 8. Examples of the first decorative scheme.



Figs 9, 10 and 11. Examples of the first decorative scheme.


Figs 12 and 13. Examples of the first decorative scheme with second scheme overlapping.

repainting.[4] Nonetheless it is very fragmented, with yellow and green colours missing, and often alternated with boards and wooden elements decorated more similarly to those we will find in the west *riwāq*, especially as regards the square elements of the upper coffers.

The archaeological investigations suggest that the wooden ceiling of this sector might have been raised and rebuilt in the 12th century since the style of the entrance door on the wall, whose arch reaches almost to the ceiling, is from that period. It is likely that the intervention took place simultaneously with some maintenance works carried out in other areas of the ceiling, which was badly damaged by a violent earthquake. To explain the variety of decorations observed, it cannot be ruled out that the ceiling of the first south aisle was rebuilt reusing the elements that survived the earthquake.

The second type of decoration, TYPE B, seems widespread inside the mosque. It is much richer in details and suggests skill and technical preparation and a good artistic sensitivity. Although still limited to six colours (white, black, red, blue, green and yellow), compared to TYPE A, this typology uses a broader palette by varying in shades with light brushstrokes to create the sense of depth. However, given the scarce and fragmented presence of these decorations, which can be stylistically assimilated by resemblance and for use of same colours, it is not easy to establish whether they all belong to TYPE B. It is not impossible that the first decorative scheme comes from two different ceilings, perhaps from the same building.

The first decorative scheme is often found also on the beams. However, most of this scheme is only seen as a vague design or in the form of black lines through the light background of the second decorative scheme. Some well-preserved fragments were found on the heads of the beams which were inserted and hidden by the masonry.

In conclusion, the north *riwāq* and the two central aisles of the south *riwāq* are the oldest and probably the original sectors of the first Umayyad mosque. Beams and boards, salvaged from the same building/s, possibly from the mosque itself, were assembled and adapted to be accommodated in the ceiling of the mosque.

The demolition of so many pre-Islamic buildings during the advent of the Muslim religion provided large quantities of beams and boards readily available for reuse. It is no surprise that the radiocarbon analysis dates the timber back to from four to eight hundred years, and that the predominant style of the first decorative scheme appears to be pre-Islamic with Sasanian influence.

Mediterranean influences are seen in the Middle East during the first centuries of our era. Connections with the Greek, Hellenistic and Roman world were strong and facilitated by the spice trade routes.

Eastern Mediterranean craftsmen were already active in Yemen in the early centuries AD, whose Greek names were found in some places. Although relatively little is known about late pre-Islamic architecture and arts, the general impression of the older decorations of the great mosque of Ṣan‘ā’ presents a strong Mediterranean influence, like the use of cluster motif of grapes and vine leaves.

4 In the innermost aisles of the southern *riwāq* the first decoration scheme is completely deceived by the second.


Figs 14a and 14b. Example of the first decorative scheme, TYPE B and its detail.



Figs 15, 16 and 17. Examples of the first decorative scheme, TYPE B.

Figs 18a and 18b. Example of a board with the first decorative scheme, TYPE B, reused as closing panel for a coffer.

Fig. 18c. Example of reuse of a wooden board painted with the first decorative scheme, divided for the installation of the new coffer, and painted with the new motif.

Second decorative scheme

This scheme, intended as repainting over the first paint scheme, is found only in the north and south *riwāq*, with interesting analogies that provide important information about the construction phases of the two *riwāq*.

We can confidently assert that the second decorative scheme was painted once the coffer was already in place; in fact, there are numerous paint overflows between adjoining coffers.

Regarding the second decorative scheme in the coffers of the two external aisles of the north *riwāq*, we noted a variety of materials and styles, which almost certainly reflects the numerous interventions carried out over the centuries along the external wall and around the *miḥrāb*. Because of its importance, the latter is subjected to periodic interventions.

On the other hand, in aisles 3, 4 and 5 of the north *riwāq* (where the *riwāq* 1 is the outermost) and in most of the south *riwāq* in aisles 2 and 3, the situation becomes more homogeneous and the second decorative scheme is presented coherently, orderly repeating an almost identical motif, on both the coffers and the beams. This suggests that the re-painting was carried out simultaneously in both *riwāq* during what we believe was the third construction phase, or the last extension of the 9th century mosque. It cannot be ruled out that at the same time the north and south sectors, or part of them, were also repainted. Although structurally well preserved they were a few centuries old and perhaps in need of a refresh. However, it is also likely that part of the second decorative scheme was created in a different period, as reported in historical sources cited in Professor Ronald Lewcock's publication.[5] According to historical sources, part of the ceiling of the north prayer hall was redecorated during the works commissioned by the emir al-Ḥusayn ibn Salāmah, carried out in 389/397 h. (999/1002).

The general impoverishment of the style of the second decorative scheme, which now portrays floral and plant motifs in a more crude and pure way, and the appearance of the first Koranic inscriptions on the lateral bands of the beams and at the base of the ceilings, seems in line and consistent with the style of the period, influenced and inspired by the Persian art in the late 9th and 10th centuries AD.

East and west *riwāq*

The information collected by the archaeologists suggests that the ceilings and related decorations in the east and west *riwāq* also show strong affinities. Although, from a stylistic point of view, the similarities do not seem to appear as substantial as those found between the north and south *riwāq*. For instance, the east section is predominantly carved and gilded whereas the west is painted, but it is possible to observe similarities in the structure (both architectural and decorative). In all four *riwāq*, the principle of the coffered construction system is free interlocking with the components resting one on top of the other, without nails or other types of fastening or glue, where diagonal boards, strips and frames, overlap with a truncated pyramid arrangement. In the east and west *riwāq* the coffered structure is made up of four levels of overlapping elements with a total of thirteen pieces. Whereas in the north and south *riwāq* there are five levels for a total of seventeen elements.

In both east and west *riwāq* the four main levels of the coffers are framed by thin bands of different wood species. These elements have the same decorative motif in both *riwāq*, which consists of a series of palmettes organized in a triangle, alternately oriented towards the upper part or towards the lower part of the band to form a cordiform motif. The palmettes pointing upwards are white, while the palmettes pointing downwards are green or blue. The only difference is that in the east *riwāq* the palmettes are punctuated by small red triangles in the empty spaces of the upper edge, while in the west *riwāq* the small triangles are white.

The coffers of the east and west *riwāq*, in the upper closing square, have a very similar motif, with well-made gilded carvings. Even the analyses carried out on paint samples taken from the tops of the coffers of the two *riwāq* revealed some common features.[6]

5 R.B. Serjeant and R. Lewcock, *Ṣan'ā' an Arabian Islamic City*; Aḥmad al-Ḥajarī, *Masājid Ṣan'ā'*(Ṣan'ā'1942).
6 See Sect. 4 - Chapter 2.

Figs 19 and 20. On the left a detail of the ceiling in the northern sector; on the right a detail of the southern sector.

Figs 21 and 22. On the left a detail of the ceiling in the northern sector; on the right a detail of the southern sector.

- The gilding method is a mission application and a similar preparation made of cinnabar, although traces of red lead were also found in the eastern samples.
- In both *riwāq* the blues are made up of a mixture of indigo carmine and lazurite (i.e., ground lapis lazuli). The blues of the square panels closing the coffers of the west *riwāq* generally have a blackish preparatory layer, to enhance the brilliant colour of the lapis lazuli. This dark preparatory layer was also identified in the sample taken from the east. Although the analyses here relied on one sample only, it is accepted as representative for the entire *riwāq*.[7]
- The reds are in both cases based of cinnabar, although traces of red lead have been found in samples from the west.
- The blacks and whites, relating to the circle of the central gilded carving, are in both cases respectively smoke black and white lead in oil binder.

Although the chemical characteristics of the pigments identified in the two *riwāq* are

7 See Section 4 - Chapter 1, sample C43 E1-C65b.

similar, it can be argued that they mostly belong to classes of pigments used for centuries.[8] Even the similarities in the styles between the two sectors are not sufficient to establish a coeval execution of these decorations, which is quite unlikely. In fact, the two *riwāq* are visibly different, whereas similarities may be found among the various manifestations of Arab art.

Furthermore, the condition of the wooden material is also different, precarious in the west and good in the east, which further validates the theory that the two sectors have very different origins and history, with the east ceiling being of more recent construction, not only than the west but also from the rest of the ceiling of the mosque.

Recent archaeological findings have proved that the two *riwāq* were rebuilt around the 9th century following a general modernisation and enlargement of the mosque.

During this intervention, the west *riwāq* was rebuilt with the same dimensions and in the original position of the Umayyad mosque, replacing pillars and arches with the same type of cylindrical pillars and brick arches that we will find in the new east *riwāq*.

It is not clear whether the west *riwāq* had been completely demolished at first or if the intervention consisted of a gradual replacement of arches and pillars only. However, it is certain that in this period the west ceiling was structurally rebuilt and a new paint scheme applied, thus losing the character and similarities with the north and south sectors from the Umayyad era.

It is probable that the reconstruction of the west ceiling was made using already available material, perhaps coming from the demolished ceiling. This would explain the presence of numerous traces of the first decorative scheme also present in the north and south.

The new decorative schemes, which we can still see nowadays, therefore have their own characteristics. The decorations, which were once very bright and vivid, are recurring arched motifs painted with bright blue lapis lazuli pigment on a contrasting red-orange cinnabar background (see Fig. 27). Some analyses carried out on samples taken in the west *riwāq* also reveal the presence on the entire surface of a mixture of red lead and cinnabar based preparation layer. This would explain the characteristic reddish-purplish tone that today the surfaces of the wood have assumed in the areas left exposed by the numerous losses that have occurred. These decorations, very different from the first paint schemes in the north and south sector, still present a strong Sassanid influence. Under the Yuʻfirids in the 3rd-4th/9th-10th centuries, a different and apparently more conservative style seems to begin to dominate the decorative work in the Great Mosque. From this moment, the Aksumite Christian component and Mediterranean derivation starts to disappear, leaving the way for the prevailing production of decorations that have more affinity with the classical models found in Ctesiphon, the capital of the Sassanids in Mesopotamia.

The coeval eastern *riwāq*, built in a new location, is almost double the size of the original from the Umayyad-era Mosque. It is likely that the material rescued from the demolition of the previous *riwāq* was partly used for the reconstruction of the west *riwāq* and perhaps

8 See Section 4 - Chapter 2.

Figs 23 and 24. Above an example of decoration in the western sector; below an example of decoration present in the eastern sector.

Figs 25 and 26. Above an example of decoration in the western sector; below an example of the present decoration in the eastern sector.

Fig. 27. Detail of a coffer in the eastern sector with carved golden pinecones on the first frame.

also to replace part of the structure of other *riwāq*. It cannot be ruled out that the new east *riwāq*, with decorative motifs similar to those in the west *riwāq*, was built using brand new materials. This would not only explain the scarce similarities previously described but also the current differences in the condition of the wooden support of the two *riwāq*.

A second hypothesis sees a different sequence of the facts described above. Suggesting firstly the building of the east *riwāq* sourcing brand new material and secondly the reconstruction of the west utilising the recycled material available, emulating the structure, rather than the decor, of the new east sector.

A third hypothesis, which seems to better fit with the tradition, suggests that the works in the east *riwāq* were carried out by will of the Sulayhi Queen Arwā. An inscription on the north wall records in the year 513/1119 the works in the name of Sulayhi Queen Arwā[9] (see Chapter 2 and Chapter 5, "Inscriptions with mention of Queen Arwā"). There might have been a second phase, after the Yuʻfirid domain, in which the eastern sector was redecorated in its present configuration. However, this seems less convincing as an intervention of such proportions would be recorded with pride, as happened for the other sectors. It is possible, however, that the inscription refers to a general maintenance on the wall structures and openings instead.

Most of the historical references, as well as the evidence reported by archaeologists (see Chapter 2.5 and footnote 4), in fact suggest that it is unlikely that the Queen Arwā acted so considerably in favour of this mosque, in light also of the fact that during the last period of her life she abandoned Ṣanʻāʼ and moved to the new capital Dhū Jiblah, which then became the new centre of power.

The historical information collected until now and the results of the radiocarbon investigations reported in Table 2, helped to put together a few hypotheses, but failed to answer the main question to determine the actual chronology of the two sectors, perhaps because they were built within a short period of time, using different materials and possibly different craftsmen. Discrepancies can easily be found, as it was in the case of sample DSH6199 in Table 2, also in elements from the same coffer, as these are composed of elements recovered from a much older wood batch that had survived various constructive phases.

Conclusions

In conclusion, with the information collected from direct observations, chemical and radiocarbon analyses and the data provided by the archaeologists, we can hypothesise the following.

The original construction was erected by tradition in 627 AD, whose size (much smaller) and features had little in common with the current mosque.

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9 The Queen Arwā can be considered an Islamic revival of the mythical Sabaean Queen Bilqīs. Sayyidah Arwā bint Aḥmad is an important figure of popular tradition, still very much alive, which attributes the construction of various mosques and buildings for public use to Suleihid Queen.

SAMPLE CODE	LOCATION	CONVENTIONAL RADIOCARBON DATIND	CALIBRATE AGE INTERVALS	RELATIVE PROBABILITY	DATE
DSH5793	O3T58 bram (west)	1348±30	650-680 AD	100%	09/06/2014
DSH5604	O3T61bram (west)	1374±38	633-676 AD	100%	03/03/2014
DSH6197	O2C62f 1(west)	1121±26	875-990 AD	99.3%	27/10/2014
DSH6198	O2C62f 2(west)	1141±41	796-983 AD	92.6%	27/10/2014
DSH6199	O2C62f 3(west)	1733±32	239-389 AD	100.0%	27/10/2014
DSH6200	O2C62f 4(west)	1115±23	888-985 AD	100.0%	27/10/2014
LTL3234A	E3C47c(east)	1212±45	668-900 AD	92.6%	22/07/2008
LTL3664A	Eastern Quranic Inscription	1165±40	770-990 AD	95.4%	23/10/2008

Table 2. List of the results of the analyses carried out on the samples taken in the east and western *riwāq*.

The ceiling in the northern *riwāq* is the oldest; it dates back to the first Umayyad mosque of 705–715, and its wooden structure seems never to have undergone major changes, surviving almost unchanged up to the present day.

The decoration corresponding to this historical period is the one identified as the first decorative scheme. Probably not originally created for the mosque itself but made for the ceilings of one (or more than one) older building and for this reason characterized by pre-Islamic influence.

The western *riwāq* is coeval, but its ceiling will undergo a significant makeover in the 9th century, the results of which probably correspond to what we see today. Although there is not much evidence to confirm this, traces of a first decorative scheme found in various points of the ceilings suggest that originally the decorations in the first west sector and in the first east sector were very similar to those in the northern sector.

Almost simultaneously with the north and west *riwāq*, the south *riwāq* was built in the 8th century. Its ceiling, in terms of structure and decorative schemes, is similar to the northern sector and its two central aisles remain largely unchanged today.

Nevertheless, in the 12th century, the first external aisle was modified and raised during the reconstruction of the east *riwāq*, which was necessary after the earthquake in 1111. For the construction of this aisle, salvaged material from the rubble of other collapsed ceilings was used. Its appearance, which mainly consists of the first decorative scheme, except for minor interventions, survives today.

The repainting or second decorative scheme present in the north and the south *riwāq* is probably the result of several interventions, carried out in different historic periods. The most important maintenance works are the complete modernisation of the mosque in the Yuʿfirid period in the 9th century, and the works wanted by the emir al-Ḥusayn ibn Salamah carried out in 389-397 h. (999-1002).

Also, the works of expansion by the Yuʿfirid family in the 9th century, takes the mosque to its present size, with the structure and decorative scheme of the western sector as we see it today.

The timber used is probably sourced from the previous west *riwāq* and redecorated with new pictorial motifs.

The eastern sector also dates back to this period but built with completely new material as the remaining timber from the demolition was insufficient. Precisely because new material was available, a new decorative scheme was created. The current decoration, albeit inspired by the one in the western sector, is characterised by the presence of the numerous gilded carvings on the underside faces of the beams.

Fig. 28. Reconstruction of the decorative scheme present in the western sector (watercolor on paper, D. Ballarin, 2009).

Fig. 29. Reconstruction of the first decorative scheme present in the northern and southern sectors (watercolor on paper, D. Ballarin, 2009).

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Section 1 - Chapter 5

THE GREAT MOSQUE OF ṢAN‘Ā’: THE QUR’ANIC INSCRIPTIONS

GIOVANNI CANOVA*

1. Ṣan‘ā’: The Great Mosque

In 1971, heavy rains caused serious damage to parts of the Great Mosque (al-Jāmi‘ al-kabīr, also known as al-Masjid al-jāmi‘, the Congregational Mosque or Friday Mosque) of Ṣan‘ā’. In the years following this event, an extensive project of conservation and restoration was undertaken. Paolo Costa, Archaeological Advisor responsible for preparation of the Yemen National Museum (officially opened in 1971), participated in the meetings with the Yemeni authorities and published a report on the work comprising a historical-architectonic introduction, a list of archeological artifacts, a map of the building, and extensive photographic documentation. Some of the photographs illustrate the decorations on the wooden ceiling, the joining band with Qur’anic inscriptions, the discovery of fragments of ancient Qur’ans and their recovery.

> The Yemeni government, aware of the need of preserving the country’s historical heritage and in accordance with the Antiquity Law promulgated in June 1972, decided that any work of alteration to the mosque had to meet the approval of the General Organisation of Antiquities and Libraries. […] It was finally agreed that any work bound to alter the architectonic appearance of the building was unsuitable and the mosque had only to undergo measures of conservation, mainly for static nature, made necessary by the decay of some of the structures.[1]

Growing interest in Yemen, and in particular, its capital, inspired the “Nomad and City Exhibition”, held during the World of Islam Festival, London, in 1976. The volume that resulted from this initiative, *Ṣan‘ā’ An Arabian Islamic City*, edited by R.B. Serjeant and R. Lewcock,[2] represents the most authoritative and detailed study of the state capital. The chapter, “The Architectural History and Description of Ṣan‘ā’ Mosques: The Great Mosque”, published by the same authors with R. Rex Smith and P. Costa constitutes an example of a fruitful multidisciplinary collaboration of high scientific value.

A new exhibition was organized in Munich in 1988 at the Staatliches Museum für Völkerkunde: *Yemen 3000 Years of Art and Civilisation in Arabia Felix*, with a rich catalogue

* University of Naples “L’Orientale”.
1 Costa 1994: II, 1, note 1. Cf. Costa 1974: 487.
2 London 1983.

edited by Werner Daum, and with the participation of academic experts on various aspects of Yemeni history and civilisation.[3]

1.1 Historical epigraphic documents

In the volume *Ṣan'ā'* cited above, Serjeant and Rex Smith give extensive attention to the historical documentation, publishing the Arabic text and the translation of three inscriptions on marble: i) 13 lines in simple Kufic, dated 136/753-4: orders to the governor, 'Alī ibn al-Rabī', to repair the mosques of Ṣan'ā' (see below, § 4.2); ii) 7+2 lines, *naskhī*, dated 603/1206-7: repair of the eastern minaret at the expense of the Ayyubid governor Wurdashār; iii) 21 lines, rough *naskhī*: construction of the western minaret, the cemetery, and the well [of the Great Mosque]; iv-x) various identical inscriptions in simple Kufic, approximately 6 metres above the ground with the *basmalah* and a blessing, likely of the 2nd/8th century.[4]

At the time of the extensive restoration of the northern prayer-hall in 1974, fragments of the truss beams conserved in the Ṣan'ā' Museum were analysed in the laboratories of the British Museum including

> a section of the wooden frieze running continuously round the upper wall of the northern prayer-hall immediately below the beams, with a carved Kufic inscription. The radio-carbon dating is 1060 AD with a margin of ± 50 years… This strongly supports, among others, the tradition that Queen Arwā renovated the Jāmi' […].[5]

1.2 Qur'anic fragments

The library of the Great Mosque contains precious Qur'ans attributed to the first centuries of Islam (7th century and later). Paolo Costa recounts the accidental discovery of manuscript folios during restoration work in 1972-73:

> It was during these works that the present writer recovered a large cache of early Islamic manuscripts. The manuscripts, mostly simple sheets of early Qur'ans in poor condition, were found in July 1973 stuffed between the coffered ceiling and the slightly raised roof of the mosque western gallery. Cleaned from the debris with the help of Mr. Ahmed al-Sayaghi of the National Museum, the manuscripts were handed over to the Chairman of the General Organization for Antiquities and Public Libraries [Qadi Ismā'īl al-Akwa'] with a written report and a recommendation for their urgent conservation.[6]

Later on, Ursula Dreibholz managed to install an on-site laboratory for restoration and

3 Innsbruck, Frankfurt/Main 1988. Among the most interesting essays, see Rex Smith, "The Political History of the Islamic Yemen"; Lewcock, "The Medieval Architecture of Yemen"; Finster, "The Architecture of the Rasulids". Plates 2-10: Qur'anic fragments in Ḥijāzī (*mā'il*) and Kufic script.

4 Lewcock *et al.* 1983: 347-349. Also see Finster 1978; Finster, Schmidt 1979.

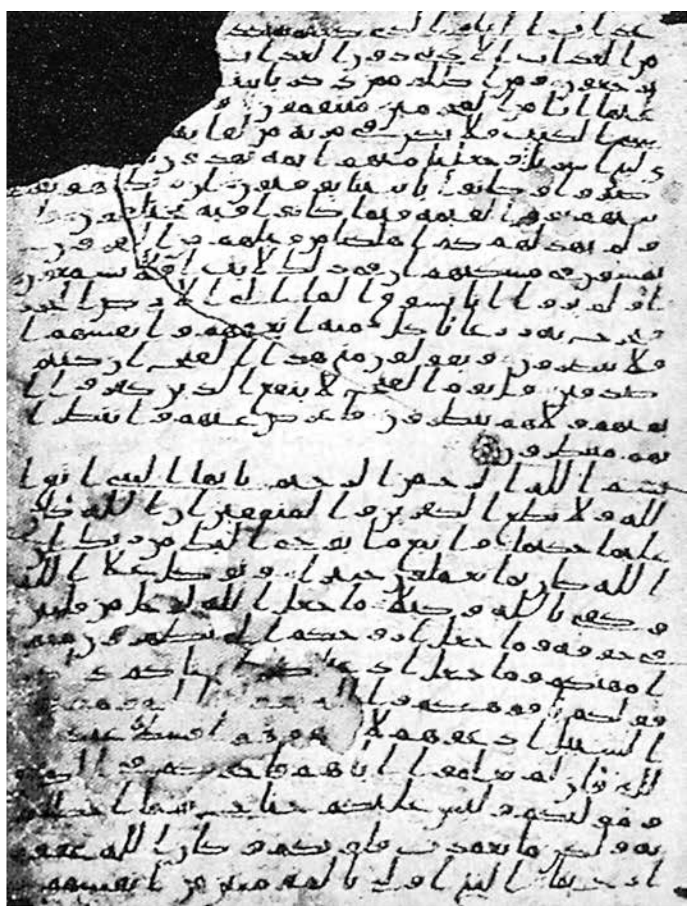
5 Lewcock *et al.* 1983: 350. See below § 2.

6 Costa 1992: 38. Robert Serjeant stressed the importance of this material in a conference at Cambridge under the auspices of UNESCO, material "which represent the most valuable and complete treasure of original material for the history of the Qur'an script and Arabic calligraphy from the earliest up to the modern times" (Serjeant 1980: 208 "Recommendations").

train a number of Yemenis in restoration techniques. Numerous parchment codices and some ancient bindings have been recovered (Dreibholz 1985; 2000).[7] The codices are preserved at the Dār al-Makhṭūṭāt and al-Maktabah al-Sharqiyyah.

In October 2007, manuscripts DaM 01-25-1, 01-29.1 and 01-27.1 have been photographed in the premises of Dār al-Makhṭūṭāt under the supervision of Alba Fedeli, within the Project "De l'Antiquité tardive à l'Islam" in agreement with the Ferni Noja Noseda Foundation. The palimpsest has been photographed applying ultraviolet light (Noja 2003; Fedeli 2008, and forthcoming).

Several researchers are studying this palimpsest. The *scriptio superior* contains the final part of *sūrah* 32, al-Sajdah (*Prostration*) and the beginning of *sūrah* 33, al-Aḥzāb (*The Confederates*).[8]



7 According to Gerd-R. Puin, "After restoration the text of the pages was determined according to the number of the now recognized Qur'anic numbering. Within four years of work of the German Restoration Project close to 8,000 sheets of parchment were restored – about one quarter of those found in the Great Mosque during the restoration campaign of 1971/72" (Puin 1985: 10).

8 See Hilali 2016 with large bibliography. DaM 01-27.1 is here reproduced after Blair 2006: Fig. 4.7, and Daum (ed.) 1988: 186, Pl. 1.

A new large group of documents was discovered in a niche in the western minaret in 2007 by the Istituto Veneto per i Beni Culturali. A larger and well-preserved group of manuscripts was found in January 2013, in an area very near the 1973 discovery. All new materials have been deposited at the House of Manuscripts (Dār al-Makhṭūṭāt) annexed to the Great Mosque and are awaiting classification and study.

2. Historical profile of the Great Mosque

The main sources on Yemeni history are the great *History of the City of Ṣan'ā'* by al-Rāzī (d. 460/1068), and the works by al-'Umārah (d. 569/1173-1174), al-Janadī (d. 732/1324), al-Khazrajī (d. 812/1410), and Ibn al-Dayba' (d. 944/1537).[9] The mosque of Ṣan'ā' was founded by a Companion of the Prophet, Farwah ibn Musayk, although there is not unanimous agreement on this attribution.[10] The governor of Ṣan'ā', Ayyūb ibn Yaḥyā al-Thaqafī, received instructions to enlarge the mosque from the Umayyad Caliph al-Walīd I (r. 705-715), who had already promoted construction of the mosques of Damascus and Medina. The governor extended the north side – the side facing Mecca – with a new *miḥrāb* and a minaret with decorations and inscriptions.[11]

The first governor of Ṣan'ā' in the Abbasid era, 'Umar ibn al-'Abd Majīd, installed doors in the Great Mosque.[12] The door on the right of the *miḥrāb*, where the *imām* enters, is covered by a metal plate with Himyarite inscriptions, probably derived from the nearby palace of al-Ghumdān. Inscriptions on some tombstones in the courtyard document the restoration of the mosques of Ṣan'ā' by the governor 'Alī ibn al-Rabī' in 136/753-754.

Muḥammad ibn Yu'fir ibn 'Abd al-Raḥīm al-Ḥiwālī[13] was governor of Yemen beginning in 257/870. Al-Janadī reported a disastrous flood that, in the month of Dhū al-Ḥijjah in the year 262/876, destroyed many homes in Ṣan'ā' and seriously damaged the Great Mosque.[14] Making the pilgrimage to Mecca, Muḥammad ibn Yu'fir left the regency to his son, Ibrāhīm, who remained effective governor even after his father's return.[15] The inscriptions recall the reconstruction work of the Great Mosque by Ibrāhīm, giving two dates: 265/878-879 and 270/883-884. Most likely, these are the start and completion dates of the work. In this period, the truss was replaced by teak beams.[16]

9 Al-Rāzī, *Tārīkh*; al-'Umārah, *Tārīkh al-Yaman*; al-Janadī, *al-Sulūk*; al-Khazrajī, *al-'Asjad al-masbūk*; Ibn al-Dayba', *Qurrat al-'uyūn*.

10 Al-Rāzī, *Tārīkh*: 259; al-'Arshānī, *al-Ikhtiṣāṣ*: 530.

11 Al-Rāzī, *Tārīkh*: 135. Cf. al-Ḥajarī, *Masājid Ṣan'ā'*: 28

12 Al-Rāzī, *Tārīkh*: 137; al-Janadī, *al-Sulūk*: 181.

13 On Āl Yu'fir al-Ḥiwāliyyīn, see al-Hamdānī, *Ṣifah*: 211; *al-Iklīl*: Part 8, 151. The editor, Muḥammd al-Akwa', draws attention to the correct vocalization of the name, Yu'fir, according to al-Hamdānī.

14 Al-Janadī, *al-Sulūk*: 200; al-Khazrajī, *al-'Asjad al-masbūk*: 33; Ibn al-Dayba', *Qurrat al-'uyūn*: 120. Cf. al-Ḥajarī, *Masājid Ṣan'ā'*: 29; al-Muṭā' 1986: 71-72.

15 Bikhazi 1970: 37. Also see Appendix.

16 Al-'Arshānī, *al-Ikhtiṣāṣ*: 547.

Al-Hamdānī (d. 334/945) writes that

> Ṣan'ā' continued to grow under Islam until a few years after 290 H [903] when it was destroyed. Soon, however, it regained its prosperity and is now almost as it was during its heyday. The learned men of Ṣan'ā' vision the day when it will again flourish, its buildings crowding the basin between its two mountains [Nuqum and 'Abyān], while its market place will occupy the centre of the valley.[17]

According to al-Janadī, 'Alī ibn al-Faḍl al-Qarmaṭī intentionally diverted water to the courtyard of the mosque during a flood by closing the drainage canals, with the purpose of damaging the building, its inscriptions, and decorations. He did this after his conquest of Ṣan'ā' in 299/911-912.[18] Nonetheless, the inscription with the date of reconstruction and the mention of the al-Ḥiwālī family remained visible, "so that his name would be remembered by the envious".[19] These inscriptions are still visible, although the name Ibrāhīm has been partially erased (see below § 4.2).[20]

Yemen experienced political upheavals in the centuries that followed, due to the birth and expansion of Zaydism, the advent of the Sulayhid dynasty (439-532/1047-1138), and its close relations with the Fatimids of Cairo.

The Isma'ili sources extol the work of the Sulayhid queen, al-Sayyidah al-Ḥurrah bint Aḥmad "Arwā" (440?-532/1045?-1138). The Isma'ili historian, Idrīs 'Imād al-Dīn al-Qurashī (d. 872/1468), reports extensive excerpts from the life of Queen Arwā in the *'Uyūn al-akhbār*, including her testament, containing a list of jewels left to the community.[21] Among the works commissioned by the queen are palaces, religious schools, and mosques in the city of Dhū Jiblah, that became her capital (c. 480/1087). Queen Arwā promoted works and decorations in the prayer-hall of the Great Mosque of Ṣan'ā', and gave order to add Qur'anic inscriptions, religious expressions, and the names of the *imāms* according to the Isma'ili tradition, from 'Alī ibn Abī Ṭālib on.[22] A white, marble plaque placed on the *qiblah* wall over the main door displays her name and the date 513 h./1119. (See § 5.2).

Al-Ḥajarī mentions two inscriptions carved in the chalk above the *miḥrāb* with the names of *qāḍī* 'Umar ibn Sa'īd al-Rubay'ī and of the artisans who undertook the work: 'Abd al-Ṣamad ibn Aḥmad, helped by his son, Aḥmad (665/1266-1267).[23]

According to the numismatic sources, we have only one extant coin from the Ṣulayḥid capital, Dhū Jiblah, dated 530 h./1135 (Bikhazi 1970:7, 99-101).

17 *Al-Iklīl*: vol. 8, 36-37. Trans. by Faris 1938: 9, note 9: "Al Hamdānī probably has in mind the turbulent times after the Ya'furids became masters of Ṣan'ā'". Cf. al-Ṭabarī, *Tārīkh*: vol. 10, 84 (year 288 h.), 122 and 128 (year 293 h.).

18 Al-Janadī, *al-Sulūk*, cited in Kay 1892: Ar. text 144-145, trans. 199-200. Cf. al-'Arshānī, *al-Ikhtiṣāṣ*, 547; al-Rāzī, *Tārīkh*, 136, note* (addenda by the copyist).

19 al-'Arshānī, *al-Ikhtiṣāṣ*: 547-548.

20 Al-Ḥajarī, notes that "the ceiling, in its present state, has retained all of its beauty, conserving many Qur'anic inscriptions in ancient Kufic script that are clearly visible and legible, carved into the wooden boards". *Masājid Ṣan'ā'*: 30.

21 Idrīs 2019: 279-290. Cited by al-Hamdānī 1955, Appendix 9, 323-329. This extraordinary bequest was studied in detail by Eva Chavez Hernández 2002-2008. See also Cortese, Calderini 2006: 127 ff.

22 Idrīs 2019: 304. Cf. Al-Hamdānī 1955: 323-324. See below § 4.2.

23 Al-Ḥajarī, *Masājid Ṣan'ā'*: 28. Cf. Ghaylān 2004.

THE KUFIC SCRIPT OF THE INSCRIPTIONS

3. The Kufic script

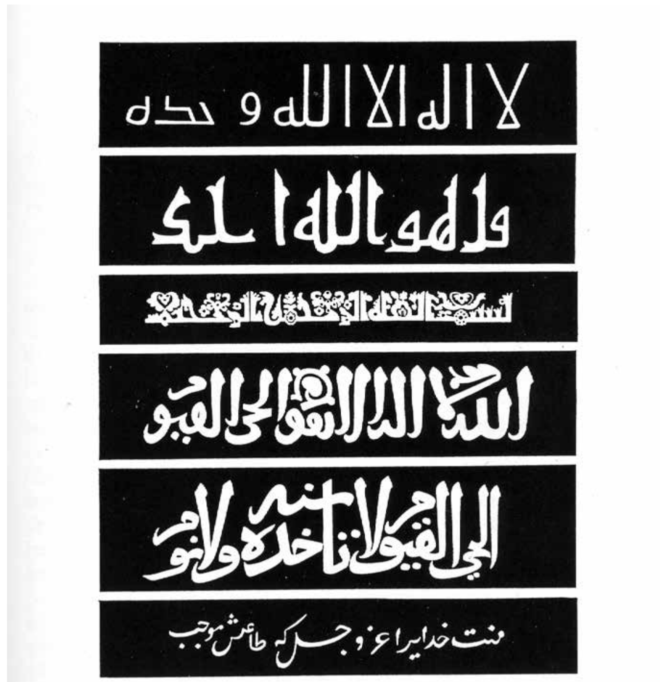
The main field of academic research in Yemen has been archaeology and Epigraphic South Arabian (*ESA*), aiming at discovering the vestiges of ancient Arabia Felix. The situation for Islamic monuments and their inscriptions is quite different. The *Répertoire Chronologique d'Épigraphie Arabe* (*RCEA*) and general studies in Arabic paleography and epigraphy reveal few Yemeni testimonies due to limited documentation and difficulty in carrying out research.

Anne Regourd undertook the study and cataloguing of Yemeni Arabic Manuscripts. Sabine Schmidtke and Jan Thiele promoted the "Manuscript Digitalization Project" with the aim of preserving the Yemen's cultural heritage. Barbara Finster studied the typology of Yemeni religious architecture, drawing distinctions among cubical mosques, hypostyle mosques, and domed mosques as places of worship. Several reports are dedicated to the Great Mosque of Ṣan'ā'. Madeleine Schneider published the text of some funerary stelae, and in particular, the inscriptions in the monumental complex of Ẓafār Dhī Bīn (first half of the 7th/12th century). The plasterers and the inscribers of the writings carved in wood that worked in the mausoleum of Dāwūd in the restorations of the 9th/16th century left their names: Abū al-Su'ūd and 'Abd Allāh ibn 'Awas. Giovanna Ventrone Vassallo revealed and commented on 18 inscriptions of the Ashrafiyyah of Ta'izz that cast light on the patronage of the Sultan al-Ashraf Ismā'īl, seventh Rasulid ruler. The restoration of the 16th century al-Madrasah al-'Āmiriyyah of Radā' has been carried out by Selma al-Radi; Yahya al-Nasiri and Venetia Porter analysed the foundation inscriptions. Noha Sadek studied the architectural heritage of Yemen, with a focus on the "Colors of Power and Piety in Rasulid Yemen". The artistic features and the epigraphic texts in *thuluth* script of the *miḥrāb*s have been studied by Ghaylān Ḥamūd Ghaylān (2004).

Different styles of Kufic script have been identified on monuments: 1) Primitive or simple Kufic; 2) Kufic with elaborate apices; 3) foliated Kufic; 4) floriated Kufic; 5) plaited or interlaced Kufic; 6) bordered Kufic; 7) architectural Kufic; 8) Kufic rectangles. The name of this style refers to the Iraqi city, Kufa, where it appears to have originated (Grohmann 1957: 183-184). The floriated Kufic is also known as Qarmatian, which points to the Fatimids.

Sheila Blair notes that "It should be taken, however, not as a name of a specific script used at a particular time or place, but as a generic rubric for the angular style used in early Islamic times to transcribe the Qur'an and inscribe monuments" (Blair 2007: 598a). This is a style based on geometrical constructed letterforms with a strong, flat, horizontal ligature between letters that sit on the baseline.

Kufic script, among the main styles of Arabic writing, evolved over time (Hillenbrand 1999: 37).



22 Types of Islamic writing (*top to bottom*): simple Kufic; foliated Kufic; floriated Kufic; *naskhi*; *thulth*; and *nasta'liq*.

The Iraqi calligrapher, Ghani Alani, compares the Kufic script of the ancient Qu'rans, written using ink and reed pen (calamus, *qalam*) on parchment (*kūfī al-maṣāḥif*) (Fig. 1), with that of epigraphic Kufic script, which is to be sculpted or carved (*al-kūfī al-handasī*) (Fig. 2). In both cases the text is the *basmalah*, the expression, "In the Name of God, the Merciful, the Compassionate."

1

2

Ghani Alani also provides a reconstruction of the alphabet in Kufic characters in the sequence, *'abjad*, with letters in isolated form:

This sequence is to be read, respectively, *’alif*, *b* (*t/th/n/y*), *j* (*ḥ/kh*), *d* (*dh*), *r* (*z*), *s* (*sh*), *ṣ* (*ḍ*), *ṭ* (*ẓ*), *‘ayn* (*ġ*), *f*, *q*, *k*, *l*, *m*, *n*, *w*, *h*, *lām-alif*, *y*. Without diacritics, the letters in parentheses are possible alternative readings (Alani 2001: 32 and 39). They could only be understood in context.

The following table, conceived by Lisa Volov, presents the basic geometric features in the structure of the letters in Kufic script, against a horizontal baseline.[24] This reconstruction is also partially applicable to the inscriptions in the Great Mosque of Ṣan‘ā’.

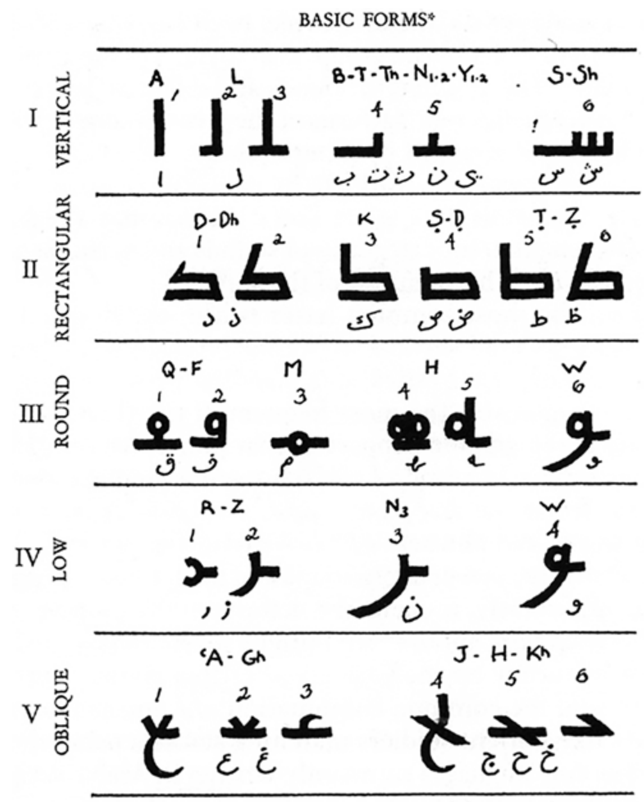


Table: Five-Form Kufic Chart.. Basic Forms and Decorative Transformation.

3.1 Foliated Kufic and Floriated Kufic

Kufic script has a rigid, geometric structure. Examples of Foliated Kufic can be found on many Egyptian funerary steles from the 8th–10th centuries, beginning with those of the Nilometer of Cairo.

The script on architectonic monuments reached its height of development in the Fatimid era (11th/12th century), most notably in Cairo, where highly skilled architects and artisans gathered. The mosques, al-Azhar, al-Anwar of the Caliph al-Ḥākim, and al-Aqmar, are held to be models in terms of the harmony of their construction, with their decorations and inscriptions. They exercise wide influence in the Islamic world, as

24 After Blair 2006a: Fig. 1.4.

emphasized by S. Flury (1912: 4). Historians of Islamic art have highlighted the close relationship between architecture and calligraphy in Fatimid monuments, as well as a possible political motivation in the choice of verses and in the symbolism of the decorative motifs.

The Foliated Kufic (*al-khaṭṭ al-kūfī al-muwarraq*) is characterised by the decoration of the apices of the letters, consisting of half palmettes and 2- or 3-lobed leaves. The Floriated Kufic (*al-khaṭṭ al-kūfī al-muzahhar*) shows the same decoration with the addition of floral motifs, tendrils, and scrolls. The inscribed bands assume highly elaborate forms (to the detriment of ease of reading) due to the filling of all spaces around the letters with decorative motifs.

In monumental Kufic, the letters are without diacritics that distinguish letters with the same *ductus* but with different values. Vowel signs are also missing. So a sequence of three letters presents many different possible readings, as already noted by the bewildered epigraphist of the Napoleonic expedition to Egypt, J.J. Marcel (1809: 533-535). Moreover, the letters may have different forms depending on whether they are initial, median, final, or isolated ones.

The identification of a Qur'anic passage is made possible by i) identifying a string of two or more words, ii) then checking the fragment of the verse in the *Concordances* of the Qur'ān.

3.2 Executive Techniques

Monumental Kufic, in the most highly perfected examples, is drawn, enlarged in size, with the aid of gridlines, and is subsequently transferred using carving or sculpting techniques, onto its final medium of stone, plaster, or wood. The creation of a new inscription involves a choice of texts and an evaluation of how to distribute them over the available space while respecting criteria of balance and proportionality. It may be presumed that there is a collaboration between the calligrapher and the artisan charged with sculpting or carving the inscription into stone or wood. An examination of the celebrated mosaic inscription in Kufic script in the Dome of the Rock (Jerusalem, 72/692), "shows many characteristics, of a calligraphic style and proves that the inscription was designed by a master calligrapher for execution by a professional mosaicist".[25] Similar stylistic elements present in inscriptions in various parts of the Islamic empire suggest the mobility of artisans from city to city and from country to country, coveted by lords and rulers.

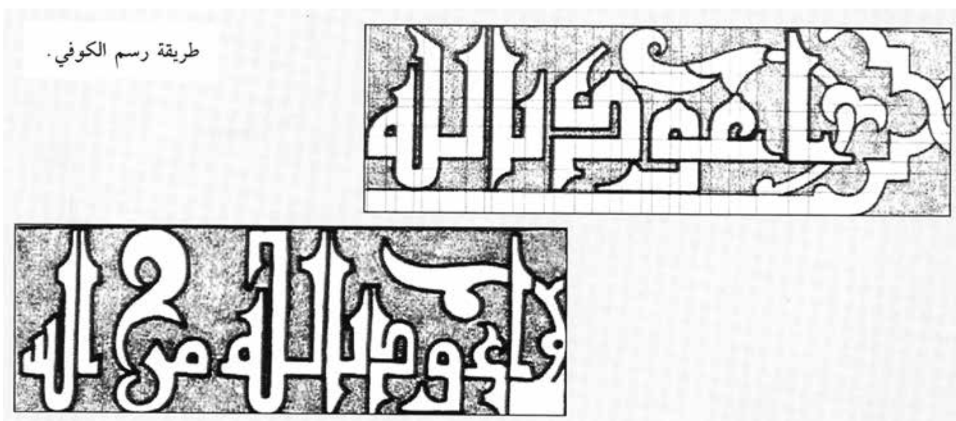
The complexity of the written text raises a problem of readability, considering that often the inscriptions – as in the Great Mosque of Ṣan'ā' – are positioned high above the floor in poorly lighted locations. As Robert Hillebrand observes, however, "It would be enough that the worshipper understood the inscription to be Qur'anic. [...] Such [Kufic]

25 Blair 1988: Fig. 7.30; Blair 2006a: 21-24. Also see Grabar 1959: 52-54; Nuseibah, Grabar 1996.

inscriptions have to be decoded rather than read, but anyone sufficiently familiar with the Qur'an could break the code if he could decipher a few words".[26]

I include an example of foliated Kufic from a manual of calligraphy, drawn over a square grid, with a precise horizontal baseline, extension of ascenders and descenders, and delimitation of the decorative space. This is the beginning of the apotropaic expression, *a'ūdhu bi-l-Lāhi* (*min al-shayṭān al-rajīm*) "I ask for protection from God (from Satan the lapidated)":

أعوذ بالله (من الشيطان الرجيم)



Many inscriptions are carried out in a less rigid manner, so much that sometimes the words are interrupted and are completed on the next line, or the ligatures connecting the letters are shortened or lengthened to occupy the available space.

3.3 Niehbur's epigraphic records

The first epigraphic evidence from Yemen to reach Europe dates from the 18th century. The traveler, Carsten Niebuhr, visited Yemen in 1762-63 at the head of an ill-fated Danish scientific mission. Niebuhr left a detailed report of the journey in *Travels in Arabia* and in the famous *Description of Arabia*, which is still today a precious document on Arabia and its people. Niebuhr copied, to the best of his abilities, the writing on three tombstones in Kufic script and an inscription in a mosque near Ta'izz.

26 Hillebrand 1986: 178, quoting R. Ettinghausen. "The main purpose of these [lengthy Qur'anic] inscriptions was to emphasise one role of the building as a repository of scripture: a Sacred Book in brick or stone" (Hillebrand 2012: 20). Hoyland remarks that "A fair proportion of people knew the Qur'ān by heart, and its memorization was often the principal mode of primary education. They thus needed only to decipher a word or two in order to identify the verse being quoted, especially as the repertoire of verses used was very limited" (Hoyland 2002: 27b).

بسم | الله الرحمن الرحيم | ﴿ (ا) دْخُلُوا الْجَنَّةَ لاَ خَوْاف عَلَيْكُم وَلاَ أَنْتُمْ | تَحْزُنُونَ ﴾ قبر
يعقواب بن أحمد بن (؟) | محمد (؟) العمر(ي) | تؤفي في ذي القعد(ة) | سنة خمس
وأربعين (أ)رابع مئة سنة

"In the Name of God, the Merciful, the Compassionate. 'Enter Paradise. No fear upon you, nor shall you sorrow' (Q 7:49). [This is the] tomb of Ya'qūb ibn Aḥmad ibn (?) Muḥammad al-'Amr(ī). He died in the month of Dhū al-Qa'dah in the year 445 (= 1054)".

Niebuhr includes a facsimile of this sepulchral inscription found in Bayt al-Faqīh in the *Description of Arabia*, together with two other tombstones. He was not able to decipher it but is consoled by the fact that it eluded even knowledgeable Yemenis (Niebuhr 1774: Tabs. VI, VII and VIII, 85). The shapes of the letters effectively make their reading problematic. The text of two of these tombstones has been published in the *Répertoire*,[27] Madeleine Schneider has translated the third (Schneider 1979a: 72-73, Pl. 1). Significantly, Adolf Grohmann, in his seminal study on Kufic script refers to some letters drawn by Niebuhr in the 18th century, in the absence of more recent Yemeni epigraphic documentation (Grohmann 1957: 83-85, Diagram A).

In the past, the identification of texts on tombstones or monuments was not an easy

27 *RCEA*, vol. 6, 1935, no. 2568; vol. 7, 1936, no. 2568.

task, with consequent errors or graphic approximations. J.J. Marcel, member of the Napoleonic expedition to Egypt, describes the technique he employed. Having cleaned the inscription, it was rubbed with a pad soaked in typographic ink. A moistened sheet of paper was then applied by pressing it to the inscription with the palm of the hand. Thus, the letters appear black against a white background when they are in relief.[28] In the tables of the mosque of Ibn Ṭūlūn, founded in 879, the wooden bands in Kufic script that unfold for hundreds of meters are revealed in great detail.[29] The characters appear very similar to those carved into the sleepers of the Great Mosque of Ṣan‘ā’.

THE INSCRIPTIONS OF THE GREAT MOSQUE
(Plates 1-9 / 10-14)

4. The inscriptions

At the basis of this study is the photographic documentation gathered between 2007 and 2015 by the Istituto Veneto per i Beni Culturali (IVBC), kindly put at my disposal for this contribution. In 1994 I paid a visit to the library of the Great Mosque, where I was shown with pride the great Qur’an that local tradition attributes to the Caliph ‘Alī. Unfortunately I did not have the opportunity to view the inscriptions inside the mosque.

In the frame band that runs along the perimeter walls, the inscriptions are found at an average height of approximately 5 meters. They are carved in relief in a circa 30 cm tall band of *ṯunub* wood (*Cordia abyssinica*), a wood that is reddish in colour and not very hard. Based on what we know of Yemeni tradition, the artisan would have traced the outline of the letters with a reed pen (*qaṣab halal*) and ink (*midād*). He then proceeded to work with a scalpel (*minqār*) or gouge (*maqaddah malwiyyah*). In “Arabic carving” (*naqsh ‘arabī*) the letters or decorative motifs reveal themselves in relief, following the removal of material in the surrounding space, called *bayt* (house). The traditional Yemeni techniques were reported in a study by Guillemette and Paul Bonnenfant (1987: 10-15).

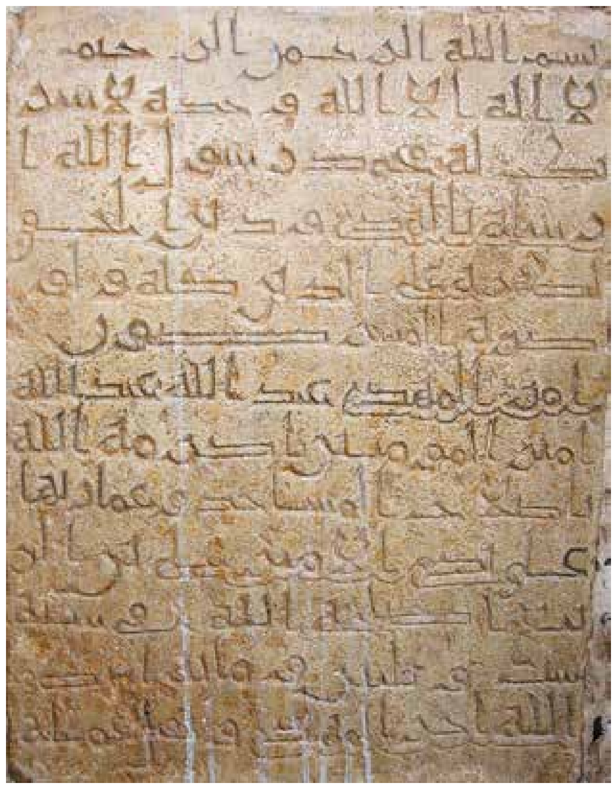
With respect to the inscriptions of the Great Mosque, the letters and decorative motifs were found covered by layers of plaster or blackened due to lengthy exposure and lamp smoke. They required a delicate process of cleaning and restoration, and when necessary, integration. The photographic documentation of the IVBC show their appearance both before and after restoration, along with numbering of individual words. The restoration project in the western hall dealt with only some of the inscriptions due to the forced interruption of this work.

28 Marcel 1809: “Mémoire sur les inscriptions koufiques”, 542.

29 Cf. Marcel 1809: *Description de l’Égypte*, État moderne, vol. 2, Pl. a-f.

4.1 Historical evidence

In the courtyard next to the east minaret there was an inscription, dated 136/754, with an order made by the caliph, al-Mahdī, to the governor of Ṣan'ā', 'Alī ibn al-Rabī', to repair the mosques of the city. The inscription is today placed in the stonework of the staircase to the eastern library, at its entrance.



بسم الله الرحمن الرحيم | لا اله إلا الله وحده لا شرايك له محمد رسول الله | ارسله ﴿ بالهدا ودين الحق | ليظهره على الدين كله ولو | كره المشركون ﴾| أمر المهدي عبد الله عبد الله | أمير المؤمنين أكرمه الله | باصلاح المساجد وعمارتها | على يدي الأمير علي بن الرابيع أصلحه الله في سنة | ست وثلثين ومائة اعد | الله أجر المهدي وقبل عمله .

"In the name of God, the Compassionate, the Merciful. | There is no god but God alone; no part|ner does He have. Muḥammad is the Apostle of God. | He sent him 'with the Guidance and the Faith of Truth and | to make it triumph over every (other) religion, even though | the polytheists are averse' (Q 9:33). | Al-Mahdī, the servant of God, ordered | – Commander of the faithful, may God make him noble – | the mosques and their constructions to be repaired | at the hands of Amīr 'Alī ibn al-Ra|bī', may God make him righteous, the year | one hundred and thirty-six. May God make ready | the reward of al-Mahdī and accept his deeds."[30]

A memorial constitutive text[31] is found in the western wing and at the beginning of the southern wall, with the name of the commissioner of the works and the date. From the photographic documentation of the IVBC it is possible to reconstruct the inscription that is found on the sleeper at the head of Corridor 1 (western side). The name, *amīr* Ibrāhīm ibn Muḥammad ibn Yu'fir, is clearly legible, even if it has been partially erased. The shadow visible in the photographs (taken from below) shows the relief of the letters is missing only on his name, revealing a badly executed attempt to erase it. Of note is the date, 265/878-879, present also in an inscription in the sleeper at the head of Corridor 2 (eastern side), since the date 270 h. figures in other memorial constitutive texts.

أمر بعمله الأمير ابرهيم بن محمد بن يعفر سنة خمس وستين ومئتين

"Work commissioned by the *amīr* Ibrāhīm ibn Muḥammad ibn Yu'fir in the year 265 h. (878-879)."

The architect, Abdulhakim Al-Sayaghi, kindly provided me with supplementary photographs that document the work performed by Yemeni restorers in two other memorial constitutive texts. Also in this case, the name Ibrāhīm ibn Muḥammad ibn Yu'fir has been erased. The restoration workers traced its outlines on gloss (Map n. A/01): this is a hypothetical reconstruction judged "certain" for Sector 1, while a similar inscription in Sector 2 remains "probable". Below, I include the first of the two inscriptions, followed by details of the inscriptions of the name and date.

30 This reproduced the reading and the translation published in Lewcock *et al.* 1983: 348 and Fig. 18-57. Cf. Finster 1978: 123-124, Tafel 32.

31 The structure of the typical memorial constitutive texts in historical inscriptions is analyzed by Blair 2007: 43b.

مما أمر بعمله | الأمير ابرهيم بن محمد بن يعفر سنة سبعين ومئتين

"Among the works commissioned by the *amīr* Ibrāhīm ibn Muḥammad ibn Yu'fir in the year 270 h. (883-884)."

4.2 The Qur'anic inscriptions

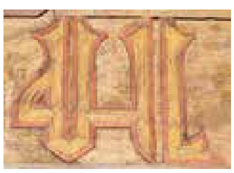
Regarding the inscriptions inside the Great Mosque, architect Al-Sayaghi compiled a list of chapters of the Qur'an, indicating the choice of inscribed *sūrah*s and verses. They include the *sūrah* 1, al-Fātiḥah (*The Opening*); 2, al-Baqarah (*The Cow*); 3, Āl 'Imrān (*The House of Imran*); 8, al-Anfāl (*The Spoils*); 9, al-Tawbah (*Repertance*); 15, al-Ḥijr; 16, al-Naḥl (*The Bee*); 17, al-Isrā' (*The Night Journey*); 21, al-Anbiyā' (*The Prophets*); 22, al-Ḥajj (*The Pilgrimage*); 23, al-Mu'minūn (*The Believers*); 24, al-Nūr (*Light*); 39, al-Zumar (*The Companies*); 48, al-Fatḥ (*Victory*); 59, al-Ḥashr (*The Mustering*); and 112, al-Ikhlāṣ (*Sincere Religion*).

These *sūrah*s and verses are commonly found in the inscriptions in mosques. For instance, Qur'an 9 refers to God's mosques; Qur'an 2 contains the Throne verse extolling God's majesty; Qur'an 48 is about God's granting the Victory; Qur'an 17 is about prayer and vigil, often found on *miḥrāb*s. With high frequency, only parts of the *sūrah* are present, at times introduced by the *basmalah.*

> Throughout the eastern and northern halls, and in areas of the western and southern halls, long Kūfic inscriptions run along the walls immediately below the ceiling beams. These are of two types (…). Those of the eastern, western and southern hall are in a rounded Kūfic; those in the northern hall are in a form of Kūfic which has borders and a hollowed-out central space to each letter. (Lewcock *et al.* 1983: 337)

In various sectors of the sleeper, as with the beams of the northern hall, the name Allāh is written in different styles, ranging from a basic Kufic to elaborate forms in Foliated or Floriated Kufic, or in cursive. In the examples given, whether carved or painted, one can notice the absence or presence of a ligature connecting the letters, the different descenders and ascenders, the addition of a decorative element at the end of the letters. The letters may present traces of gold-like leafing or a red line that highlights their borders.



In the corridor of the western wing there is the profession of faith, the *shahādah*:

لا اله إلا الله محمد رسول الله

"There is no god except Allāh, Muḥammad is His Prophet."

The first part of the *shahādah* can be also found on a beam in the northern hall. This inscription includes the first part on the unity of God, painted in Floriated Kufic.

Also in the northern hall one finds the eulogy to the Prophet in different style of Kufic. The text reads, *Ṣalawāt Allāh ʻalā Muḥammad* ("Blessings of God on Muḥammad"), an eulogy often recited by the faithful.

صلوات الله على محمد

Based on a stylistic evaluation, the strips of carved Qur'anic inscriptions in the sleepers of the western and eastern sectors of the Great Mosque of Ṣan'ā' should date to the 3rd/9th century, in the Yu'firid era. This is confirmed by the inscription shown above dated 270 h. (883-884).

In the northern sector the inscriptions and decorations are more recent, and can be ascribed stylistically to the Sulayḥids, possibly to the reign of Queen Arwā (al-Sayyidah al-Ḥurrah bint Aḥmad, d. 532/1138). Phrases like *tafarraq a'dā' Allāh* or *takhawwaf a'dā' Allāh al-ẓālimīn* 'may God's enemies be scattered' or 'be intimidated, the wrong-doers' seem to evoke an Isma'ili/Fatimi slogan (Cf. Lewcock *et al.* 1983: 348).

In the decorative band of the west and east sectors are local models of simple Kufic. Their reading is made more difficult by the foliated and floriated Kufic styles of the inscriptions in the boards of the northern prayer hall. The spaces left empty by the letters, which are already highly elaborate, are filled with decorative arabesques based on the idea of *horror vacui* that characterizes Islamic art. As Ronald Lewcock has observed, "Almost all types of Islamic calligraphy known in the Middle East are represented in the Great Mosque".

In the following pages, examples of various script styles are given from the northern, western, and eastern halls. After an initial selection and identification, we proceeded to a reconstruction in sequence, beginning with individual photographic frames. Each of these comprised multiple words, with overlaps at the edges of the frames. This reconstruction was accompanied by a graphic rendering of the outline of the letters, with a text in front transcribed in cursive letters (*naskhī*) and fully vocalized. The size of the page made it necessary to fragment the verses into groups of words.

The presence of discrepancies in the forms of the letters suggests the work of various craftsmen, probably working in different periods for restorations or additions to existing inscriptions. It is possible that there was only a general design scheme that was adapted over the course of the work. The forms of single letters often change or present minor variations even within the same Qur'anic verse.

4.3 Northern hall: Inscriptions on the sleepers

The Qur'anic bands in the northern wall, where the *miḥrāb* is located, are particularly important because they contain significant Qur'anic writings in simple Kufic. After the cleaning and restoration of the boards, with the removal of the layer of plaster, several findings were brought to light: the first *sūrah* of the Qur'an, al-Fātiḥah (*The Opening*) (Tables 2 and 3); Qur'an 2, al-Baqarah (*The Cow*), verse 158 that mentions the pilgrimage to Mecca; Qur'an 9 al-Thawbah (*Repentance*), verse 18,[32] with reference to places of

32 As Hillebrand observes, this is the most commonly found Qur'anic verse in the mosques (Hillebrand 1986: 175). "This verse was particularly popular in Fatimid times, probably because it includes the word *al-muhtadīn* 'the guided ones', and was therefore doubly suitable for the Fatimids, descendants of the *mahdī* 'the right guide' " (Blair 2007: 45b).

worship (*masājid*), to prayer, and legal almsgiving. At the end of the verse is the eulogy for the Prophet Muhammad (1), followed by mention of ʿAlī ibn Abī Ṭālib (2), Fāṭimah al-Zahrā' (3), al-Ḥasan and al-Ḥusayn (4), Zayn al-ʿĀbidīn (5) and the Imams (6) (their names are missing). This is evidently an inscription that reflects the Isma'ili Shi'ite doctrine. (Full Arabic text below)

1

2

3

4

5

6

والحمد لله رب العالمين وصلى الله على رسوله محمد خاتم النبيين وسيد المرسلين
وعلى وصيه علي ابن أبي طالب أمير المؤمنين وعلى فاطمة الزهراء سيدة نساء العالمين
وعلى ولدَيْها الفاضلَيْن الحسن والحسين وعلى زين العابدين (...) والأمير وعلى الأئمة
الطاهر(ين...)

> "Praise God, the Lord of all being. God's prayer for His messenger, Muhammad, the seal of the prophets and the lord of messengers. And for his spiritual legatee (*waṣī*) 'Alī ibn Abī Ṭālib, prince of the believers, and Fāṭimah al-Zahrā' (the Radiant), lady of all women, and her two virtuous sons, al-Ḥasan and al-Ḥusayn and Zayn al-'Ābidīn (Ḥusayn's son) and all the pure *imāms* [lacuna]."

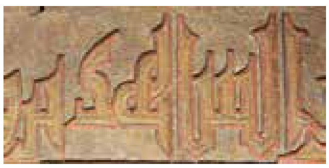
The wooden beams of the northern hall are quite diverse, with a prevalence of inscriptions in the foliated Kufic style, or in some cases, floriated style, but there are also cursive scripts. The inscriptions are difficult to reconstruct, according to the available documentation, because they run along the beams, continuing at the joints. I limit myself to reporting examples of the *basmalah*, the expression "In the Name of God, the Merciful, the Compassionate" with which each *sūrah* of the Qur'an begins. See Plate 1, and for the graphic reconstruction, Plate 10.

A photograph of the northern hall with decorations and Qur'anic inscriptions on the beams gives us an idea of the overall appearance of the aisle. On the bottom-right of the photograph, the strip on the sleeper is visible, which runs along the entire perimeter wall (after cleaning and restoration).

4.4 Northern hall

The writing is relatively homogeneous in foliated Kufic. Note the ligament of the letters below the baseline. I have included some examples from the inscription that quotes the *sūrah* al-Tawbah (*Repentance*) 9, verse 18: "Only he shall inhabit God's places of worship who believes in God and the last day, and performs the prayer, and pays the alms, and fears none but God alone; it may be that those will be among the guided" (translation by Arthur S. Arberry).

1) *ya'mur* with a peculiar *'ayn*. 2) *masājid* with final *d*, cf. final *r* of *ya'mur*) 3) *al-shāhidīn* ("who believe"), with interwoven *h*. 4) *al-zakāt* with writing of *alif* and *ta-marbūṭah* in the form of a small circle with a curl. 5) *ṣalāt*, with rectangular *ṣ* and interwoven writing of the *lām-alif*.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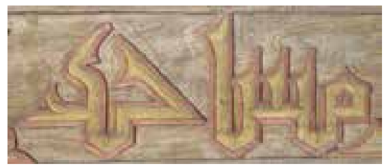
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4.5 Western hall

The writings in the western hall (Plates 4 and 6) are in a simple Kufic script in which the letters are linked by a ligature. 1) *Allāh*, with elongated line between *l* and *h*; 2) *al-'azīz* with the typical 'cat's head' form of the letter *'ayn* and the peculiar shape of the two *z*; 3) *al-Qur'ān*, note the structure of the letters *q*, *r* and final *n*; 4) *al-Jannah* (Paradise) with oblique course of the *j*, without ornamentation; 5) *al-Nār* (the Fire, Hell); 6) *lā bī'* with *lām-alif* in a different form, as also the final *'ayn*.

The inscriptions in the western hall show noticeable differences in the forms of the letters. This could be due to the intervention of different carvers and the lack of precise models.


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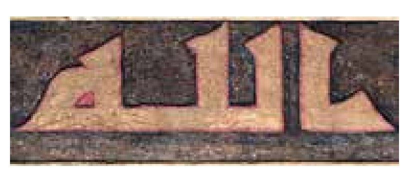
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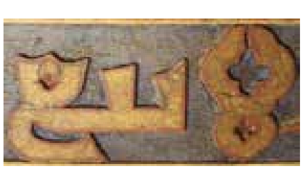
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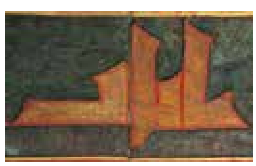
4.6 Eastern hall

The grouping of words appears very compact, with geometric shapes that we could define "rationalist". The letters are positioned along a continuous baseline, without ligature lines or, when isolated, without even a small space before the next letter (e.g., the *alif*). See also the characteristics of the writing in Plates 5, 7, 8, and 9, referring to Qur'anic inscriptions on the eastern wall.

I include some words from *sūrah* 3, Āl 'Imrān (*The House of Imran)*, verses 113-116. 1) *al-Kitāb* (the Book): note the particular shape of the *k* and the compactness of the whole; 2) *Ummah* (community, nation); 3) *āyāt* (God's) signs; verses of the Qur'ān: the final *t* is slightly longer than the final *b* of *kitāb*; 4) *yasjudūna* (bowing themselves): *yash-* on a register higher than the baseline represented by the extension to the right of the *j*; 5) *fī al-khayrāt* (in good works): note the long backward-turning ending of the letter *y* of *fī*, and the shape of the *l* in the sequence, *l-kh*; 6) *mā yaf'alū* (whatsoever [good] they do): the distinction between the drop-like form of *f* and the "cat's head" form of the *'ayn*; 6) *lan tughnī* ([their riches] shall not avail them): note the juxtaposition of *lan+y* and the shape of the final *y*; 7) *aṣḥāb al-nār* (the inhabitants of the Fire): the link between *ṣ* and *ḥ*, the vertical crescent shape of the final *r*.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THE INSCRIPTIONS ON THE EXTERNAL WALLS OF THE GREAT MOSQUE

5. Queen Arwā[33]

5.1 The name of the queen in the historical works is al-Malikah al-Sayyidah (The Lady Queen) or al-Sayyidah al-Ḥurrah (The Noble Lady) (r. 477-532/1084-1137 or 1138). These are perhaps honorific titles while her proper name was Arwā.[34] She was "perfect in noble qualities, possessing a clear-sounding voice, and the ability to read and write (*qāri'ah kātibah*), her memory stored with poetry, with history and with the chronology of past times (*al-akhbār wa-l-tawārikh*)".[35]

A useful synthesis of the queen's life based on Arab sources is presented by G. Rex Smith in the volume *Yemen*, edited by Werner Daum (1988: 132).

> Al-Mukarram Aḥmad married Arwā bint Aḥmad in 461/1069 and the union produced four children. In either 467/1074 or 479/1086 he handed over the affairs of the state to his wife, Arwā, who later, perhaps 480/1087 left Ṣan'ā' for the new capital, Dhū Jiblah, which itself had been founded about the year 459/1066. Thus begins Sulayhid rule over southern Yemen and Tihāmah, a period of some brilliance presided over by this legendary queen, "Bilqīs the Younger" (Bilqīs al-Ṣughrā). The history of the Sulayhids in Dhū Jiblah is the history of Arwā bint Aḥmad and her henchmen. She lived long and died in 532/1138 at the age of 88.

The decision to definitively leave Ṣan'ā', the capital of the kingdom, was probably due to the climate of turbulence that reigned in that city, which was quite different than that found in Djū Jiblah. The historian, Najm al-Dīn 'Umārah, thus describes the queen's attitude:

> She said to al-Mukarram: "My lord, send notice to the people of Ṣan'ā' to assemble tomorrow and to come unto this plain". On their assembling she told him to cast down his eyes upon the people at what he should see. He did so, and naught met his eyes but the lighting-flashes of drawn swords and lance-blades. On going to Dhū Jiblah she desired al-Mukarram to assemble its people and those of the neighborhood. They gathered together on the morning of the following day, where-upon she said: "Look down, my lord, and behold these people". He did so, and his eyes fell upon men leading rams or carrying vessels filled with ghee or with honey. "Life among these (industrious) people" she said to al-Mukarram, "is to be preferred."[36]

Al-Mukarram built at Dhū Jiblah the royal palace (Dār al-'Izz) with a large garden (480 or 481 h.). Arwā ordered that a second Great Mosque be built, after that of Ṣan'ā'. Her tomb

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33 On Queen Arwā see in particular al-Hamdani 1931, Lewcock, Smith 1973; al-Imad 1990; Traboulsi 2003; Cortese, Calderini 2006; Hernández 2007, 2008. For the correspondence between the Fatimid Caliph-Imam of Cairo al-Mustanṣir bi-llāh and the queen see *al-Sijillāt al-mustanṣiriyyah*, ed. Mājid, Cairo 1954.

34 The word *arwā* indicates in Arabic 'the female ibex'. As a woman's name it is quite rare.

35 'Umārah, ed. Kay 1892: 39, Ar. text 28; *al-Mufīd*, 113; Idrīs, *'Uyūn al-akhbār*, 294.

36 'Umārah, ed. Kay 1892: 40-41, Ar. text 30; *al-Mufīd*, 115-116, and Note 2 (al-Akwa').

is found in the western corner of the mosque. It is decorated with calligraphic inscriptions in foliated Kufic similar to, and probably contemporary to those of the *miḥrāb*.[37]

Palace and Mosque of Queen Arwā. Dhū Jiblah (G. Canova, 1993)

5.2 Queen Arwā and the Great Mosque of Ṣan'ā'

Paolo Costa remarked in his seminal study that the Great Mosque of Ṣan'ā' is "popularly known as Jāmi' al-Sayyidah Arwā bint Aḥmad, after the name of the Suleihid queen who restored and extended the building…" (1974:1; 1994, II, 1).[38] In reality, the historians 'Umārah, al-Janadī and al-Khazrajī do not mention the works ordered by Queen Arwā on the Great Mosque. We only have records from a late source, *'Uyūn al-akhbār*, by 'Imād al-Dīn Idrīs (d. 872/1469), nineteenth *dā'ī* (Ṭayyibi agent of the Isma'ili mission):

> She it was who extended the Jāmi' of Ṣan'ā', restored its structure, decorated it (*wassa'athu*[39] *wa-ṣaḥḥaḥat 'imāratahu wa-zayyanathu*) and ordered that the names of the *imām*s, from 'Alī ibn Ṭālib to the *imām* of her age, be inscribed in it. So that was recorded on the north wall of al-Masjid al-Jāmi'. (…) The names of the *imām* have been inscribed on the ceiling (*saqf*) of the mosque, until now, in the month of Jumādah II of the year… [lacuna]. Ḥasan b. Idrīs of the Āl Muḥammad made an accurate reading of the letters in Kufic script. The reading was confirmed to me by a member of the confraternity who examined the inscriptions. But the wicked do not cease their efforts to erase the good that has been done by the best people (*faḍl ahl al-faḍl*).[40]

37 The Jāmi' can still be seen to this day and the tomb of the queen is still preserved in it. Cf. Lewcock, Smith 1973: 119-121, Plates 6-12; Smith 1997: 816; Hernández 2007: Plates 1-3.

38 Ibn Abī al-Rijāl (d. 1092/1681) writes that "The eastern side is As'ad ibn Abī Yu'fir's work" (*Maṭla' al-budūr*, cited by al-Akwa' 1995: ii, 1012).

39 Later sources add after *wassa'*: *al-jānib/al-jināḥ al-sharqī* (the eastern side/wing). Cf. Yaḥyā ibn al-Ḥusayn (d. 1035/1689), *Ghāyat*, 295; al-Kibsī (d. 1300/1890), *al-Laṭā'if*, 86.

40 Idrīs, *'Uyūn al-akhbār*, vol. 7, 2019: 304-305. Cf. Lewcock *et al.* 1983: 324 (after Sayadna Taher Saifuddin Saleh, *Ghurrat al-ḥaqq*, 1344 h.).

There are two external inscriptions with the name of the Queen, al-Ḥurrah al-Sayyidah al-Malikah or al-Ḥurrah al-Malikah. The first is located above the central doorway on the northern *qiblah* wall (the *imām*'s doorway) of the Great Mosque.

al-Ḥurrah (*partially erased*) al-Sayyidah al-Malikah

In the IVBC photograph, the inscription can be seen at the top. On the sides of the door there are carved stones with the silhouettes of birds (probably falcons) and the very damaged carvings of two lions.[41]

41 Finster 1979: 190, Tafel 69a, 70a, b. Cf. Serjeant, Lewcock 1983: 342, 344, Fig. 18.52. The symbolism is clearly Islamic.

To my knowledge, Barbara Finster was the first scholar to publish a photograph of these inscriptions and to attempt their transcription in a report published in 1986.[42] Their legibility is difficult due to their height above the ground and their state of conservation. In the first inscription, the name of the queen, al-Ḥurrah al-Sayyidah al-Malikah, is found in the second line. The date appears at the end of the same line and continues on the third. B. Finster proposed the reading 553 h. (which would place the memorial inscriptions after the death of the Queen 532 h./1138). Also the *qāḍī* al-Akwa' reads the date as 553 h., whereas the Mosque Project Epigraphy that examined the inscription at close range reads it as 513 h. (1119).

I. Foliated Kufic inscription on the outside of the northern wall above the central doorway.

بسم الله الرحمن الرحيم نقلت هذه الحجارة من دار الإمارة باليمن و|
البركة عن أمر **الحرة السيدة الملكة** أجزل الله ثوابها وأحسن مأبها في رجب من سنة ثلا|
ث عشرة وخمسمائة وصلى الله على سيدنا محمد النبي واله الأئمة الطاهرين وسلم تسليما

In the name of God, the Compassionate, the Merciful. This stone (*lit.*: these stones) was successfully transferred from its place in the kingdom's seat (*dār al-imārah*) with blessing by order of the Queen al-Ḥurrah al-Sayyidah. May God bless her and make her conduct good. In the month of Rajab in the year 513 [October 1119]. May God pray for Muḥammad the Envoy and his people (and) the pure Imāms.

II. A second undated inscription carries the name of the queen, al-Ḥurrah al-Malikah.

نقلت هذه الحجارة من دار الإمارة باليمن والبر|كة عن أمر مولاتنا **الحرة الملكة**

This stone was transferred from the kingdom's seat with success and blessing by order of our patroness (*mawlātunā*) the Queen al-Ḥurrah.

42 The three inscriptions are reproduced from Finster 1986: Tafel 71e and b; 192. Cf. Serjeant, Lewcock 1983: 344, Fig. 18.53.

On both plates the words *nuqilat hādhihi l-ḥijārah min* appear ("This stone has been transferred, brought by…"). This indicates that they were not carved in Ṣan'ā', but most likely in the seat of the kingdom, Dhū Jiblah. There is a lack of information on actual works in the Great Mosque by order of the Queen. The Yemeni scholar *qāḍī* Ismā'īl ibn 'Alī al-Akwa' remarks that according to the historical sources any major structural work in the Great Mosque was carried out in Yu'firid time. The Queen's intervention would be limited to some restoration works (*tarmīm wa-iṣlāḥ*). The purpose of transferring (*nuqilat*) the inscription to Ṣan'ā', putting it above the main northern door of the Great Mosque, was to let "any excellent monument (*athar*) to be attributed to them [the Ṣulayḥis]" (al-Akwa' 1995: ii, 1012-1013).

The style of the writing reflects the foliated Kufic of the 12th century (Ṣulayḥid period). Of note is the elaborate form of the letter *l-alif* in *mawlātunā* and of the name al-Ḥurrah.

III. A third inscription on the west wall does not concern the queen but carries the name of the Imām al-Manṣūr Billāh and is limited to religious expressions. Barbara Finster notes that the identification of this *imām* is problematic.[43]

بسم الله الرحمن الرحيم لا إله إلا الله وحده لاشريك له
محمد رسول الله علي والي الله الإمام المنصور بالله

In the name of God, the Compassionate, the Merciful. There is no God but God alone. Muḥammad is the Messenger of God, 'Alī is the *wālī* of God. The *imām* al-Manṣūr bi-llāh.

THE INSCRIPTIONS AND DECORATIONS ON THE NORTH AND EAST FAÇADES OF THE GREAT MOSQUE

I. Numerous inscriptions in simple Kufic are located approximately 6 meters above the ground. The inscription reproduced below is built into the northern wall while six other

43 Finster 1986: Tafel 71 c, 193: "Die Schrift, ein blühendes, zusammengedrängtes Kufi, ließe sich mit Einwand in die zweite Häfte des 12. Jhs. datieren". Al-Wāṣi' mentions three *imāms* bearing the title al-Manṣūr bi-llāh: Abū al-Ḥusayn al-Qāsim (d. 393/1002), whose agent (*'āmil*) promoted the construction of the Ghayl al-Āf (south of Ṣan'ā'); the pious 'Abd Allāh ibn Ḥamzah, known for his miracles (*karamāt*, worked by a saint) (d. 613/1216); Aḥsan ibn Badr al-Dīn (d. 670/1271) (*Tārīkh*: 25, 29-32).

inscriptions are set in the eastern wall. Only the *basmalah* remains, sometimes followed by *barakah min Allāh* ("blessing from God"), while the one or two lines remaining were deliberately mutilated.

بسم الله الرحمن الرحيم بركة من | الله (...)

In the name of God, the Compassionate, the Merciful. Blessing from God (…).

We can conclude on stylistic grounds that these inscriptions date from the period before the 5th/11th century [i.e., the reign of Queen Arwā], and they probably should be considered as belonging to the 2nd/8th century, at the time of the 'Abbasid governors.[44]

II. On the external walls of the Great Mosque, birds, probably doves in pairs facing one another, have been inserted as decorative elements.[45] The hypothesis has been advanced that these are of Christian origin: "On the other hand pigeons (or doves) are a common feature on domes and minarets in Ṣan'ā', used as a symbol instead of the crescent, e.g., al-Madrasah and Ṣalāḥ al-Dīn minarets".[46]

44 Serjeant, Lewcock 1983: 349. The authors examine various hypotheses regarding their dating, favouring the earliest of these. They specify, however, that "the above should not be taken as an argument that the eastern side dates from the 2nd/8th century. If the inscriptions are as old as this, they could without difficulty have been built neatly into the northern and eastern walls at a later date as they do today". Cf. Finster 1979: Tafel 56.

45 After Finster: 1979, Tafel 68b, 70. Cf. 190, Tafel 71f, g: Where falcons would be represented. Cf. Costa 1974: Pl. xxvii.

46 Serjeant, Lewcock 1983: 340, Note 44; 344, Fig. 18.52. The doves take on particular importance in the Islamic tradition: a couple of these birds flew out of the cavern where the Prophet found refuge after leaving Mecca. Their appearance led his pursuers to believe the cave was empty.

A Qur'an lesson at the Great Mosque

Qur'anic lessons have taken place in the aisles of the Great Mosque, but also outside in the shade cast by the Qubbah in the middle of the central space. The writing on the wall recalls that the Qubbat al-Zayt was built by the *wālī* Sinān Bāshā in 1018 h. (1609). The upper floor is intended to conserve copies of the Qur'an and documents of the mosque; the lower floor was used to store olives for oil that served to illuminate the complex.

(photo: Fawzi Dubhani)

The teacher has written the topics for his lesson on a large whiteboard:
1. Request for the protection of God from "Satan the lapidated" (traditional formula before a Qur'anic recitation).
2. Sūrah 112 al-Ikhlāṣ, "Sincere Religion" On the oneness of God.
3. Grammatical exercise on the verb in the passive, followed by the expression, *al-sirāṭ al-mustaqīm*, "the right way" (cf. Q 1: 6).
4. Single letters of the alphabet with vowel-marks (in usual Arabic writing letters do not have these marks).

References to the Photographic Archive of the Istituto Veneto per i Beni Culturali

Plate 1: N1 T8-9ab; N1 T60ab; N1 T17ab; N1 T29ab; N1 T29ab; N1 T16ab + T16cd. (northern hall)

Plate 2 and 3: from N1 DF64 to N1 DF45. (northern hall)

Plate 4: from O3 DF69-70 to 2 03 DF64. (western hall, before restoration)

Plate 5: from E1 DA28 to E1 DA36. (eastern hall)

Plate 6: from O1 DF56.1 to O1 DF45. (western hall)

Plate 7: from E1 DF54 to E1 DF44. (eastern hall)

Plate 8: from E1 DA21 to E1 DA27. (eastern hall)

Plate 9: from E2 DF85 to E2 DF75. (eastern hall)

Translation of Qur'anic verses reproduced in Plates 1-9

The translations are taken from *The Koran Interpreted*, by A.J. Arberry (London, 1955).

The *Basmalah* (Plates 1 / 10)
In the Name of God, the Merciful, the Compassionate.

Qur'an 1 *The Opening* (Plates 2-3 / 11)
In the Name of God, the Merciful, the Compassionate.
Praise belongs to God, the Lord of all Being,
the All-merciful, the All-compassionate,
the Master of the Day of Doom.
Thee only we serve; to Thee alone we pray for succour.
Guide us in the straight path, the path of those
whom Thou hast blessed, not of those against
whom Thou art wrathful, nor of those who are astray.

Qur'an 22 *The Pilgrimage* verse 77 (Plates 4-5 / 12 a-b)
O men, bow you down and prostrate yourselves, and serve your Lord,
and do good; haply so you shall prosper (…)

Qur'an 2 ***The Cow*** verse 254 (Plates 6 / 13a)
O believers, expend of that wherewith We have provided you,
before there comes a day wherein shall be neither traffic,
nor friendship, nor intercession;
and the unbelievers –
they are the evildoers.

Qur'an 3 ***The House of 'Imran*** verse 117 (Plates 7 / 13b)
(The likeness of that they expend in his) present life
is as the likeness of a freezing blast that smites the tillage
of a people who wronged themselves, and it destroyed that.
God wronged them not, but themselves they wronged.

Qur'an 112 ***Sincere Religion*** (Plates 8 / 14a)
Say: "He is God, One,
God the Everlasting Refuge,
who has not begotten, and has not been begotten,
and equal to Him is not anyone."

Qur'an 48 ***Victory*** verse 5 (Plates 9 / 14b)
And that He may admit the believers, men and women alike,
into gardens underneath which rivers flow, therein to dwell forever,
and acquit them of their evil deeds;
that is in God's sight a mighty triumph (…).

Appendix

Muhammed al-Thenayian discovered two interesting rock-inscriptions relating to Muḥammad b. Yu'fir and Ibrāhīm b. Muḥammad b. Yu'fir at the pass of al-Manḍaj (now called Maṣlūlah), on the Yemeni highland pilgrim route connecting Ṣan'ā' with Mecca. According to the historical sources, Muḥammad b. Yu'fir performed the pilgrimage to Mecca in the year 262/876, leaving the regency to his son Ibrāhīm (al-Khazrajī, *al-'Asjad al-masbūk*: 120). The Manḍaj pass (*naqīl*, Yem.) is mentioned by both al-Hamdānī and Aḥmad b. 'Īsā al-Radā'ī in the *Urjūzat al-ḥajj* (al-Hamdānī, *Ṣifah*: 116, 225, 354).

Al-Thenayian published pictures and drawings of the inscriptions, a transcription of the text, a translation, and a commentary.

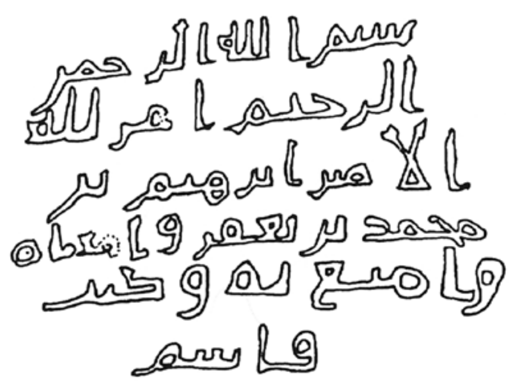
Fig. 2


Fig. 1


1 اللهم | اغفر | لمحمد | بن يعفر | كتبهما | قاسم
2 بسم الله الرحمن | الرحيم اقر (ا)لله | الامير ابرهيم بن |
| محمد بن يعفر | و(اهداه) | وامتع به وكتب | قاسم

1. O God | grant forgiveness | to Muḥammad | ibn Yu'fir. | He wrote them both | Qā|sim.
2. In the name of God, the Compassionate | the Merciful. May God assign | Amīr Ibrāhim bin | Muḥammad bin Yu'fir and (may God) guide him | and (may God allow the believers to) profit by him, and wrote (this) | Qāsim.

(after al-Thenayian 2002)

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Basmalah

(Northern hall)

﴿ بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ ﴾

PLATE 1

Qur'an 1 ***The Opening***
(Northern hall)

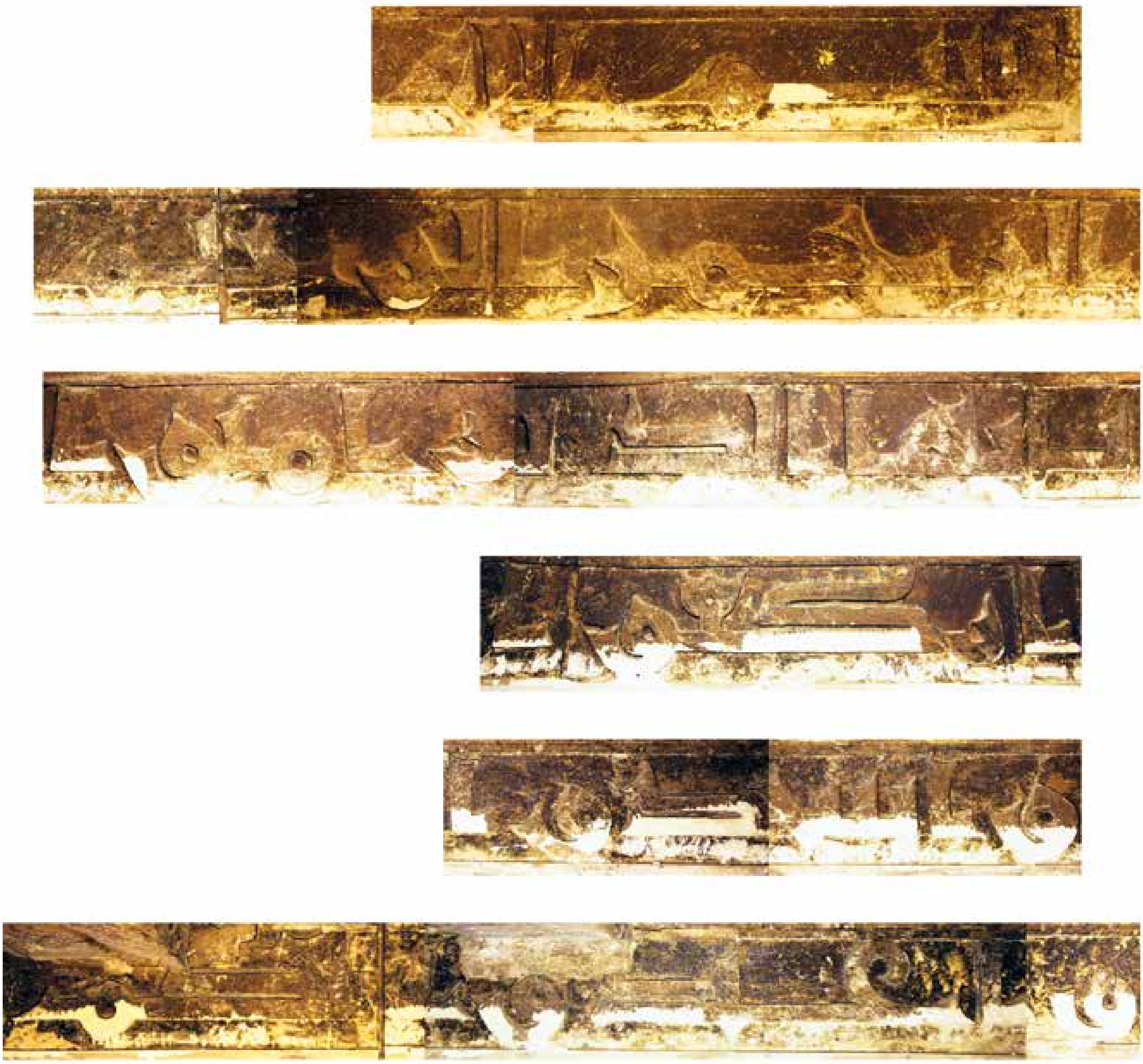
PLATE 2

﴿ بِسْمِ ٱللّٰهِ ٱلرَّحْمٰنِ ٱلرَّحِيمِ الْحَمْدُ لِلّٰهِ رَبِّ ٱلْعَالَمِينَ الرَّحْمٰنِ
الرَّحِيمِ مَالِكِ يَوْمِ ٱلدِّينِ إِيَّاكَ نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ اهْدِنَا ٱلصِّرَاطَ
ٱلْمُسْتَقِيمَ صِرَاطَ ٱلَّذِينَ أَنْعَمْتَ عَلَيْهِمْ غَيْرِ ٱلْمَغْضُوبِ
عَلَيْهِمْ وَلاَ ٱلضَّالِّينَ ﴾ سُورَة الْفَاتِحَة

PLATE 3

Qur’an 22 ***The Pilgrimage: 77***

(Western hall)



﴿ بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ   يَٰٓأَيُّهَا ٱلَّذِينَ أمَنُوا

ٱرْكَعُوا وَٱسْجُدُوا   وَٱعْبُدُوا رَبَّكُمْ ﴾ سورة الحَجّ الآية ٧٧

PLATE 4

Qur'an 22 ***The Pilgrimage: 77***
(Eastern hall)

﴿ يٰأَيُّهَا ٱلَّذِينَ أمَنُوا ٱرْكَعُوا وَٱسْجُدُوا وَٱعْبُدُوا رَبَّكُمْ
وَٱفْعَلُوا ٱلْخَيْرَ لَعَلَّكُمْ تُفْلِحُونَ ﴾ سورة الحَجّ الآية ٧٧

PLATE 5

Qur'an 2 ***The Cow: 254***

(Eastern hall)

﴿ بِسْمِ ٱللّٰهِ ٱلرَّحْمٰنِ ٱلرَّحِيمِ يٰأَيُّهَا ٱلَّذِينَ أَمَنُوا أَنْفِقُوا مِمَّا رَزَقْنَاكُمْ
مِنْ قَبْلِ أَنْ يَأْتِيَ يَوْمٌ لاَ بَيْعٌ فِيهِ وَلاَ خُلَّةٌ ... ﴾ سُورة الْبَقَرَة الآية ٢٥٤

PLATE 6

Qur'an 3 ***The House of Imran: 117***
(Eastern hall)

﴿ الدُّنْيَا كَمَثَلِ رِيح فِيهَا صِرٌّ أَصَابَتْ حَرْثَ قَوْمٍ ظَلَمُوا أَنْفُسَهُمْ فَأَهْلَكَتْهُ وَمَا
ظَلَمَهُمُ ٱللّٰهُ وَلٰكِنْ أَنْفُسَهُمْ يَظْلِمُونَ ﴾ سُورَة آلِ عِمْرَان الآية ١١٧

PLATE 7

Qur’an 112 ***Sincere Religion***

(Eastern hall)

﴿ قُلْ هُوَ ٱللَّهُ أَحَدٌ   ٱللَّهُ ٱلصَّمَدُ   لَمْ يَلِدْ وَلَمْ يُولَدْ

وَلَمْ يَكُن لَهُ   كُفُوًا أَحَدٌ ﴾ سُورة الإخْلاص

PLATE 8

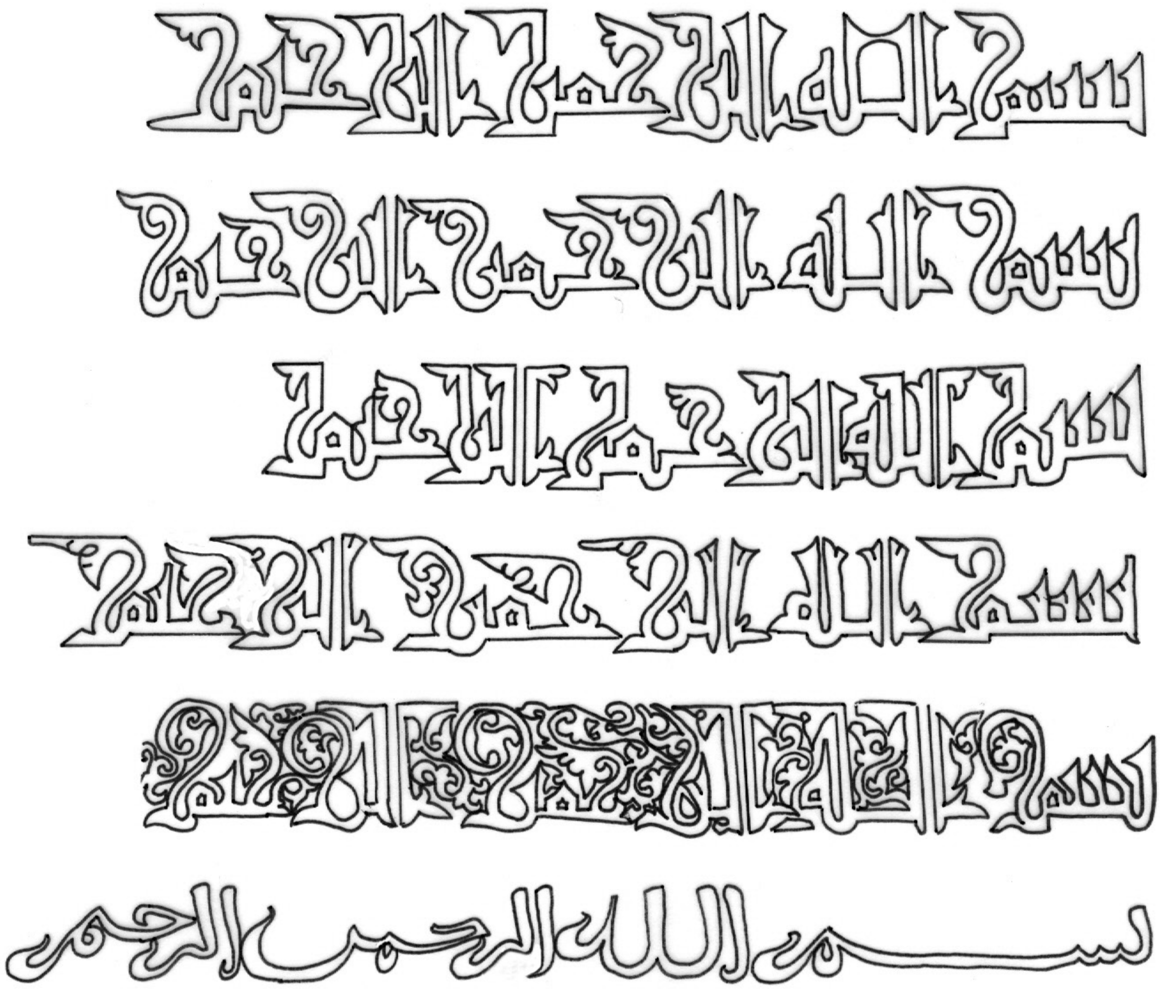
Qur'an 48 ***Victory: 5***
(Eastern hall)

﴿ لِيُدْخِلَ ٱلْمُؤْمِنِينَ وَٱلْمُؤْمِنَاتِ جَنَّاتٍ تَجْرِي مِنْ تَحْتِهَا ٱلأَنْهَارُ خَالِدِينَ فِيهَا
وَيُكَفِّرَ عَنْهُمْ سَيِّئَاتِهِمْ وَكَانَ ذَٰلِكَ عِنْدَ ٱللَّهِ فَوْزًا عَظِيمًا ﴾ سُورَةَ الْفَتْح الآيَة ٥

PLATE 9

Basmalah

(Northern hall)



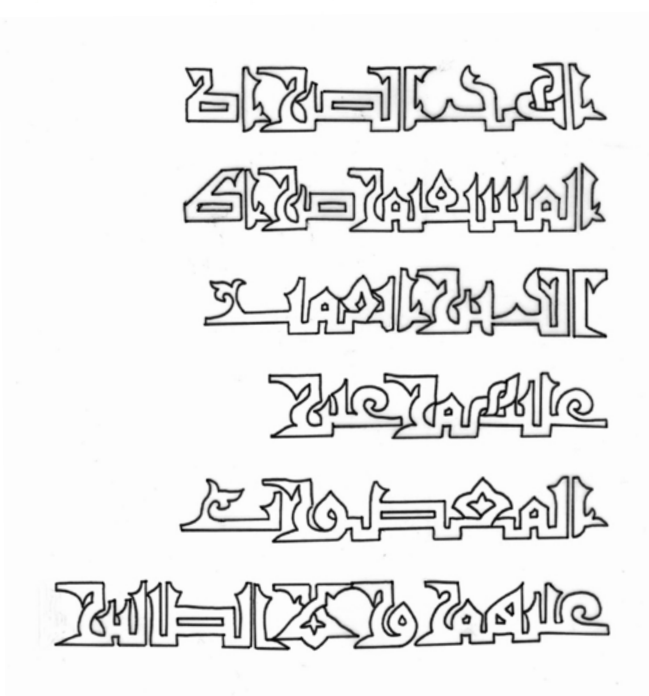
﴿ بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ ﴾

PLATE 10

Qur'an 1 ***The Opening***

(Northern hall)

بِسْمِ ٱللّٰهِ ٱلرَّحْمٰنِ
ٱلرَّحِيمِ الْحَمْدُ لِلّٰهِ
رَبِّ ٱلْعَالَمِينَ الرَّحْمٰنِ
ٱلرَّحِيمِ مَالِكِ يَوْمِ
ٱلدِّينِ إِيَّاكَ نَعْبُدُ
وَإِيَّاكَ نَسْتَعِينُ



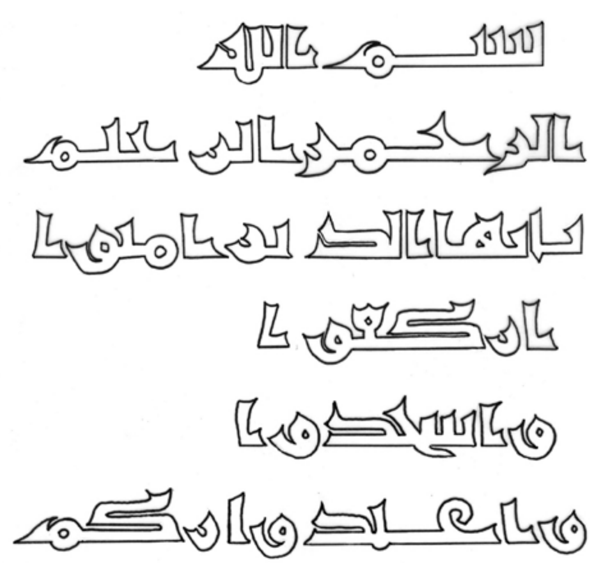
اهْدِنَا ٱلصِرَاطَ
ٱلْمُسْتَقِيمَ صِرَاطَ
ٱلَّذِينَ أَنْعَمْتَ
عَلَيْهِمْ غَيْرِ
ٱلْمَغْضُوبِ
عَلَيْهِمْ وَلاَ ٱلضَّالِّينَ

سُورَةَ الْفَاتِحَة

PLATE 11a-b

Qur'an 22 ***The Pilgrimage: 77***

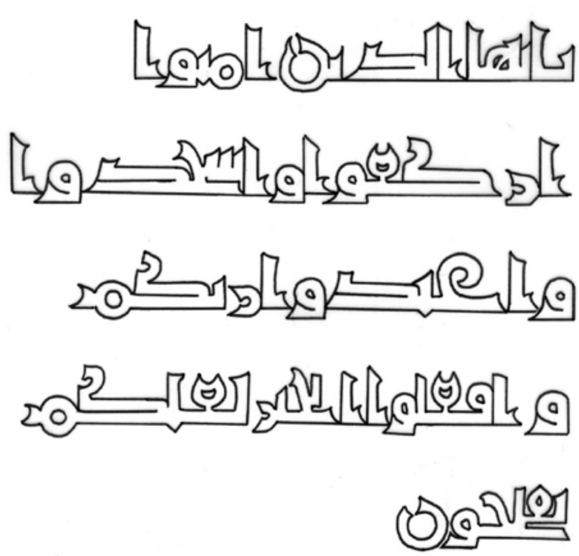
(Western hall)



بِسْمِ ٱللَّٰهِ
ٱلرَّحْمَٰنِ ٱلرَّحِيمِ
يٰأَيُّهَا ٱلَّذِينَ أمَنُوا
ٱرْكَعُوا
وَٱسْجُدُوا
وَٱعْبُدُوا رَبَّكُمْ

سورة الحَجّ الآية ٧٧

(Eastern Hall)

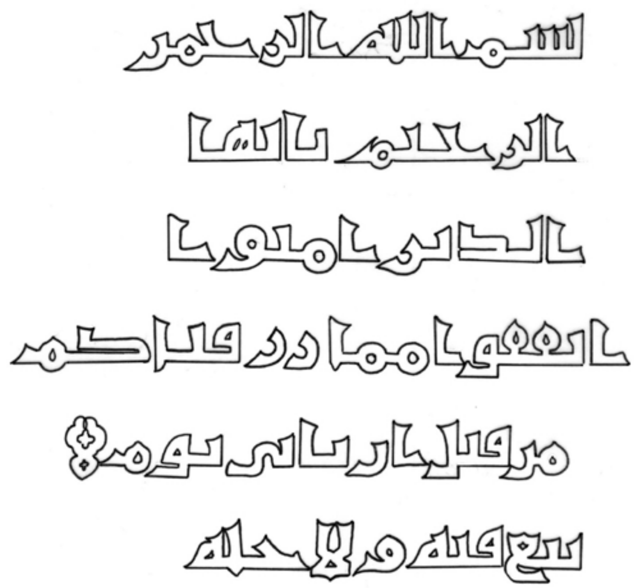


يٰأَيُّهَا ٱلَّذِينَ أمَنُوا
ٱرْكَعُوا وَٱسْجُدُوا
وَٱعْبُدُوا رَبَّكُمْ
وَٱفْعَلُوا ٱلْخَيْرَ لَعَلَّكُمْ
تُفْلِحُونَ

سورة الحَجّ الآية ٧٧

PLATE 12a-b

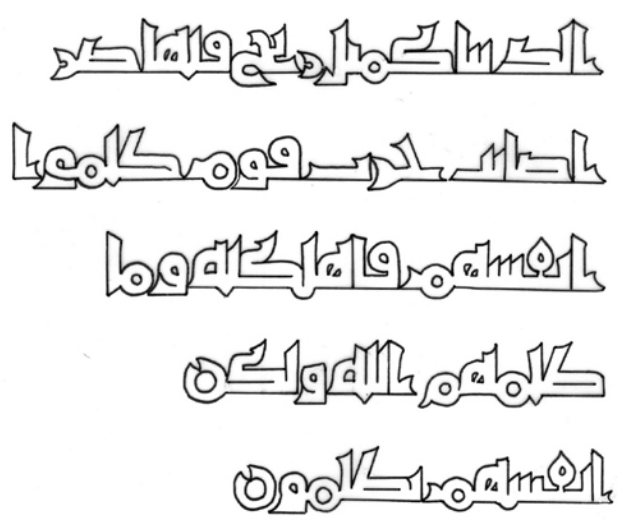
Qur'an 2 ***The Cow: 254***



بِسْمِ ٱللَّٰهِ ٱلرَّحْمَٰنِ
ٱلرَّحِيمِ يَٰأَيُّهَا
ٱلَّذِينَ أَمَنُوا
أَنْفِقُوا مِمَّا رَزَقْنَاكُمْ
مِنْ قَبْلِ أَنْ يَأْتِيَ يَوْمٌ لاَ
بَيْعٌ فِيهِ وَلاَ خُلَّةٌ

سُورة الْبَقَرَة الآية ٢٥٤

Qur'an 3 ***The House of Imran: 117***

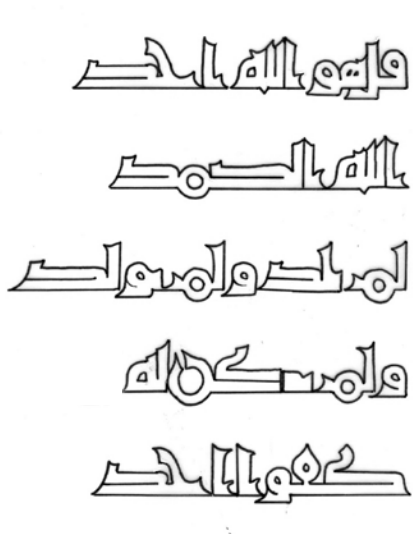


الدُّنْيَا كَمَثَلِ رِيحٍ فِيهَا صِرٌّ
أَصَابَتْ حَرْثَ قَوْمٍ ظَلَمُوا
أَنْفُسَهُمْ فَأَهْلَكَتْهُ وَمَا
ظَلَمَهُمُ ٱللَّٰهُ وَلَكِنْ
أَنْفُسَهُمْ يَظْلِمُونَ

سُورَة آلِ عِمْرَان الآية ١١٧

PLATE 13a-b

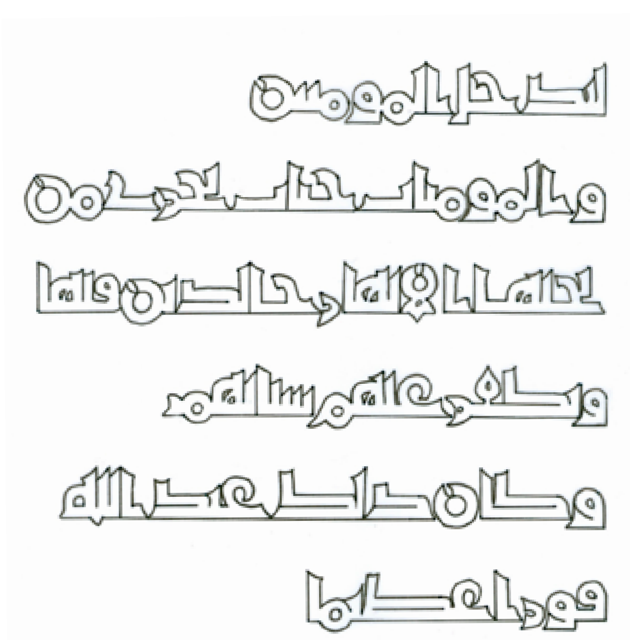
Qur'an 112 ***Sincere Religion***



قُلْ هُوَ ٱللَّهُ أَحَدٌ
اللَّهُ ٱلصَّمَدُ
لَمْ يَلِدْ وَلَمْ يُولَدْ
وَلَمْ يَكُنْ لَهُ
كُفُوًا أَحَدٌ

سُورة الإخْلاص

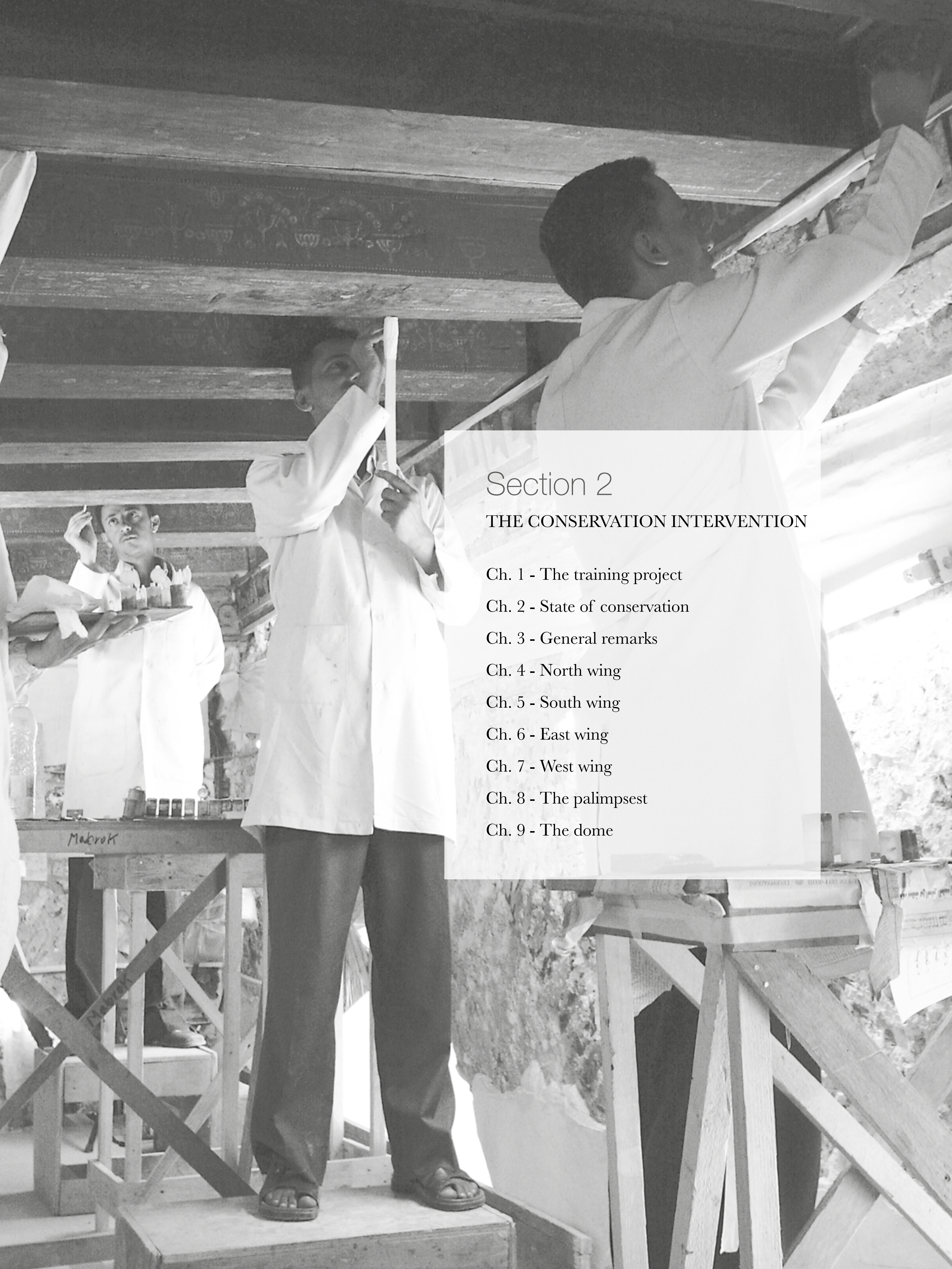
Qur'an 48 ***Victory: 5***



لِيُدْخِلَ ٱلْمُؤْمِنِينَ
وَٱلْمُؤْمِنَاتِ جَنَّاتٍ تَجْرِي مِنْ
تَحْتِهَا ٱلأَنْهَارُ خَالِدِينَ فِيهَا
وَيُكَفِّرَ عَنْهُمْ سَيِّئَاتِهِمْ
وَكَانَ ذَٰلِكَ عِنْدَ ٱللَّهِ
فَوْزًا عَظِيمًا

سُورَة الْفَتْح الآيَة ٥

PLATE 14a-b



Section 2

THE CONSERVATION INTERVENTION

Section 2 - Chapter 1

THE TRAINING PROJECT

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

The restoration project of the Great Mosque of Ṣan‘ā’ began in 2006 with a pilot construction site. A first inspection of the mosque had already been carried out in 2005, with the aim of establishing the contacts and becoming acquainted with the Yemeni client, as well as collecting all the data necessary to undertake the planning of an initial test intervention. A few months later, in October 2006, as previously mentioned, the pilot site got under way, in which only the specialists chosen by the IVBC worked independently to verify the feasibility of the project, identify the methodologies to be adopted and quantify the timing, costs and materials. Detailed graphic and photographic mapping of the state of conservation of the areas in question was done and a number of cleaning, consolidation and integration tests were carried out. At the same time, various analyses were carried out on sedimented materials and decorative techniques. At the end of the six-month pilot study, the experience gained made it possible to draw up a detailed plan to be completed over a period of about eight years.

The first inspection that preceded the works was made in 2005, at a time when the antiquity and splendor of the decorations and, at the same time, the serious state of deterioration made clear the absolute and urgent need for intervention. The project was seen at the time as bold and ambitious, but today, the courage of its proponents has been rewarded by the amazing results visible after years of work. The most important success achieved is the didactic element of the project, which has led to the training of a large number of local operators, specialized in different types and fields of intervention, who can be entrusted with the future conservation of the countless historical assets throughout the Yemeni territory.

From the beginning, the project was intended to achieve two parallel objectives: the restoration of the polychrome wooden ceilings of the Great Mosque of Ṣan‘ā’ and the professional training of local restoration crews. The start of the work was preceded by theoretical courses in which more than forty students participated. With this training project, promoted by IVBC and SFD and developed over the years of collaboration, the goal was to increase awareness among the operators involved in all areas of responsibility, with specific reference to young people, who are, of course, the future of their country.

However, the training courses would also serve a much broader scope, that is, promoting social participation throughout the country in safeguarding its countless historical, artistic and cultural assets of unparalleled value, a treasure not yet understood, to some extent even unknown, yet with great potential, in a country where the political but also the economic situation is often critical, because it is necessary to know how to read the world with new eyes in order to restore foundation and substance to the future. From these considerations came the idea for a training school which, in continuous collaboration with the Yemeni state, personified in the SFD, would train young people to safeguard of assets in a territory as rich in works of art as Yemen but with such a fragile condition as regards their conservation and maintenance.

It should also be said that in recent years the IVBC, given the atmosphere of optimism and the excellent results obtained with the initial program, has engaged in other projects, such as the restoration of the mural paintings of the Al-Ashrafiyyah mosque in Ta‘izz (1400 AD) and has increasingly intensified and significantly increased the number of experts and teachers in charge of the courses, in an effort to expand training and refine communication techniques adapting them to recipients of such a different culture. The number of commitments, the quality of the initiatives and the profound significance of the undertaking enabled the Institute to open up new opportunities for numerous Italian experts as well, if they were interested in exploring new professional challenges which, it should be remembered, required outstanding ability as well as strong relationship and language skills, punctuality, the ability to make critical assessments, and the willingness lead their students along a completely new path.

The courses gradually came to involve teachers in a wide range of disciplines, from basic chemistry to more specific areas of chemistry as they apply to the restoration sector, from the transmission of traditional intervention techniques to the use of the most modern materials and tools. Different didactic strategies from those usually applied in Italy had to be implemented, since the operating conditions were so different and specific. In Italy, the training course is currently divided over a five-year period. In Yemen an attempt was made to contract theoretical teaching and focus above all on the practical aspects, using the ancient method of on-the-job training, or apprenticeship, accompanied by ongoing refresher courses.

The training courses

It was necessary, first of all, to train the local staff. This involved launching theoretical courses in which several young Yemeni students participated, selected among students who had completed university degrees in archeology, architecture or ancient history. The

Fig. 1. The project's supervisors during a meeting.

Fig. 2. Group photo with managers and some operators.

course consisted of 400 hours of theoretical study and about 500 hours of practical activities, for a total of 900 course hours.

Teaching, which has evolved over many years in various restoration sectors, is the foundation of the IVBC, and must always be considered essential in the training of new professional restoration experts. The theoretical subjects are taught by educators with experience at the IVBC in Italy and who have demonstrated a high level of preparation and serious commitment to the field. They contribute their professionalism and experience for limited periods of about two weeks per subject. In this particular case, the theoretical lessons were also carried out with the aid of an Arabic-speaking interpreter, and using video and multimedia material as well as the distribution of handouts in Arabic. The breakdown of the theoretical training course can be summarized as follows:

- Lessons in Restoration Chemistry
- Lessons in the Technology and Biological Deterioration of Wood
- Lessons in Technology and Conservation of Materials
- Lessons on Graphic, Photographic Documentation and Degradation Mapping
- Lessons in the artistic techniques of Islamic Art

At the end of the theoretical courses, the practical part took place at the restoration site of the polychrome wooden ceilings of the Great Mosque with the fundamental objective of introducing students to the operational part of the restoration. In this way the concepts acquired with the theoretical subjects found immediate and appropriate practical application.

At the end of the course the students were subjected to a selection made individually and collectively by all the teachers of both the theoretical and the practical parts. The first twenty selected worked continuously on the construction site of the Great Mosque of Ṣan‘ā’ under the direction of the restorers of the IVBC, continuing to acquire greater confidence and security day by day in the application of restoration methods.

It seems important to us here to emphasize the request for participation of a significant number of girls, a remarkable signal given by the Yemeni counterpart embodied in the SFD, which has often shown itself open to possibilities of this kind. 2007 therefore marked the year of the actual start of the restoration work on the wooden ceiling of the mosque, with the start of a first construction site that saw the Italian operators of the Institute and twenty Yemeni operators selected by the participants of the theoretical courses operate at the same time.

Given the typology of the artifact, it was subsequently also necessary to set up a more specific course on wood and on the restoration of wooden artifacts, for the training of specific and specialized personnel to intervene on the ceiling structure.

The first part of the course was open to about twenty-five restorers, and set itself the goal of understanding and restoring wood in depth. Aspects concerning the processing

Fig. 3. The photo shows a meeting and discussion between the project managers during inspections.

Fig. 4. The restorer during a training session at the construction site.

and construction of works of historical and artistic interest were dealt with. The causes of decay and methods of restoration were illustrated through the use of projected images from reports of interventions on wooden works of historical and artistic interest. This was followed by some practical exercises.

In the second part of the course, this time open to about eight operators/restorers, specific laboratory activity was carried out, useful to gain knowledge and experience to deal adequately with carving and the restoration of artefacts in actual practice. Particular attention was given to the operations necessary to make good integrations. In this way, at the end of the course, the students were able to evaluate, recognize and perform the various actions on site, and use manual tools competently and safely.
The program followed during these courses is illustrated below.

First Part

Contents
1. Notes on wood: its technological properties and the various processing methods: practical demonstrations.
2. The factors that degrade ancient wooden structures.
3. Disinfection and disinfestation of wood.
4. Material consolidation with impregnation of resins.
5. Structural consolidation with wood grafts.
6. The reintegration of missing parts.
7. Illustration of reports concerning interventions on ancient wooden artefacts of various origins and nature.

Second Part

Practical workshop of wood processing and integration
The workshop dealt with the techniques of traditional carpentry and aimed to teach students how to obtain a finished product, or a part of it, from rough wooden boards. They were taught how to prepare the various parts, how to assemble them and how to prepare them for subsequent carving. The main wooden decorations in low and high relief used in the geographical area of reference were made with the traditional carving techniques. The exercises were performed on special boards of suitable seasoned wood.

On-site training and the role of operators

On entering the Great Mosque of Ṣan‘ā’ it is easy to see that the entire structure was recently subjected to an intense and complex restoration, and that the Yemeni operators are justly proud of their involvement in the work.

Going back in time, recalling aspects relative to the practical management of the construction site and the many workers simultaneously engaged there (electricians, scaffolders, plasterers, archaeologists, etc.) it is impossible to deny that there were a great many difficulties and that the work was enormously complicated, but bit by bit, the entire team managed to overcome them all with great satisfaction and in growing harmony alongside the professionals who instructed and supervised them. This was possible thanks to the commitment of the young Yemeni operators who were gradually entrusted with the responsibility of direct management of the works and organization of the construction site in relation to their professional competence. All the various experiences supported each other: the art historian was able to collaborate with the chemist, the restorer with the biologist, the restorers of the carpentry sector with the static engineer, and so on.

The IVBC is not new to promoting and coordinating actions of this particular type (construction site-schools and construction site-laboratories) organized according to a strategy that has been extensively tested over the years, both in terms of content and results: selection of operators-students, identification of the restorers-tutors for the construction project to be assigned, logistic organization for the on-site activities, planning from a practical point of view on the basis of the existing structures, and elaboration of the theoretical notions acquired previously, whether the solution planned can be defined as correct, functional and adequate for the restoration of the Great Mosque of Ṣan‘ā’, The deployment of an interdisciplinary team made up of academics, experts and a construction site-school of students operating in loco, seems to be the only operational choice when considering how to tackle projects of such significance with the certainty of a technical-scientific result and reasonable timing.

In 2007, the construction site-school project got under way. However, what really made it possible to manage the heavy "load" and attain the exceptional results visible today has to be attributed less to the skill of the workers or respect of the commitments made by each of the partner institutions, including the particular the SFD, though they were essential and extraordinary, and more to the passionate collaboration and devotion to the task shown by every single team member. This is, as we have always seen, the component that makes it possible to overcome every possible problem and achieve unexpected outcomes.

Those results are visible today in the restoration of the wooden ceilings but above all in the professional growth of all concerned. Today, with enormous satisfaction, the work can be entrusted to the local staff of polychrome restorers and the team of restorers carpenters, and they can carry out assignments with direct responsibility for the management of the construction site and the progress of the restoration. In particular, after taking additional further refresher courses and advanced technical in-depth training courses over the years, the restorers have professionally matured in their approach to the delicate "subject of restoration" and in the direct organization of the work site.

If we retrace the years of work on the site, we can focus on two moments that marked essential stages for the growth of Yemeni restorers.

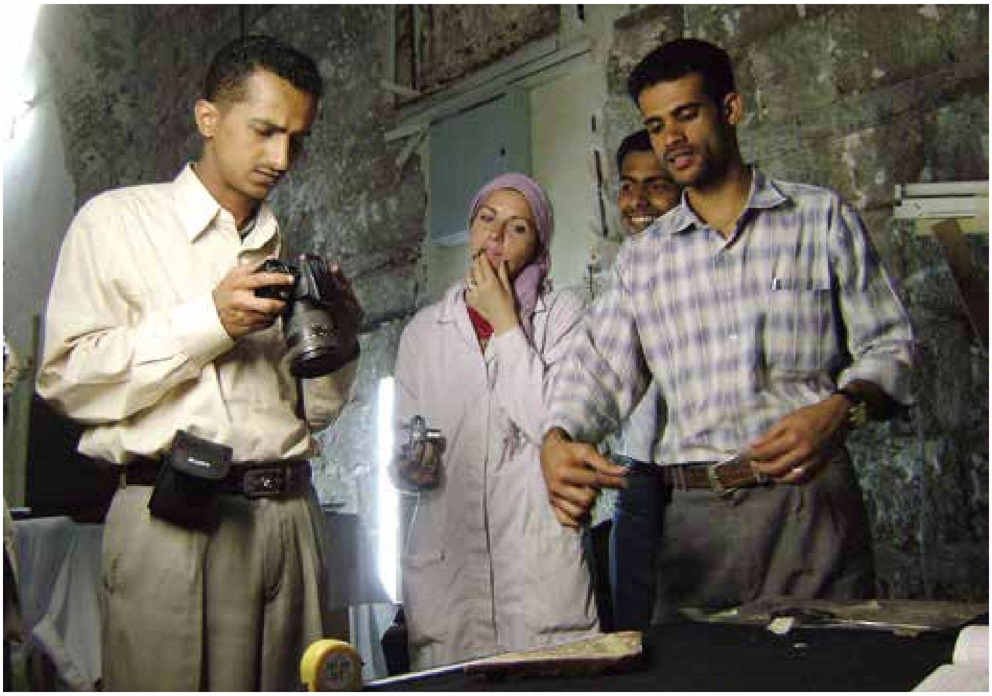


Fig. 5. A moment of the photography course.

Fig. 6. The conservators team while working on the consolidation of the painted wooden ceiling.

Figs 7 and 8. In the images some moments of wood carving training course.

2009 was certainly a turning point for the Great Mosque Project, a year that saw the technical operational problems grow on the one hand, with the beginning of intervention on badly deteriorated areas and with the opening of larger areas of work and relative increase in organizational complexity, and on the other the steady increase in the serious commitment and sense of responsibility exhibited by the team in dealing with the work.

Every day, about fifty people entered the mosque to tackle the restoration work, from the roofing to the decorations, from the plastering to the columns and archaeological excavations. The IVBC, which has always supported local operators, understood that it was absolutely essential and appropriate to entrust each of the workers on the team with more responsible tasks.

Already at the beginning of the year, the Yemeni team of restorers had taken on the role of compiling the "construction site journal" and the "attendance register".

The preparation of the daily site report is an operation involving collection of all possible information about every significant event occurring at the site each day. It mainly includes the list of workers, the materials or vehicles entering and leaving and the type of work performed. This serves to facilitate making estimates of timing and consumption even for extended periods. From October of the same year, team managers were appointed to supervise the various teams assigned to the different sectors, as well as scaffolding

Fig. 9. Yemeni boys on scaffolding, engaged in the final stages of pictorial retouching of the wooden decorated surfaces.

Figs 10 and 11.
The warehouses where local and Italian materials were stored and organized.

managers. At the beginning of February 2010, local operators then began to assist the Italian warehouse crew for control and organization of the material. Warehouse control has always been an extremely important job given the size of the warehouse, the long list of consumables and tools and the large number of operators who use them. The job of the warehouse workers is fundamental, it requires great constancy and precision in the archiving of data and in the ordering of materials, given the lack of availability of useful material at the site and the complexity of any procurement, which often required rather long lag times.

This training project for management of the construction site seriously involved everyone. The transfer of the organizational and direct management skills from the Italian operators to the Yemeni (now no longer students) certainly marked, for the latter, a sort of professional promotion that they received with gratification and with a great sense of responsibility. The program achieved its most notable progress after the assignment of part of the eastern sector to one of the Yemeni teams with the sole supervision of an Italian foreman. Also, for the team of wood restorers, local operators were picked to act as "team managers" supporting the Italian restorers in every methodological and organizational choice. These changes were decisive for the professional growth of the operators, and proved to be a very valid means of optimization, for the awareness of roles and operational choices, for the calculation of timing, for the control of material consumption and, as a direct consequence, for everyone to achieve better results.

2011 was a time of particular excitement and a year that represented a real unexpected test for the project the Yemeni team, the IVBC operators and the Institute itself. It was a period of political crisis for Yemen, in the wake of the "Arab Spring" which swept through the Middle East, and the country was seized by social and political turmoil, to the point that the Italian team suddenly had to leave the country for safety reasons, only to resume in May 2012, more than a year later. It was at this time that the local operators, despite all the enormous difficulties of the moment, with scarcity of means such as electricity, water, gas and fuel, showing great commitment and professionalism, and continued the work independently, staying in touch much as possible with the Italian operators.

It was a great satisfaction for the IVBC to note that during this period, in which the project could even have undergone a violent interruption, the Yemeni team was absolutely able to work with great energy and courage.

In conclusion, it seems appropriate to claim that together with the good conservative result, an exceptional result was also obtained from the project with regard to the collaboration and training in the sectors of restoration and construction site management, as demanding as that of the decorated wooden ceiling of the Great Mosque of Ṣan'ā'. Needless to say, the project result can be seen in the current state of conservation of the mosque and in the skill acquired by the workers. That is the only way in which we can judge the success of the project as conceived: an effective example of a working method and inter-institutional collaboration. An innovative aspect of the project is to be found precisely in the benefit of combining technical-scientific skills and the enthusiasm of those who learn new working methods and put them into practice, testing them in the field. Finally, it is in the construction site that moments and episodes of the training activities are documented and the identity of each student who took part in the school is revealed. It is they who are the real subjects of the entire project. A positive experience which, as the young people themselves testify, goes from the training opportunity in direct contact with the satisfactions and difficulties of an authentic construction site, up to the opportunity to experience what can only be characterized as a real life experience, of collaboration and meeting of different cultures and sharing teamwork. Beyond the conservative and project results, this is the real success, the real satisfaction that continues to strengthen the institutional commitment and makes all the difficulty in organizing and conducting a restoration intervention at construction sites in countries as far away as Yemen absolutely worthwhile.

Section 2 - Chapter 2

STATE OF CONSERVATION

Introduction to the general state of affairs and the main causes of deterioration

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

Structure of the ceiling

Located on the western side of the most important *sūk* in the old city, the Great Mosque of Ṣan‘ā’ al-Jāmi‘ al-Kabīr is one of the main and largest mosques in the capital, ready to host the numerous faithful during the hours of prayer. This monument of remarkable beauty is among the oldest Muslim religious buildings known until today, with construction traced back to 600-627 AD, when the prophet Muḥammad was still alive.

Fig. 1. One of the most classic views from the outside of the Great Mosque of Ṣan‘ā’.

The interior of the Great Mosque consists of four wings or, more properly, using the Arabic term, *riwāq*. The *riwāq* are in turn divided into a variable number of aisles: five to the north, four to the south, three to the east and three to the west. From here on we will


Figs 2 and 3. Two images of the interior of the Great Mosque of Ṣan‘ā’.

refer to the *riwāq* naming them in relation to their position and relative cardinal point and in reference to their historical development inside the mosque.

The flat roof is supported by arches and columns in various styles whose systematic use in the Mosque can be probably explained by the exposure of Ṣan‘ā’, in previous centuries, to the structural systems with Byzantine and Sassanid arches. The layout, rectangular in shape, now measures 78 x 64.70 meters approximately, with a wide inner courtyard where a simple two-story building stands, covered by a dome, called the *qubbah*.

This building has historical value only and, contrary to the opinions that are often read in popular or travel books, it does not appear to have any religious or symbolic significance. Its function was always to store documents, bequests and records, a sort of *bayt al-māl* or treasury for legal documents.

The ceiling of the mosque proper consists of 5,200 coffers, divided into rows of five or six depending on the *riwāq* and separated by beams, covering an area of about 3000 square meters, all painted and some partly carved. The structure of the ceiling is stratified and generally composed of four distinct levels whose thickness can vary, even considerably, depending on the *riwāq*. Proceeding from the external upper level we will have a structure as follows:

- The ceiling cover is sealed on the outside, generally with hydraulic plaster composed of lime mortar and inert material several centimeters thick, known locally as *qaḍāḍ*. The particularity of this compound is not so much the type and quality of the materials, but rather the methods by which it is applied. The plaster does not appear stratified, as is sometimes the case in the western tradition, but is rather applied according to the local technique which consists of application of a first layer of mixture with coarse aggregate granulometry, repeatedly beaten with a cut stone, on which a further layer with a finer granulometry of aggregates is applied. This is also continuously beaten, resulting in a complete interpenetration of the mixtures reaching even considerable thicknesses (the number of layers applied generally varies up to a maximum of four).

Fig. 4. View of the exterior surface of the mosque ceiling.

Fig. 5. Yemeni master intent on executing one of the drafts of the *qaḍāḍ*.

Subsequently, the plaster is further finished by rubbing it with a flat stone until the surface is very smooth and shiny. Finally, the application of the final veil of animal fat gives the surface water-repellent characteristics.

- The *qaḍāḍ* layer rests on a second layer consisting of a mixture of clayey earth, stones and inert material of different kinds. This layer is the one that has the greatest depth of all, even if its thickness also varies greatly depending on the *riwāq*. Since its function is that of filling and support for the *qaḍāḍ*, its thickness is relatively important.
- The next layer consists of a thin bed of compact plant material, composed of branches, fagots and straw, which serves to prevent direct contact of the overlying earth with the wood of the coffering, and acts as a protective cushion to lighten the weight of the cover and probably also insulate the materials and spaces below from thermal excursions.
- With the surveys made at various points it was possible to calculate the weight on the entire thickness of ceiling which, although differing in various points of the roof, was proportional to the thickness of the layers, and amounted on average to 400-500 Kg/sq.mt. An incidental load such as one or two people per square meter in charge of

Fig. 6. Part of the open ceiling with the coffered panel exposed.

Fig. 7. Stratigraphic view of the ceiling cover.

maintenance walking on the roof, i.e., 150 Kg / sq.mt. was also considered. However, these values could significantly increase in the event of water seepage, due to wetting of the layers of soil.

- The last level is the wooden ceiling whose characteristics vary according to the *riwāq* and which we will consider more fully later.

At the base of the ceiling, supporting the entire coffered system, there are large, sturdy supporting beams positioned transversely to the direction of the *riwāq*. The roof consists of more than 1200 such beams, measuring 14 x 22 cm, the length varying between 3.5 meters and 4.00 meters. The beams are spaced about 70 cm apart. The two ends of the

Fig. 8. Detail of the rear of the coffered ceiling, visible following the opening from the outside.

beams rest on the walls of the colonnades remaining embedded in the masonry for about 20/40 cm per side.

The coffered system, made up of diagonal boards, strips and frames, consists of a truncated pyramid, formed by five or four rows or levels, closed at the top by a square tablet. The first level consists of two joists that rest on the load-bearing beams, mounted perpendicular to the beams themselves. These joists are generally 65 cm long, 12 cm wide, 6.5 cm high and have four vertical grooves, 1.5 by 1.5 cm, 7.5 cm from the ends of the joist. The tablets, mounted parallel to the supporting beams, 47 cm long, 6.5 cm high 3 cm wide, with a relief of 1 cm, are inserted into the grooves of the transverse joists.

The second level consists of 4 joists 55 cm long, 9 cm wide and 5 cm high, with overlapping joints of 9 cm. These elements are installed in a square, resting on the joists of the first level.

The third level consists of 4 joists 47 cm long, 7 cm wide and 5 cm high, with overlapping joints and mounted parallel above the second tier.

The fourth level is made up of 4 triangles with two right-angled sides that form the 23 cm catheti while the hypotenuse of 33 cm is 3.5 cm high. The two edges between the catheti and the hypotenuse are rounded by 1.75 cm to allow them to overlap and interlock. They are mounted with the legs parallel to the underlying joists, leaving a square void, in the center, rotated 90° with respect to the supporting beams.[1]

The fifth level is a 30 cm square tablet, its side 3 cm high, mounted in the center of the pyramid with the sides rotated 90 degrees with respect to the beams so as to close the top of the pyramid.

The whole system thus consists of fifteen separate elements including dividing subbeams, except for the east and west wing whose coffering is composed of only four levels for a total of eleven elements.

Fig. 9. Interior detail of the ceiling and coffer in the west sector.

1 All the measurements shown here refer to a generic model of a coffered ceiling, which we deemed necessary to provide in order to give the reader a more concrete image of the dimensions of the artifact.

Fig. 10. Exterior detail of the "pyramid" formed by the elements of the coffering.

Fig. 11. A coffer in the north sector broken down into a counter.

Some coffers, for example in the west *riwāq*, and in some cases also the beams, as in the east sector, are decorated with carvings. The basic construction is wood interlocking with the components simply resting one on top of the other, without nails or other types of fastenings or gluing but held together by the weight of the upper ceiling. The main wood types used for beams, joists, coffers and for the carved parts is *ṭunub* (Cordia abyssinica), a native acacia with excellent mechanical characteristics and durability over time which makes it a very versatile wood widely used in past but now a rare and protected species. When available *ṭunub*, was also used for machining the restoration.

Since the characteristics of the coffering and its deterioration vary according to each *riwāq* and given the presence of particular construction situations and the great variety of decorative systems, the discussion will be more detailed in the following chapters devoted to the individual wings of the mosque.

STATE OF PRESERVATION

Degradation analysis

As a first step toward the restoration of the wooden ceiling of the mosque and its decorations, it was necessary to make a complete relief drawing of the building, with all the useful information. This would ensure that the materials were treated in an appropriate manner, and any pathological conditions, and causes of deterioration dealt with adequately in their contextual situations. This elaboration of in-depth analysis and diagnostic investigation was not limited to a preparatory phase for the actual intervention, but it was considered an integral part of the actual work, accompanying the operations planned according to their evolution, verifying their effectiveness, adapting to the acquisitions as work progressed and possibly suggesting new solutions. The restoration project thus became the result of an assessment made on the basis of a detailed study of the existing situation, from the preliminary investigations, starting from the historical analysis of the building, and continuing with a survey in the appropriate scales, while fully identifying physical structures, as well as identifying, cataloging and quantifying materials and pathologies.

At a later stage, a macroscopic morphological study of the object and the artifacts was carried out. This involved a photographic survey at various levels, visual and tactile analysis, etc., with the aim of arriving at an in-depth chemical-physical-mechanical analysis that would permit identification of both qualitative and quantitative material as well as of the chemical composition of the materials employed in producing each artifact. The same kind of operation was then partly carried out also on the pathogens afflicting the building in order to identify them fully, with all their physical, chemical, biological and microbiological characteristics.

These studies made it possible to identify, to a great extent, the physical and chemical characteristics of the artifacts in order to highlight any alteration while identifying the intrinsic causes and extrinsic, direct or indirect problems generated by deterioration. General instructions were provided in this way for a set of measurements which can be performed at a later stage, on different levels of data acquisition, although, for the time being, those acquired at the first level were considered sufficient.

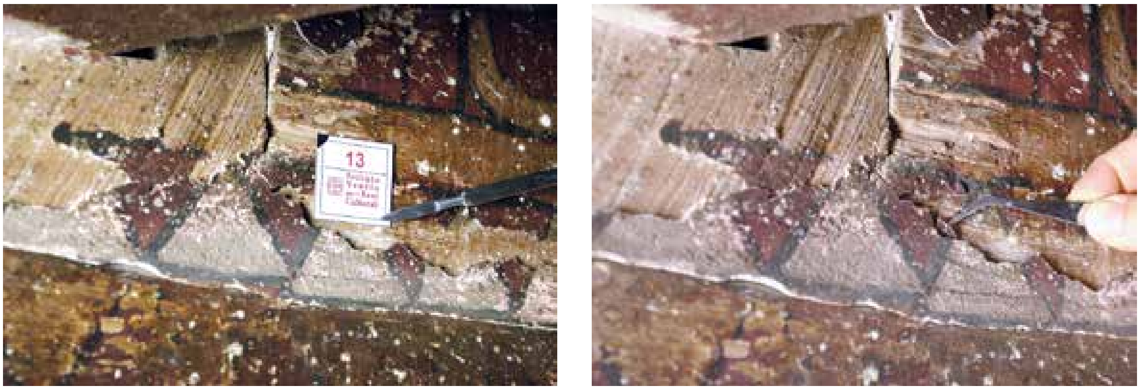
First level: this consists of visual inspection, useful for establishing intervention priorities and planning subsequent second level diagnostic investigations. It consisted of observing the outer surface of the artifact directly, highlighting any significant peculiarities for the purposes of a first macroscopic diagnosis: color, adhesive quality of the pictorial layers, layers of sedimentation, degradation pathologies, executive techniques, etc.
It was then possible to perform other tests to identify any surface roughness, alterations, cracks, foreign bodies used for tie-off, consolidation or fastening of artifacts, areas altered due to water damage, fumes, greasy deposits or other pathogens of various types and origins.

Second level: this consisted of detailed in-depth investigations. Based on the information acquired at the first level of investigation, in-depth analyses of a minimally destructive nature were carried out to help determine more precisely the physical and chemical properties of the materials.

Surveys, photographs and chemical analyses highlighted three types of deterioration: physical, anthropic and biological.

Degradation due to physical causes

The physical causes of deterioration can be traced back to mechanical, thermal events sometimes accompanied by water damage or damage connected to the absorption of



Figs 12 and 13. Identification of the sampling point and the moment of collection of the pictorial film sample.

radiant energy. The mechanical damage could be accidental, when not referable to events that can be framed according to rational and predictable schemes, such as collisions, earthquakes, etc., or non-accidental, referring to events such as induced vibrations, dilatations / contractions determined by the thermal gradient and by temperature variation.

The thermal gradients with the relative humidity variation, have similar effects to those due to heat transfer with the relative mechanical tensioning, and it is all the more significant the more the material under examination shows a hygroscopic character. The mosque ceiling materials, for example, are strongly hygroscopic, being composed of wood, protein binders, mainly present in tempera colors, and layers of glue and plaster, thus particularly subject to variations of temperature and humidity.

The transformations connected to the absorption of radiant energy are in most cases those due to solar radiation, though artificial light also can be a source of alteration. It was noted how inside the mosque, the aisles adjacent to the windows facing the inner courtyard, which for many centuries were left open, are the most damaged and present patchy areas. Furthermore, the wood has often changed color due to the action of air and light, fading and becoming more discolored.

In studying the physical causes of deterioration, reference must be made to "Thermo-hygrometric" conditions inherent both to the environment and to the asset considered, in particular to variations in temperature and thermal energy transfers. The greatest damages are in fact due to repeated or abrupt temperature changes that have the same effect as the freeze-thaw phenomenon and are therefore typical of regions with extreme temperature excursions, such as Yemen. In addition, the presence in the product of several materials with different coefficients of thermal expansion, also leads to damage which increases with the differences in expansion.

The control of internal and external relative humidity is fundamental for the conservation of assets, especially when referring to a painted wooden structure such as the ceiling of the Great Mosque of Ṣan'ā'. The low relative humidity of the region, generally

Figs 14 and 15. Examples of severe transverse beam fractures.

below 20%, does not pose a threat to the wood, which was attacked, instead, by dangerous infiltrations of rainwater, penetrating due to poor maintenance and the particular morphology of the roof covering.

Rainwater caused degradation that involved both the wooden support and the painted surfaces and was at the origin of the structural failure of some supporting beams; the disintegration of frames, joists and coffering and of the alteration of the surface of the wood of which the pictorial film has been lost.

Anthropic damage

Over the centuries, various maintenance interventions were carried out, with the intention of safeguarding the damaged parts of the ceiling or to repairing the damages caused by defects in the external covering of the ceiling. It is therefore not uncommon to find a second support beam inserted under or near one of the original beams which had fractured and was creating a risk of structural collapse; beams with metal elements of different types were used (hooks, nails, chains, containment bands, etc.); areas with infill walls in wood, plaster or mortar, many times performed to make up for missing elements, fallen, lost or damaged coffers; the coffered areas were sometimes or disassembled and reassembled, not always respecting the correct original position of the single elements. Furthermore, the splendor of the decorations was hidden for a long time by a very thick surface crust of dust and greasy soot left by the oil lamps used until a few decades ago to illuminate the interior of the mosque.

Figs 16, 17 and 18.
The images show one of the most common degradation factors of the wooden structure: water dripping with meteoric effect from the outside resulting in the washout of the pictorial matter and formation of white rot.

Figs 19 and 20.
Example of collapsed caissons due to infiltration of rainwater which weighed down the coverage material by weighing down the load.

Another disturbing element was represented by the application on the walls, over the centuries, of several layers of plaster and more recently of acrylic paint, which overflowed onto the wooden ceiling, hiding part of the decorations. It was common practice in years past, particularly in the days leading up to Ramadan, to perform maintenance operations inside the mosques. The simplest and most obvious operation consisted of whitening the walls with a paint based on plaster, replaced in more recent times with acrylic or enamel. This type of cosmetic maintenance was sometimes done carelessly and hastily, almost completely covering a large part of the decoration on the ceiling and bands corresponding to the Koranic inscriptions along the base perimeter of the ceiling itself.

Deterioration due to biological causes

The causes of biological deterioration derive from the establishment and growth of colonies of microorganisms (fungi, bacteria), which interfere with the constituent materials of the artifact. The phenomenon is also referred to as biological pollution or biodeterioration.

Fig. 21. Example of an old maintenance intervention that attempted to repair or avoid a complete fracture of the beam.

Fig. 22.
Example of an old maintenance intervention that fills the lack of one of the four triangles with one plaster grouting.

Fig. 23.
Example of an old maintenance operation where the coffer probably covered with plaster to fix and stabilize its unsafe elements.

Fig. 24.
The same coffer in fig. 23, following cleaning and structural restoration.

Fig. 25. The same coffer seen in fig. 23 and 24 after the restoration is completed.

The category of biodeteriogens includes not only microscopic organisms, but also organisms such as insects, birds, rodents, etc. One of the main problems related to biological degradation is in fact caused by birds with their feces. These induce an action of chemical erosion (and this is what happened mainly in the first rows of coffers in the west ailes). Guano is very acidic due to the presence of uric acid (C5H4N4O3), containing phosphates and nitrates which can penetrate into materials. This, combined with the direct attack of the materials, water seepage and the relative increase in humidity, creates the ideal environment for the life of other aggressive microorganisms. Again, the relative humidity conditions can be considered essential for the prevention of biological degradation of the product. The wooden species used in the ceiling of the mosque all belong to the genus of the acacias, a family of broad-leaf trees that resist well to the aggression of deteriorating agents. In fact, most of the wooden surface, at a first visual inspection, seems to have remained fairly intact. However, the removal of the roofing material above the coffers and beams revealed a rather critical situation, also due to the presence of other less resistant wood species and more severe environmental conditions, which enhanced the effect of fungi and parasites.

In fact, many wood species less resistant to deterioration, in this case essentially conifers, also subject to the prolonged and incessant attack of insects, revealed rot, separation and pulverization of the wood, with an almost total loss of polychromy. The ceiling was also covered with layers of dirt, of organic residues of various kinds such as cobwebs, insect or bird nests, guano, soot, etc.

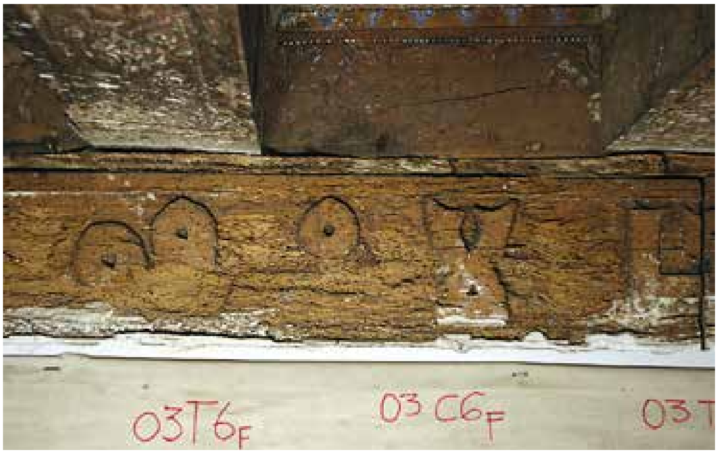


Fig. 26.
Detail of one of the bands of Koranic inscriptions severely damaged by the action of xylophagous insects and brown rot.

Fig. 27.
Detail of the west ceiling affected by an intense bird nesting action.

Figs 28, 29 and 30.
Examples of beams affected by the particularly destructive action of brown rot.

Section 2 - Chapter 3

GENERAL REMARKS

Restoration intervention

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

In the field of cultural heritage conservation, design choices are made on the basis of the outcome of preliminary, fundamental studies and an organic set of investigations aimed at deepening the knowledge of the work of art to be restored, its execution techniques, the previous actions applied for its conservation and the environment in which it exists. The designer coordinates and makes use of studies carried out by specialized professionals (chemists, biologists, physicists, photographers, art historians, architects) to formulate intervention proposals.

At the basis of the methodological choices made is the desire to restore the original decoration but also to maintain any previous interventions, especially older and more esthetically valuable ones, and those considered compatible with the conservation of the artefact itself. One of the critical issues in this sequence of operations is the problem of integration: to what extent is it legitimate to restore missing color or design? What is the limit between restoration and reconstruction?

Restoration is also a work of esthetic retrieval, which can lead to different results. A cleaning can be more or less incisive, a more or less heavy retouching, the general tone more or less opaque or clear. The balance between conservation, legibility and adaptation to the needs of use is not always an easy one to achieve, so the interventions that are carried out, especially on a millenary asset, require care and attention for the balance and harmony of the whole. A work of art is by definition unique. The Great Mosque of Ṣan‘ā’, with its message that crosses the boundaries of place and time, in addition to being an inestimable religious asset, stands as a testimony to the culture of the people who built it and, as such, summarizes in itself the added value of historical evidence that must be safeguarded and made accessible for generations to come. For the same reason, the entire historic center of Ṣan‘ā’ has been declared a World Heritage Site by UNESCO.

Restoration of the wooden structure

The degraded conditions of the ceilings made it necessary to carry out an in-depth study of the load-bearing structure, involving specific professionals, in order to determine the best conservation methods, especially of the beams, some of which had collapsed. The importance of a structural intervention on the wooden support led over the years to the formation of a real professional team specialized in wood restoration.

The operators were first of all engaged in correcting the maintenance interventions carried out over the centuries, in particular those performed clumsily on the structural failures of the beams, and in restoration of all the elements that required complete or partial disassembly, given their particular conditions of deterioration. For two specific conditions, broken beams or large areas in which a coffered panel was collapsed or was in extremely critical conditions, an intervention methodology was developed which, over the years, while constantly being improved upon, has become routine practice and is now thoroughly tested.

By broken beams we mean those that clearly show a break in the fibers of the lower part in an area close to the middle of the beam involving about 1/3 - 1/4 of the support.

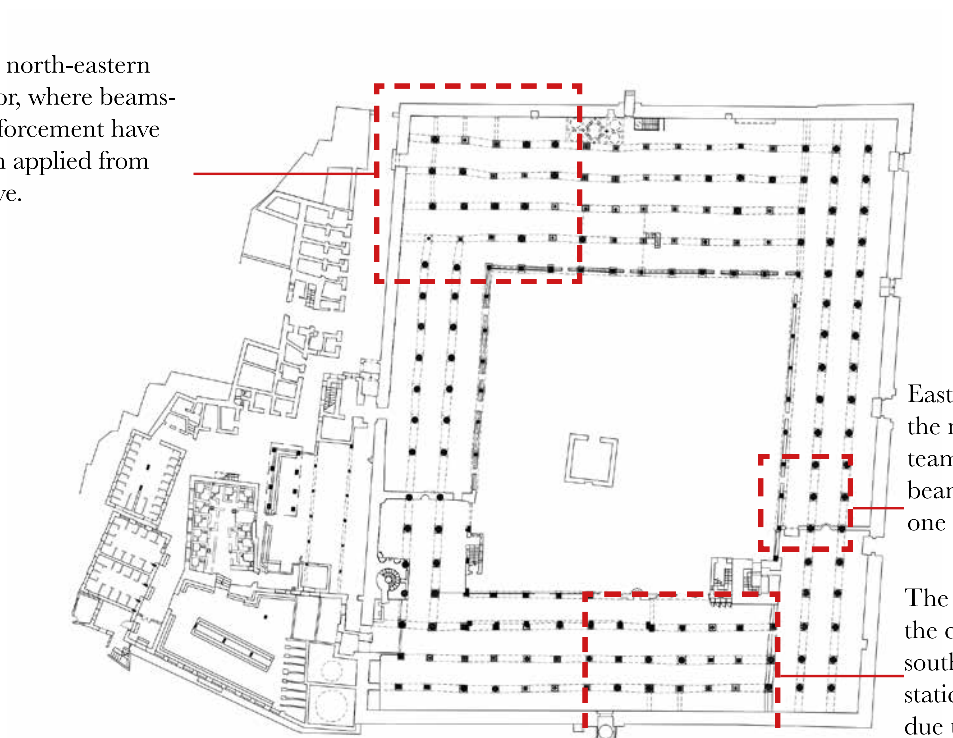


Fig. 1. Plan of the roof slab.

For example, in the area to the east, near the minaret, there were five beams that were broken and were quite close to each other.

It appeared that in that area the load of the roof, created by the *qaḍāḍ* assembly, was high precisely because of the choice then adopted to drain the rainwater towards the south.

This meant that in order to guarantee the slope, it was necessary to increase the overlap of material with a consequent increase in weight. All the beams in that area appeared to be noticeably bent downward by the weight above.

The method chosen to reinforce the beams which, in keeping with the principle of conservation, appeared initially to be a rather complex process, was studied at length. Finally, it was decided to intervene from above, inserting steel girders (IPE 180 or HEA140 type profiles), previously painted and resting on the walls of the underlying arches, capable of absorbing the load of the roof above and relieving the damaged wooden beams of the weight, so that they no longer had to be replaced as they no longer performed a structural role. In fact, a framework of rafters will be placed transversely above the beams on which the roofing assembly will be reconstituted.

Fig. 2. Example of one of the most common types of maintenance work performed in the past to solve the problem of a fractured beam at risk of collapse.

Figs 3, 4 and 5. Some examples of borderline situations of transversely fractured beams and the related past repair attempts.

A proposed intervention, alternative to the one just outlined and which would have been much simpler to implement, provided for the insertion of steel plates on the two side faces of the broken beams. In addition to the questionable esthetic effect, this type of reinforcement would not have fully guaranteed restoration of the load-bearing capacity due to the impossibility of extending the support of the profiles inside the walls, which would then be fastened only with lateral screws to the same broken beam.

The first step was therefore to dismantle the external *qaḍāḍ* of the ceiling and remove of all the covering material, in order to be able to disassemble the entire wooden structure of the coffer and proceed with a more effective and precise intervention.

Subsequently, the portion of coffer bordering the damaged beam, after being secured with an adequate shoring system, was necessarily disassembled. In the event that the damage to the beams was such that it could not even support its own weight and that of the coffer structure, the beam was fastened and an attempt was made, if feasible, to reduce the warping caused by the fracture, using steel rods threaded into a pair of steel beams, also supported and anchored to the load-bearing walls.

Fig. 6. The coffer free from covering material.

Fig. 7. The dismantled coffered beam and joist system is visible in the image.

Fig. 8. Side view of a beam to which a support beam has been attached.

Figs 9 and 10. Detail of the threaded rod for coupling between the wooden beam and metal beams.

In those cases when it was possible to raise parts of the beams in order to re-connect the fractured areas and reduce the curvature, the lifting process always had to be slow and gradual, with just a turn or two of the bolts on the threaded rod every day or so.

Particular attention was given to the position in which to drill the hole for the tie rod and housing dowel for the nut and washers on the lower surface of the beams.

Figs 11, 12 and 13. Detail of the system used for inserting the hook bolt to the threaded tie rod.

Most of the beams are decorated and some are carved, so this operation had to be carried out with extreme care. The choice of the portion to be removed was determined as the best possible compromise between the most advantageous position on the decorations present in the area in question and the most functional position for the draft. The removal of the dowels on the lower inner face of the beam was performed with a small cutter capable of making fine and precise cuts, after localized raising of the area where the cut was made with 5% Paraloid solution in acetone. Also in this case, the removal of the dowels was accompanied by accurate photographic documentation, as well as by labeling so that correct repositioning of the dowels was guaranteed.

After anchoring the beams to the load-bearing walls, the tie rod with its nut and two washers were installed in both the upper and lower end of the bar. The tie rods were then tensioned, repeating this operation once a day, until the fractured beam was repositioned as close as possible to its original form. Once it was found that the beam had reacquired an adequate structure, the cavities were closed with the original plug previously removed, thus also reducing the esthetic impact of the intervention.

Proceeding as described above, although the beams no longer possessed physical characteristics adequate to play a structural support role, now performed by the new steel girders, their esthetic qualities were preserved, thus preserving both the originality and the authenticity of the ceiling.

It should be noted that for the entire duration of the restoration work only three beams were replaced. These replacements were justified by the fact that the beams were both badly damaged, with compromising fractures from a static point of view, and devoid of any esthetic and historical value. All the beams that required structural reinforcement, even those that could no longer perform any static task, were maintained and secured with metal support beams as previously described.

Those parts of the coffer that had yielded and collapsed, or where evident cracks had opened in around the joins, were disassembled, restored and repositioned as much as possible in their original position and then fastened with small applications of aliphatic resin Dap-Weldwood. The adhesive based on aliphatic resins (Dap glue) diluted in water has excellent compatibility with the original materials and can also be used for fixing small raised wooden splinters, as is actually done, by inserting the same glue with syringes or small spatulas. Some elements of the coffered ceiling were also fastened and secured with wooden pins. The use of wooden dowels, instead of metal screws, follows the principle of respect and conservation, and the compatibility of the materials that we were going to insert in such an ancient ceiling, originally assembled only by interlocking.

Even where the state of preservation was critical only for the coffered panel and not for the beams, which could still perform their structural support task well, we preferred to operate from above with the removal of the roof covering, in order to carry out more correct and precise intervention.

The inspections conducted on the extrados of the false ceiling members revealed that almost all of the wooden elements had undergone considerable biological deterioration over the centuries, such as to have considerably reduced the size (especially in thickness) of individual elements. In cases where it was possible to operate from the outside, the disassembled element was treated so as to restore, as far as possible, its original size. This operation was essential in order to guarantee both the solidity and the functionality of the structure.

When the coffered ceiling was disassembled, each element was numbered and documented, both graphically and photographically, to verify its exact position in the subsequent reassembly phase.

The disassembled elements were then treated, where necessary for the presence of fungi or other microorganisms, with a fungicide such as Biotin T, while woodworm treatment was carried out on almost all the surfaces.

Subsequently, given the state of deterioration on the back of the surfaces, consolidation was carried out using acrylic resin such as Paraloid, with solutions varying between 5% and 10% in acetone, applied with a brush or with injections for a deep treatment.

Missing parts, gaps or thinning were reconstructed through integrations and shaped wooden dowels or by reinforcing the structure with a bi-component resin of the Araldite type. The wood used for the additions was generally, when available, a local wood called *ṭunub* (*Cordia abyssinica*), a rare and valuable wood species whose excellent mechanical characteristics are already well known and documented by historians and scholars.

Alternatively, *sdra* was used, as teak wood (*Tectona grandis*) is called by the Yemeni carpenters. This is an imported wood, probably from India, and its qualities, although inferior to those of the nobler *ṭunub*, are good and functional for the necessary processing. *Sdra* was never used for visible parts or works of particular importance, always favoring the use of *ṭunub*. All the wood and new dowels used for the restoration work, before being installed, were treated with woodworm repellent.

In the event that the coffered elements had split or cracked, the edges were joined and fixed with Dap Weldwood glue or with bi-component resin packed with sawdust, also aided by clamps or props and sometimes with wooden pins. Finally, the coffered panels were backed from the outside, with wooden strips (casing) of adequate size and size, in order to close any cavities or gaps between one element and another on the panels. This operation will prevent any particulate matter or dust from the external plaster from falling inward.

During reassembly, always accompanied by the photographic documentation carried out at the beginning of the intervention, the levels of the coffers were fastened horizontally and not vertically, so that the coffer was still mobile for any future inspections and checks on the inner surface. Precisely to facilitate these inspections, a map was drawn up of all the coffers left mobile.

As a final stage of the work, complete photographic documentation of the reassembled and restored ceiling area was made.

Here we would like to focus in particular on the work of closing the ceiling, as it posed problems that inevitably required lengthy study. The main issue was particularly concerned with the suitability and real need of using the original closing technique, consisting of the four levels illustrated above, or whether it would be better to use a different technique. It was evident that the layer that acted as a cushion, made up of branches and straw, and that the humidity contributed by the upper earthy compound, favored biological degradation due to the proliferation of mold and insects of various kinds, harmful to the wooden structure of the ceiling. It was therefore decided, for reasons pf conservation, to replace the fine twigs with larger branches adequately treated with woodworm repellent to prevent the proliferation of insects and, thanks to the presence of the new metal girders as support surface, they no longer came into direct contact with the lower wooden structure.

In the event that the conditions of the coffered panels and beams was not so critical as to justify the removal from the outside of the roof and complete disassembly of the area, the restoration work carried out can be considered in general the same as in the open areas, as described above. The difficulty of this work was in some ways greater than in a situation of opening the ceiling where, although more time-consuming and complex, it was much easier to dismantle the elements of the coffered ceiling. Working from the intrados, however, meant disassembling the coffered ceiling according to a method that contrasted with the nature, conformation and predisposition of the joints and above all caused a large amount of precipitation of the material used to fill the space between the ceiling structure and the roof (twigs, earth, stones, plaster, etc.).


Fig. 14. First phase of closing the ceiling.


Fig. 15. Intermediate phase of closing the ceiling.

Restoration of the polychrome elements (intervention phases)

General method of intervention

From a methodological point of view, the actual restoration intervention can be described according to general guidelines that characterized the work itself in all four sectors, while noting that there were some typological differences and states of conservation. The following operational description is a generic outline of the methodological and executive process of the essential phases that characterized the restoration work in the Great Mosque. The intervention stages can therefore be summarized as follows.

Documentation

Each step of the restoration was meticulously and constantly accompanied first by a graphic documentation and then by a photographic documentation, which made the learning process clearer for the Yemeni operators, and documented the state of affairs and progress of the work.

Graphic documentation

A graphic mapping was carried out, using felt-tip pens of various colors, highlighting the areas with the different types of deterioration. On the side of the graph, the interventions performed were described, completing the documentation step by step with the progress of the work. This type of documentation, which gradually accompanied the work in all the operations performed, facilitated more rapid and precise compilation of the weekly and monthly periodic reports, as well as direct control of timing and material consumption.

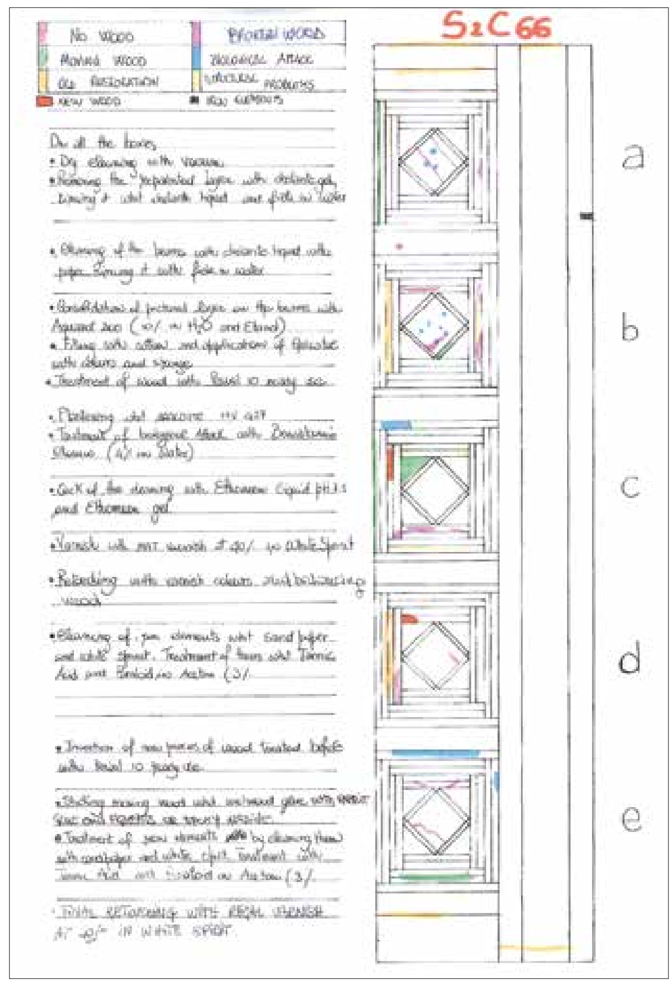


Fig. 16. Example of the form used for the first graphic documentation, compiled with observations on the state of affairs.

Photographic documentation

Before the intervention, all the ceilings' elements were photographically documented in high resolution digital: coffers, sub-beams, beams, metopes and sleepers. All the details affected by the different types of decay were photographed, all the areas that needed carpentry work, the cleaning pads and the retouching pads. The photographic documentation also meticulously followed the development of the work, documenting particularities that came to light during the course of the work, as well as documenting all the work, step by step, and not just limited to a summary report of work stages at the end.

Removing the plaster

Following the various graphic and photographic documentation stages, we proceeded with the removal of the plaster present on the walls and on the perimeter of the ceilings. The removal of the perimeter plaster made it possible to recover the original compositional elements of the coffers, like the of Koranic inscription and metopes, which were previously hidden, permitting more thorough and timely intervention.

Mechanical cleaning

Mechanical cleaning serves, through the use of tools such as scalpels, brushes or brushes with soft bristles and sponges of the wishab type, to remove powdery deposits and organic or inorganic materials of various kinds on and around the sections unrelated to the artifact. This last operation, also known more generally as the "*descialbo* phase", was concentrated mainly around the ends of the beams, on the sleepers and on the metopes where there were countless layers and splatters of plaster or white acrylic paint applied in previous slapdash maintenance interventions, which proved to be very delicate. Particular attention was necessary to avoid damaging the very thin and fragile paint layer below.

Preliminary consolidation and cleaning tests

Before starting to operate anywhere in the building, preliminary tests were always performed to identify a consolidation and cleaning system. This operation, often preceded by detailed chemical analysis, allowed us to take a professional approach to the work. As we know, full understanding of the subject to be restored is essential in order to plan and implement a correct method of intervention.

Color consolidation

This was necessary for all those areas in which the pictorial layers were not cohesive, with raised scales or powder. We first intervened with localized fixative of the raised scales, by brush or injection with syringes, and subsequently with a more general adhesion by application of Japanese tissue paper, as protection against the possible abrasive/mechanical effects of the brush. Consolidation preceded the cleaning phase thus making it safer.

The adhesive used most is Klucel G, as it has the necessary adhesive power and, as a cellulose, is also the most respectful of the fundamental principles of restoration such as compatibility and reversibility. A second binder used was Aquazol 200, as it has good resistance to aging and high reversibility. Both materials were used in low concentrations.

Figs 17 and 18. Some blocks and cleaning tests carried out in the eastern sector.

Chemical cleaning

Cleaning is one of the operations most frequently performed in restoration and is also one of the most complex, for a number of reasons. In the first placem, it is an essentially irreversible process, because it tends to remove materials that can no longer be retrieved in any way. In addition, it takes place in a vital area of the painting, the area in direct contact with the layer of color, on the painted surface of the work, to remove material that is extremely close to the pictorial film, but it is almost always indispensable. In fact, in addition to providing greater legibility, it also serves to remove substances that over time can prove harmful to the color and to the structure of the product as a whole.

Of all the various operations carried out in restoration, along with chromatic integration, it is also the one that has the most immediate impact on the viewer of the work of art. This aspect too has very significant implications in determining the criteria that regulate the modes of intervention. Finally, the fact that there is also a real "esthetic" factor should not be underestimated. This is what gives the restored work something of the flavor of the particular historical period and culture in which the restoration was done.

As often happens for interventions of this type, on painted surfaces sensitive to water, without adequate preparation or without any final protective coating, cleaning is the most difficult and delicate stage of the intervention. The greatest problem for the restorer is not so much removing the substances, but performing the task without affecting the original materials that make up the artifact itself. In this regard, careful preliminary tests were always carried out, starting from the materials identified and from the chemical analyzes performed on them and also from the experiences gained over the years, in order to adopt the most suitable methodology for the specific case in question. Although the particular specificity of the polychromies present in the various sectors makes it rather difficult to define a generic guideline followed, both in the material and in the methodologies, in general we can say that the cleaning was performed with a pad and compress, favoring gelled solutions that moisten the surface very lightly, also differentiating the application times and rinsing methods. The interposition of Japanese tissue paper ensured greater control of the action of the reagent, reducing the risk of abrasion of the painted surface and the penetration of the material.

The materials used for the cleaning phase of most surfaces were surfactants such as ox gall, Tween 20, coccocollagen and artificial saliva and chelating solutions with variable Ph depending on the need.

In particular, the use of surfactants alone proved to be very effective. Surfactants can be used in restoration for various reasons, both for the fact that they impart particular properties, so-called surface properties, to the aqueous solutions or organic solvents to which they are added, or for their detergent and emulsifying power.

At low concentrations, surfactants in solution lower the surface tension of the liquid, and show only surface properties such as greater wetting power, less vertical diffusion under the surface and less capillary rise. At a higher concentration, aggregates of surfactant molecules are formed, called micelles, which impart emulsifying, detergent and solubilizing properties to the solution. The quantity of surfactant necessary for this to occur is called the Critical Micellar Concentration, or CMC, and is characteristic for each surfactant.

This delicate cleaning operation, although it has not always obtained perfect results due to the fragility of the material on which it has been applied, has nevertheless proved satisfactory in many cases and, at times, yielded some pleasant surprises. There were several discoveries and findings during this phase, such as writings and interesting drawings unrelated to the decorative motif. Cleaning thus also becomes an opportunity for further study and the acquisition of important new information from a historical standpoint.


Figs 19 and 20. In sequence on the left, cleaning a tile, and on the right a pictorial integration test carried out on the same beam in the west sector.

Disinfestation

After the cleaning phase, a biocide (benzalkonium chloride at 4% in water and alcohol 1:1) was applied with a brush for greater penetration on all areas affected by biological attack and white caries, while woodworm protection, based on permethrin (Permetar), was applied by impregnation and by syringe on the entire surface and in particular on all the disassembled elements.

Treatment of metal parts

Metal parts (hooks, lamps, nails, chains, etc.) were left in their original locations if they were not obvious aesthetic disturbances and especially if their presence did not jeopardize correct conservation of the decorations. They required rust removal, using abrasive paper and metal wool rolled on wooden rods. Small grinders were also used. They were then cleaned with white spirit on a pad, the application of 3% tannic acid in ethanol, as an inhibitor and, once dry, with the application of 5% Paraloid in Acetone, as a protective coating.

Grouting and sealing the cracks of the joints

The operation of integration of the support gaps and sealing of cracks, voids and holes, was initially preceded by a series of preliminary tests, aimed at defining the most suitable technique and material to fill these gaps in the best possible way and maintain good surface continuity. The operation applied two methods depending on the type of work needed.

The first was to plug the gaps between the coffered elements, i.e., where the cracks are not attributable to deficiencies or breakages, but generally created by shrinkage of the decayed wood, by a previous incorrect relocation of the elements or, finally, by unusual movements of the wood structure. The need to close these voids was both esthetic and practical, as filling material in the space between the wooden ceiling structure and the external mortar roof (*qaḍāḍ*), such as twigs, earth, stones and plaster, could fall through the openings). For this operation, a natural fiber (cotton) soaked in polyvinyl alcohol (Gelvatol) and suitably pigmented was inserted in depth or sub-level, in order to match the tone of the wood.

The second consisted of actual grouting. This was done on medium-large gaps, on the breaks and cracks that had formed over time on the wooden support to recreate the unity and uniformity of the painted surface. The shallower spaces were filled with bi-component epoxy resin of the Balsite type and, while the larger cracks were patched with bi-component epoxy resin of the Araldite type as a base, then finished on the surface with Balsite resin. To obtain a color similar to that of the wooden support, stable powder pigments were added to the mixture.

Preliminary painting

The painting preliminary to the retouching stage was carried out with matt effect paint, produced by Lefranc & Bourgeas, diluted with white spirit in variable amounts depending on the case.

Retouch test

The retouching tests always preceded the pictorial integration phase and were performed, where possible, on the areas where cleaning tests had previously been performed.

Pictorial retouching

This very delicate step was the subject of much reflection among the various actors in order to adopt the best theoretical and technical operating criterion. Since today the restoration is no longer a reconstruction, or a completion of the missing parts, greater attention is given to reintegration. The gaps, both in the support and in the pictorial materials, disturb the integrity of the image that is fragmented, and the reintegration tries to reduce this disorder by "mending" this fragmentary whole.

A reconstruction of the support (also plastic if easily interpretable because repetitive of frames etc.) is justified from a critical point of view as long as it restores the potential unity of the work and observes the essential rules: to be recognizable on close observation, to respect the original materials, and to be reversible.

The gaps on a pictorial or gold leaf layer can only affect the paint film (abrasions) and therefore be treated with lowering of tone or watercolor glazes; they may also include the underlying material layers that are susceptible to reconstruction, and are therefore treated with a plaster reconstruction of the preparation and reconstruction of gaps by "hatching" or "dotting". In the case of gaps which, due to their extension and location, cannot be reconstructed, the support is left exposed or possibly treated with a glaze.

In the specific case of the restoration on the polychromies of the ceiling of the Great Mosque of Ṣan'ā', varnish colors were used with the intent to mend the pictorial fabric in tone, only where possible, or in situations in which the decoration was recognizable, where there were small shortcomings or in the points where the pictorial film appeared abraded and grainy, while for more conspicuous gaps and portions of missing decoration of substantial size, an integration with undertone glazing was opted, thus unifying the whole parts with no color, without having to reconstruct the now non-existent polychromy.

In general, we tried to act according to the principle of "minimum intervention", improving the legibility of the decorative theme where possible using the pictorial hatching and glazing technique.

Integration of the Koranic writings required an entirely different approach. In Islamic monuments, calligraphy not only fulfills a decorative function but also an iconographic one, comparable to the function of images in the Christian world. It serves to preserve and manifest the word of God. Writing, for Muslims, does not reflect the reality of the word, but is on the contrary a visible expression of the highest art of all, that which manifests the spiritual world. It is obvious, therefore, that leaving the Koranic inscriptions incomplete would be an inappropriate choice. To this end, a reconstruction in tone using the hatching technique was chosen, a choice that was considered more suited to the particularity of the situation, not only from an aesthetic point of view but also from a formal standpoint. Analyzing the missing parts of the decoration, it was then found that the Koranic inscriptions could be reconstructed by the expert calligraphers without the risk of interpretative error, since the testimonies left intact in the various sectors allowed the areas to be faithfully reintegrated, always with differentiated techniques. where the decorations were missing.

Final painting

The final painting, in addition to implementing the esthetic effect of the whole, served for protection of the painted surface. Regal Varnish was chosen (aliphatic resin diluted 30/40% in White Spirit) as it is considered very stable, elastic, reversible and with a high refractive index. Furthermore, it responds well to ambient temperatures and the physical characteristics remain unchanged, lacking particle absorption. These excellent characteristics are necessary in a very dusty environment such as that of the Great Mosque of Ṣan'ā'.

Protective cover

Before dismantling the scaffolding, the entire restored area was protected with sheets of non-woven fabric, anchored with cardboard and nails. The covering was necessary as a protection from the construction site dust and as a protection for the subsequent works of plastering.


Figs 21 and 22. Before and after the renovation and restoration of the coffered ceiling in the western sector.


Figs 23 and 24. Detail of a portion of coffered ceiling, before and after the restoration. West sector.


Figs 25 and 26. Detail of a portion of coffered ceiling, before and after the restoration. West sector.


Figs 27 and 28. Detail of a portion of coffered ceiling, before and after the restoration. North sector.


Figs 29 and 30. Detail of a portion of coffered ceiling, before and after the restoration. North sector.

Section 2 - Chapter 4

NORTH WING

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

The northern sector consists of five aisles of equal size, whose ceilings have a fairly regular and characterized structure, with very few exceptions due to alterations executed over time, in rows of five coffers. The sturdy beams are typically devoid of covering boards leaving the discontinuous trend and the natural cracks of the wooden surfaces wooden in view. The joists are narrow and not always orthogonal to the beams and enclose the coffers structures unevenly. The decorations present here and visible today are among the simplest and most irregular in the entire mosque, the result of one or more modernizations interventions on the pictorial system of the sector that generated the current decorations, superimposed on the originals from the pre-Islamic era.

A particular area of the north *riwāq* is located in the central area of the first aisle, that of the *miḥrāb*. In this area there are five domes built in a basket formation with a larger central one (2m in diameter) and two smaller lateral pairs. All five domes end with a lantern structure closed in turn by an alabaster plate. The painted decorations that characterize this area contain patterns and colors similar to those of the repainting of the entire sector.

Since the northern sector is the oldest one, the one that survives to this day almost unchanged in its general structure from the Umayyad-era mosque of 700 AD, it is also the *riwāq* which shows its age more than the others, with a large number of alteration, interventions and restorations, partial renovations or major reconstructions, as well as complete restoration and repainting of the decorative system. The northern sector can therefore be divided into different larger and smaller areas, in which different stylistic compositions of the decoration or details denote structural differences, all the result of maintenance interventions, most of them done to repair damages and lacking in any particular design. The outermost aisle of the northern sector, for example, which we will refer to as north aisle 1, turns out to be the most complex due to the presence of a high number of decorations that are different from each other, which we will try to analyze later on.

Before continuing, however, it will be necessary to describe and define a system for identifying the elements of the ceiling used during the restoration so that the reader can also broadly understand the position of the coffers and beams and relative decorations to which will we will refer. The coffers and beams were identified with an alphanumeric code composed as follows:

1. The first capital letter indicates the cardinal point to which the *riwāq* is aimed: N - north; S - south; E - east; and O - west (ovest in Italian).
2. The first capital letter is followed by a number indicating the aisle, where 1 indicates the outermost aisle and continuing toward the aisle adjacent to the internal courtyard.
3. The following lowercase letter indicates the element of the ceiling to which we are referring, or "c" to indicate the coffer and "t" to indicate the beam, or truss.
4. The lowercase letter is followed by a number that indicates the row of coffer elements and beams or trusses, depending on whether it is preceded by "c" or "t". The numbering from 1 indicates the row of coffers on the right looking at the *riwāq* in question from the inner courtyard.
5. In the case of rows of coffer elements, the number may be followed by an additional lowercase letter to indicate the single coffer in the row. The letter "a" will always indicate the closest coffer to the outer wall of the *riwāq*.

Fig. 1. This decorative typology is present in all the first six rows of coffers of the five northern sectors, those adjacent to the east sector. The structure has a top, four triangles and a single framing level. It can be assumed that some catastrophic events damaged this area which structurally represents a weak point of connection between the two north and east sectors. For the reconstruction of this portion, surviving wooden elements were used, and for this reason is closely resembles western sector 1.

Fig. 2. This typology is present in a few rows of the northern sector one, from N1 c37 to c41. The structure is the typical one, top, triangles and double framing. The motif of the top echoes that of others in the same sector, as well as the motif of the triangles.

Fig. 3. This decorative typology is unevenly present in the northern sector (N1 c7; N1 from c12 to c25; N1 from c46 to c50; N1 from c52 to c62). The structure of the coffers is typical of the northern sectors, i.e. top, triangles and double framing. The motif of the top is what is found in sectors N4 and N5.

Fig. 4. This decorative typology is present in only two rows of the northern sector one, from N1 c10 to c11. There the structure differs from the typical due to the lack of triangles under the top.

Fig. 5. This typology is present in a few rows of the northern sector one, from N1 c26 to c30. The structure is the typical one, top, triangles and double framing.

Fig. 6. This typology is present in a few rows of the northern sector one, from N1 c31 to c34. The structure is the typical one, top, triangles and double framing. The decoration resembles the one described previously.

Fig. 7. This typology is present in a few rows of the northern sector, from N1 c37 to c41. The structure is the typical one, top, triangles and double framing. The motif of the top echoes that of others of the same sector, as well as the motif of the triangles.

Fig. 8. This decorative motif is present in only two rows of coffers in north sector, N1 c42 and 43.

Fig. 9. This decorative typology is present in a single row of coffers in the north sector, N1 c44. The coffer structure lacks the triangles. The decoration is reminiscent of the style of the two previous rows described above.

Fig. 10. This decorative typology is present in a single row of the coffered ceiling in north sector one, N1c45. The coffer structure lacks the triangles. The motif present in the tops is reminiscent of that found present at the top of northern sectors 4 and 5.

Fig. 11. This decorative typology is present in a single row of coffered in north sector one, N1 c51. The motif of tops and triangles may resemble that of others in the north sector with variations of colors.

Fig. 12. This decorative typology is present in two rows of coffers in north sector one, N1 c63 and c64. The structure of the coffers lacks the triangles that are reproduced here pictorially at the top.

Fig. 13. North sector two is fairly homogeneous for its entire length, from N2 c9 to c63. The variation of the decorative motif is mainly present in the variation of the geometries and polychromies of the top.

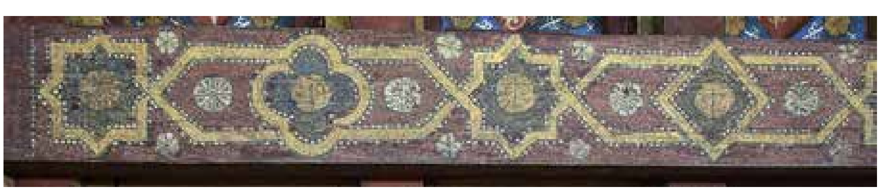
Fig. 14. This decorative typology is seen here in a single row of coffers in north sector three, N3 c7. The structure of the coffer lacks frames and the decorative typology and is very simple and primitive.

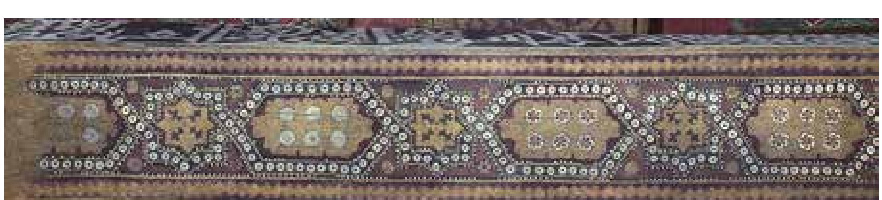
Fig. 15. This decorative typology is the main one of north sector three, present from N3 c8 to c57. The only variation is that of the floral motif painted in the triangles.

Fig. 16. This is the most common decorative module and is present in both the north and south sectors, in N4 from c7 to c66, in N5 from c7 to c66, in S2 from c47 to c74 and in S3 from c47 to c74.

Much of the decoration visible today in the north *riwāq* is thus a second level of painting performed on the coffer already in place in the position in which we find it today. For expositive convenience we will refer to this level with the term repainting, although that term could mislead us to consider it of lesser value, which, though from a stylistic and artistic point of view it may appear to be, does not reflect reality from the historical point of view, because is a historicized and historicizing element of the mosque. The oldest original decoration was executed on the workbench, directly on the bare wooden elements without any preparatory layer. In fact, in several places, it can be seen how the decoration is extends into overlapping areas of the coffer elements and in almost all perimeter areas of the beams of the five aisles that were or are still covered by masonry. The repainting. instead, was obviously performed with the coffered ceiling in place, is often spread over a preparation consisting of a chalky base, which overflows onto the adjacent wooden elements, denoting a certain imprecision and speed of execution. The beams also show a certain structural and decorative variety, the alternation of which does not appear to follow any precise pattern. Square beams without cladding, which are the most numerous and which we can define as being characteristic of the *riwāq*, alternate with round red or burgundy beam with three white medallions and floral motifs decorating the lower part. Some beams have cladding boards with completely different and much more complex, elaborate and refined decorations, reminiscent of decorative elements from other sectors.

Occasionally beams with roofing boards treated with some sort of ground preparation were also found. These were painted with floral and geometric motifs with a singular character, without any apparent connection to the decorative system of the entire mosque.





Figs 17-24. Some examples of the decorative patterns found on the lower surface of the beams. This small selection clearly demonstrates how articulated the decorations in the northern sector are.

In general, the most common type of repainting in the sector, which is also found in the south *riwāq*, can be schematized as follows:

- First series of frames of the coffered ceiling: that is the strip that rests on the beam and next to the beam is painted in a red / burgundy color on the horizontal surface and the vertical section in light ocher with black floral decorations.
- Second series of frames of the coffered ceiling: that is, the series of strips under the triangles, are painted light ocher on the horizontal sections, red / burgundy with white decorations on the vertical sections.
- Triangles: have a white and light ocher base with a black floral decorative motif. The decorative motif has largely faded completely or is barely visible. The vertical border is red / burgundy.
- Upper closing panel: blue / green background, has a light ocher circle in the center from which a white phytoform motif branches off. This motif is very varied and always different between the various sections of the coffered ceiling.

Figs 25, 26. On the left, a sample of all the components of a coffer. On the right, the same coffer after being assembled.

- Under joists: have a red / burgundy background color with three yellow or white medallions with a black decoration, often a flower. In some cases, the bottom of the underlayers does not show any trace of color but only the white preparation is observed. What could be a residue of color is definitely toned in gray / black and would almost certainly have been red originally. On the other hand, the three circles have a floral design.

Figs 27, 28 and 29. Examples of decoration on the underjoists.

- Beam sides: they are characterized by Koranic inscriptions or by decorations with colored floral motifs in yellow, black, white and red, on a chalky preparation.

Figs 30-36. Some examples of decoration of the lateral faces of the beams.

- Underbeams: The decorative typology of the underbeams is very varied even in restricted areas of the same aisle and it is difficult to establish basic recurring patterns. However, a predominant decoration has a red / burgundy base on which three circular medallions are designed, based on the motif of many under-beams, with black border and white dots that surround a central decoration with a black background and yellow designs. Others have a decoration whose background color has been lost, probably also red or ocher yellow. This is made up of four circles, with a black border and white dots that surround a central decoration with a black background and yellow designs, though for the bottom there is only the preparation.

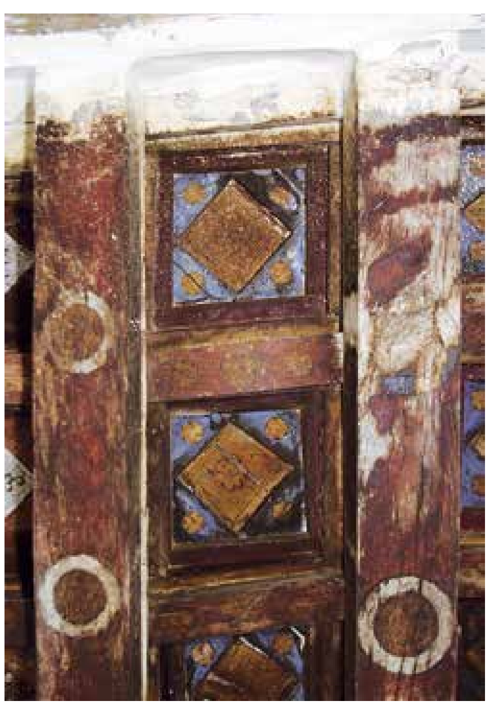
Figs 37, 38 and 39. Most common decorative motif on the underbeams of the northern sector.

The problems of decay

Over the centuries this sector has undergone maintenance interventions of the most varied types and importance. Thus, we are now confronted with simple decorative repetitions or real repainting; messy and improvised structural maintenance with the approximate replacement of beams or the addition of new beams to support the fractured walls hastily repaired with plaster and brick infill; coffers with broken and missing elements or the application of debris tablets with decorations of different structure, age and type.

What at first glance appeared most worrisome was the presence of particular areas of the ceiling with fractured beams and part of the surrounding coffered ceiling that had completely collapsed. The damage present in these areas was so severe that it led to the choice of a seemingly rather drastic intervention but one which proved to be the only way to remedy that type of structurally unstable situation in a targeted, precise and definitive way. The operation, which will be described more fully later, provided for the removal of the roof covering layers from the outside so as to be able to act from above to proceed with the complete disassembly of the coffers. The opening of the ceiling and disassembly of the coffers also revealed the extent of the biological deterioration on the back of all the wooden elements.

Given the variety of structural damage present, we will leave a better description to the photos, attempting hereafter, to provide as complete as possible a summary of the initial situation that the team of restorers had to face.



Figs 40 and 41. In the pictures some of the typical situations encountered in the northern sector at the beginning of the works are visible.

Fig. 42. Crosswise fractured beams supported by an additional support beam, generally an unworked and rather rough wooden beam, with a circular section added in the lower part and the heads set in the masonry. The large empty space between the two beams was filled with plaster and brick infill.

Fig. 43. Embossed beams without evident fractures. and cracked or fractured beams in the longitudinal direction, covered on the three exposed sides with decorated boards. These boards, often composed of several elements nailed to the internal beam, are also broken, fractured and incomplete, being forced in their movements to follow those of the internal beam.

Fig. 44. Longitudinally slotted beams entirely or extensively covered and buffered with a white plaster-based mixture.

Fig. 45. Beams with large cracks and transverse fractures with relative static and structural weakening.

Fig. 46. Beams with large cracks and transverse fractures and related old restoration intervention consisting of metal elements of the most varied type (hooks, nails, chains, pulleys, etc.)

Fig 47. Cracked and/or remodeled beams, incorrectly and unsafe inserted in the masonry, and supported on the side only by wooden and / or brick shelves.

Figs 48, 49 and 50. Beams and coffers with wooden or brick and plaster infill to fill in the gaps or the loss of original wooden elements.

Most of the structural damage and related old maintenance interventions, mostly identifiable as plaster and brick infill or insertion of beams or other wooden elements as support, were also identifiable for the coffered ceiling. In fact, there were also several plasters infills in the areas corresponding to the strips above the beams and to the first two frames of the coffers, with the presence of plaster that protruded between the spaces created by the wooden elements. In some areas, the plaster itself was used as infill to replace a missing wooden element of the coffering, and had been repainted in the same way as the surrounding elements, so it was "original" from the period in which the repainting of the second was carried out. As such, it would be preserved in our intervention as a homogeneous element of the visible decorative system. As for the paint film, part of the deterioration was closely linked to the precarious structural situation and to the old maintenance interventions carried out over time in an arbitrary way, which gave rise to the many swellings, color losses and related gaps. The original polychromy, corresponding to the first level of decoration, is a thin tempera of fine grain, applied directly on the wood without preparation and was preserved, where it was still visible, in fairly good condition. The repainting layer corresponding to the second level, i.e., the decoration visible today, is also a tempera but more thickly applied , especially as regards the red / burgundy and yellow ocher colors. In particular, the thickness is given by the presence of a gypsum-based preparation, which on most of its surface was loose and powdery. Generally, the ocher yellow color was less powdery than the red / burgundy but it too was rather incomplete. The situation of the upper panel of the coffers was also critical, with considerable swelling and loss of most of the decorative motif. All five aisles of the north *riwāq* had coherent and incoherent deposits of dust and of diversified dirt on the entire surface and blackening of various kinds, mostly caused by the fumes of oil lamps. The coffers and beams, in correspondence with the perimeter area in contact with the masonry, were affected by several superimposed layers of white plaster-based paint and acrylic paint for walls depending on the period in which the whitewashing of the walls was carried out. This white paint, which in the past was applied during the Ramadan period to ”refresh” the mosque, had a full-bodied consistency and was sometimes applied very thickly. In some areas of the wooden ceiling there were substantial deposits of organic residues such as dust, cobwebs, twigs and insect nests. On the beams, even more than on the coffers, widespread blackening and grime were visible, caused by the continuous seepage of water which formed black, shiny and very marked lines on the painted surface. This type of degradation, due to several often conco-itant factors, was primarily due to infiltrations of rainwater from the outside and therefore from repeated and prolonged wettings over time, with consequent deterioration of the woody material and the formation of “white rot”, grime, dark spots and sometimes saline efflorescence. This degradation factor then favored the migration of the tannin of the wood to the surface, with a general browning and yellowing of the tones of the decorations. Much of the blackening was also attributable to the presence, in the past, of lamps anchored to the beams. As evidence of this, there are in fact several metal hooks on the sides of the beams. However, no attacks by xylophagous insects were visible on the surface.

Intervention methodology

Cleaning

After the preliminary phases of graphic and photographic documentation of the state of affairs, the first operation carried out was the mechanical cleaning of the entire wooden surface. Dry cleaning of the coffers, beams and joists was done with the aid of a vacuum cleaner, soft and hard bristle brushes and wishab rubber as well as a scalpel for removing all those inconsistent dirt deposits that appeared scattered over the entire surface and the removal of the superimposed layers of acrylic paint, gypsum with a full-bodied consistency and deposits of protein material present homogeneously over the entire surface and which appeared clotted in small spherical deposits. Specifically, dry removal consisted of the aspiration of the atmospheric particle and organic insect deposits using a vacuum cleaner, a subsequent step with soft and hard bristle brushes to try to remove more consolidated dirt, paying attention to areas of the paint film with adhesion problems; a subsequent use of the scalpel for the dry removal of plaster and acrylic paint deposits present in a sporadic and non-uniform way on the surface. The beams had a plaster deposit with an uneven and consistent thickness that affected the vision of the Kufic inscription of the Koran, especially in the initial and final part of the inscription itself. The material was removed using soft bristle brushes, a sufficient operation given the poor consistency of the plaster without binder, and a passage with wishab rubber; once a clearer view of the letters of the Koranic script was obtained, the superimposed and strongly cohesive materials adhering to the pictorial film were removed with a scalpel. The area was finally vacuumed again to remove the rubber and material deposits. Chemical cleaning of the coffers and beams was generally done using a chelating solution at PH 7.5 or 9, depending on the type of dirt, applied by brush on Japanese paper, with contact times of a few minutes. Sometimes the solvent action of the chelator proved to be too strong, even if thickened in gel solution, so a more superficial cleaning with surfactants was opted for. Generally, especially as concerns the sides of the beams and the sub-beams, chemical cleaning was preceded by a pre-consolidation of the pictorial film since it appeared uncoated. This was done using polyvinyl alcohol (Gelvatol), spread with a brush on Japanese paper and rinsed with demineralized water. As for the thick brown layer present unevenly over the entire surface, of a proteic nature, the difficulties that emerged during the execution of the cleaning tests were mainly due to the fact that the pictorial film is a greasy tempera with an oily binder, which varies according to the pigment. The whites consisted of white lead, and were cohesive, adherent and resistant to the action of solvents, unlike the yellows which, in addition to having absorbed the protein layer, had obvious cohesion problems, presumably due to an incorrect critical volumetric concentration between pigment and binder. The hypothesis of being able to perform a selective cleaning operation with respect to the removal of the aforementioned material alone, was found to be impracticable due to the presence of material inside the cracks and the detachment of the pictorial film. We therefore proceeded as follows:

1. Central part of the coffered ceiling, the upper closing panel and the four triangular corner areas including the side parts.

- Brush sanding with 4% klucel G in ethanol. The klucel has a function of supporting the solvent, which has time to partially solubilize the material to be removed, and also acts as a is a consolidating agent for the pictorial layer.
- Removal with a buffer of ethyl alcohol. The use of ethyl alcohol made it possible to remove the layer of dirt and protein material almost completely, without softening the paint film: the whites, reds, blues and greens almost completely recovered their original chromatic value, unlike the yellows, which by now having incorporated the protein material were only partially recovered.
- The parts with exposed wood were repeatedly treated with ox gall to remove the accumulations of protein material that could not be removed with ethyl alcohol. In some cases, the cleaning was refined with the use of a scalpel.

- Finishing with aqueous solution at pH 7.5 with buffer, to remove further stains and deposits of material.

2. Small frame over the summit of each coffer and joists perpendicular to the main beams including the lateral parts.

- Spreading of citric acid ph 7.5 solvent gel with a brush.
- Removal of solvent gel and dirt with a dry swab.
- Rinsing with ligroin in acetone 1:1, to remove excess gel without softening the pictorial film.
- Finish of the cleaning with ox gall spread with a brush or a solution at pH 7.5 with a pad depending on the type of layer of dirt to be removed.

3. Cable ties with geometrical motif.

- These were practically untouchable given the condition of cohesion of the color. In this case, a light dry cleaning was performed, and 5% Paraloid BB72 72 application served to consolidate the pictorial film.

4. Front and side beams.

- Brush application of the citric acid solvent gel at pH 7.5 on Japanese tissue paper. Spreading times with a brush of the citric acid solvent gel at pH 7.5 on Japanese tissue paper. Short contact times and removal of the tissue from the paint film.
- Removal of excess with the application of a clean tissue.
- Rinsing of the treated part with the application of ligroin in acetone 1:1 over the tissue (also performing the operation twice, changing the physical support).
- Finishing with the application of ox gall over the tissue.


Figs 51, 52. Cleaning phase, before and after.


Figs 53, 54. Cleaning phase, before and after.

Fig. 55. Cleaning pad on a coffers.

Fig. 56. Cleaning pad on a coffers.

Disinfestation

Fungicide benzalkonium chloride, diluted to 4% in water and alcohol in a ratio of 1:1. The application was carried out with the use of brushes and Japanese paper.

The entire surface of the ceilings, including the new wooden elements, was treated with a permethrin-based woodworm repellent applied by brush in such a way that the material penetrated abundantly into the wood.

Consolidation

The badly deteriorated and fragile wooden elements, found above all in the joists and frames of the sleepers, were if possible, carefully removed and consolidated with Paraloid B7 2 acrylic resin, diluted 5% in acetone and subsequently reinforced with bi-component epoxy resin (Araldite). Sometimes, given the state of fragility of the wood and its extreme degradation due to the continued action of xylophageous insects, the consolidating action of the Paraloid resin being not sufficient and not wanting to exceed the use of this resin, we opted for injections of Araldite, diluted with alcohol, into the tunnels formed over the years. In this way the wooden structure was recreated, strengthened and partly restored.

Fig. 57. Yemeni restorer during the film consolidation phase.

Fig. 58. Detail of the phase of consolidation.

Fillings and grouting

In the deep spaces between one element and another of the coffers, due to the characteristic system of construction and assembly, filling cotton was inserted with the help of wooden sticks in order to make it penetrate in depth and to block the possible fall of inert material from the areas above the ceiling structure. The cotton was then consolidated with injections of Gelvatol polyvinyl alcohol adequately pigmented to the general color of the area in which it was inserted, so as to appear as a gray area. For the coloring of Gelvatol powder pigments such as yellow ocher, burnt shade and natural shade were used.

The deeper cracks and breaks were filled in two stages, first with epoxy bi-component of Araldite type, in order to create a base, then finished, if necessary, flush with another bi –component epoxy resin of the Balsite type. The gaps and missing portions of the support of lesser depth were grouted flush with Balsite only.

The missing elements, especially structural gaps of substantial size on the beams and sleepers, were integrated with new suitably shaped wooden inserts, applied depending to the cases with aliphatic Weldwood glue or with wooden pegs and finished on the edges with Balsite resin. The wood for the inserts was always treated before use with woodworm repellent and rubbed on the surface with sandpaper in order to simulate the texture of the original wood.

Preliminary painting for retouching

Prior to chromatic integration, all wooden surfaces were treated with a brush coat of Lefranc & Bourgeois matte varnish generally diluted 30% in white spirit.

Pictorial integration

For the chromatic integration operation, colored varnish for restoration was diluted with ethyl-lactate solvent and applied. The decorations present in the coffers and the triangles that frame them were reconstructed in a subdued tone where only small portions were missing or where there was a slight trace of the same original decoration, while backgrounds were balanced by darkening the light areas with light reglazing or by interrupting the areas of dark spots with the hatching technique.

In the case of the joists, in those points where the decoration was easily legible, the decoration was integrated with under-tone glazes to complete the motif in a balanced and uniform way. For the most incomplete joists, it was balanced with the hatching technique used with glazes, usually in the same color as the preparation plaster degraded to shades of gray, in order to balance and unify the tone to the rest of the sector.

On the sub-beams, it was decided not to reconstruct the contour lines of the decorations even if they could be inferred, so as not to make the overall view of the ceiling too heavy. Only the lighter areas were balanced with glazes and the darker areas interrupted the with hatching.

The decorated beams were rebuilt in the points where there were visible traces, using glazes or hatching underneath. In areas where the decoration was very incomplete, generally limited to the areas corresponding to the heads of the beams, an attempt was made to blend the tone and color of the decoration toward that of the wood.

The method of integration of the beams bearing Koranic inscriptions was the subject of long discussions and reflections, as already explained in a previous chapter. Through the best of compromises, we chose to reproduce the Koranic inscription in a light color, with the use of veils and with the hatching technique.

Even the decorative elements of the sub-beams have been integrated with glazes and hatching. The wooden parts, like the sleepers or the upper panel without pictorial film except for occasional traces, were treated with repeated applications of highly diluted glazes of varnish colors, in order to gradually reach the tone and color of the original.

The new wood was all treated with very diluted water stain with colors ranging from walnut, mahogany and natural sienna, depending on the color of the wood of the area in which it was being stained. After painting, if necessary, it was again balanced with glazes of varnish colors.

In some medium or large areas of the ceiling, the original decoration showed through the layer of repainting. In these cases, a pictorial integration was opted for in order to respect both decorative levels, leaving in sight what the normal degradation of time had achieved, integrating the necessary minimum so as to cancel only, and as far as possible, aesthetic imbalances and balancing everything to the general tone of the sector area in question.

Final painting

All wooden surfaces were treated with a brush coat of Regal Varnish matte paint diluted 40% in white spirit.

Figs 59, 60, 61 and 62. Some examples of pictorial retouching.

Section 2 - Chapter 5

SOUTH WING

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

The south wing, with its beams not perfectly squared and without cladding, but with a rather regular coffered area, appears to be a generally uniform zone in its design. The coffers and beams are painted with similar motifs and, although not identical in all the aisles, they are generally very reminiscent of the decorative motifs present in the north wing.




Figs 1, 2, 3 and 4. On the left, two examples of the coffered panel of the south *riwāq*.
On the right, examples of the north *riwāq*.

What is immediately striking when observing this sector is the diversity of the first *riwāq*, the outermost one that runs along the southern perimeter wall, compared to the other two. In particular, this diversity can be observed in the particular conformation of the beams and in a greater height of the ceiling. While the beams of the second and third *riwāq*, as well as the coffers, take up very simple decorative motifs, already seen in the northern sector, with the coexistence and overlapping of two levels of painting, the beams of the first *riwāq*, on the lower side, have carved gilded decorations. These decorations, although reminiscent of those present on the beams of the east sector, are in reality, as we shall see, much simpler and much less refined, in a completely different stylistic composition. This rules out the possibility that they might be contemporary with the construction of the eastern sector.

Figs 5, 6 and 7. Some examples of the particular carving and gilded decoration present in the southern *riwāq*.

This diversity of the *riwāq* is due to the fact that at a certain historical moment, probably in the Twelfth century, following maintenance and / or modernization interventions if not actual reconstruction necessary following a vast collapse caused by catastrophic events, the ceiling was raised and the coffering demolished and reassembled with the material then ready available, partly surviving from the collapse and partly acquired from a different section or perhaps also used for other maintenance works in other points of the mosque. The reconstruction of the coffered portion seems to take into account only a uniformity of the structural system and not of the decoration. The main type of visible decoration of the elements used here for the reconstruction of the two-level pyramid of the coffered area seems similar what has been defined as first level and already present in the north sector as well as and elsewhere in the south sectors. On the other hand, the decorative typology of most of the upper closing panels seems similar to that which can also be found in other points of the north and west sectors, where the coffering has undergone important renovations.

Figs 7a and 7b. Above an example of the decorative motifs of the first southern *riwāq*, below an example of the first spans of the north *riwāq*.

Already from this brief introduction, it is easy to understand that, although the sectors of the south wing show similarities to each other, there are substantial differences that required different methodological choices during the restoration. In particular, the second and third aisles (S2 and S3), compared to the first, show a different structural construction of the beams, and a different type of decorative system for these two wings appeared at the same time, and remained practically unchanged in the structure from the second half / late 700 AD, a few decades later than the northern sector, with which they share the structure of the decorative system with the overlapping of the two levels of painting. This differs from the first *riwāq*, which underwent a complete makeover with the inevitable change from the original conformation of the structure and decorative system.

In the case of the first level decoration, the coffers, generally made with wooden beams and boards according to the classic design that characterizes the entire ceiling of the mosque, were painted directly on the wooden surface without any type of preparation

Figs 8 and 9. Some coffers in the southern sector.

as we had already seen in the north sector. In sectors 2 and 3, where visible, evidence can be observed that testifies to a bench construction as the decoration extends into non-visible areas, covered and closed by the coffered elements, in which it would not have been possible to paint with the elements in place as well as they still appear today. Furthermore, on the same joist, the decoration develops continuously on the two visible sides, horizontally and vertically, and is not always consistent with that of the other elements of the same coffering. In various areas there are also rectangular holes of different sizes and some vertical grooves, clearly linked to old joints no longer in use and corresponding to an old installation of the ceiling. These elements suggest an adaptation of the wooden elements of the coffering to the current ceiling system, perhaps occurring when the wing was rebuilt to elevate it.

Figs 10, 11 and 12. Some examples of old exposed joints that are no longer used, reflecting a reuse of the beams.

The original polychromy, applied directly on the wood without preparation, is a greasy tempera, as confirmed by the chemical analyses carried out on the samples of the sector, of fine grain applied in a thin coat, with the exception of the yellows which are denser but more delicate.

The original color, in southern sectors one and two, is often covered with a single layer of tempera repainting, in which bands with a red background alternate in pairs with white background bands. On these were affixed white decorations in the red areas and blue-black decorations in the white ones. The semicircular medallion decorations, rendered with a sinuous line, reproduce a sort of "zig-zag" in the bands, a circular movement in the closing tablet and a coiling movement in the triangles.

The repaintings, unlike the original polychromy, were done on the coffered panel mounted in the position in which we find it today and have particular characteristics that influenced the restoration, especially in the cleaning phase. The red paint, applied thickly and showing coarse grain, is more tenacious than the white. The blue-black tempera has greater thickness and is rather in relief, but easily removable, while the white paint is more compact, with a finer grain and more tenacious than the others.

Figs 13 and 14. Some more common examples of the decorative system present in the coffers of the southern sector.

The coffers of the S2 sector have the same type of repainting as in the S3 sector in which the red bands alternate with white bands, though the decorations are slightly different. The substantial difference between the two lies in the fact that here the white paint is present all over the coffer, even under the reds, which, despite having the same pigment, have a less resistant and thinner binder.

The painting was performed on a preparatory drawing, not always present but recognizable in small details painted under the whites, and easily identifiable in different examples. In fact, where the color is missing on the circular "flower" element, usually located in the corner of the joist from which the four white-yellow bands painted in black-blue scales start, it is easy to see the black traces of two concentric rings, starting point of the contour lines and of the central axis of the bands.

Part of the beams in sector S3 have certainly been dismantled and relocated. This can be seen by observing that the beam fixed in the two walls (a sleeper of the same type as that of sector S2, with traces of decoration) is inserted into the walls with a similar non-horizontal trend in the two walls. It is likely that the entire wooden apparatus, previously resting on the sleepers, over time, following structural failures, was deformed or severely damaged and then disassembled to intervene on the masonry, reassembled and reinstalled in the current structure. There are also vertical grooves in the terminal parts of some beams where a panel clearly had to be placed to enclose the space above the sleeper according to a different arrangement. These grooves are present in sectors S1 and S2, while in sector S3, sleeper and panel were replaced by painted plaster. At this point it is logical to think that the coffers have been reassembled, if not entirely at random, often without respecting the original positions of each element.

Over the original color, the beams are also repainted. In sector S3, on a very thin first coat of white, probably plaster and glue, the decorations with dark gray colors were made on the sub-beams, near the first, third and fifth coffers, where there are three large circles, inside these there is a smaller concentric one and four semicircles, all engraved with compasses and decorated in white and gray. The same repainting is also found in the under-beams, in which a similar decoration with three circles is repeated on a reduced scale.

On the two vertical sides of the beams there are shoots with phytomorphic motifs. These patterns, although similar in some details, differ from beam to beam. The traces of plaster decoration, in the space between the beams, replicate the same friezes. The pictorial film, a kind of watercolor, is very thin. There is a very light coat on the white areas, and on the darker ones, the designs, though difficult to identify, are finished with different shades of gray and black, which emphasize the contours, the veins of the leaves and the petals of the flowers.

The repainting of the S2 beams is completely different from that on the beams in sector S3. On the two sides, Koranic inscriptions are painted and the sub-beams are decorated with different motifs. The colors also change, some have light backgrounds and black lettering, others red backgrounds and white lettering with black outlines. The pictorial material is certainly less refined and elaborate than the other.

Most of the sub-beams are decorated with three circles, similar in size and arrangement to those of the S3 sector but with a different style and internal decorations, in others the decoration develops over the entire surface with semicircular elements that intertwine to create a sort of grid painted with thick white paint of coarse consistency, similar to that of the writings; on the same beam we can sometimes glimpse traces of a similar "grid", now lost.

The hypothesis is that in this sector there are two repaintings, the oldest with the decoration of the three circles and the most recent with the writing and the white "grids". It is possible that in the second phase most of the sub-beams were recovered and not completely reworked.

The large plaster stuccoes, designed to compensate for the wooden shortcomings in the coffers or to rectify sagging in the beams, are worthy of note. It is a mortar generally placed on a brick infill, then decorated during the repainting phase.

The problems of decay

The problems of deterioration of the wooden ceilings of the south wing are not so different from what has been said about the north sector with which it has much in common, and primarily concern the presence of splattering of plaster, layers of plaster and acrylic paint on all the perimeter areas, above the walls, the rows of coffers and the heads of the beams, as well as present in all sectors of the mosque and related to maintenance interventions carried out over the centuries.

Figs 15, 16 and 17. Typical state of the art in the southern sectors.

In this sector too, the seepage of rainwater from the ceiling, dissolving the plaster and transporting inert material of various kinds present in the false ceiling, caused numerous stains with relative plaster halos or dark spots, especially between the joints and the strips.

There was also a large quantity of inert material between joints and cracks. There were large plaster stuccoes carried out precisely to compensate for the wooden shortcomings in

Fig. 18. One of the largest areas in which rainwater, seeping in from the ceiling, washed the decorated surfaces off the ceiling.

the coffers or to rectify sagging in the beams or in the ceiling as a whole. Sometimes the replacement of part of the elements of the coffers was carried out with non-polychrome wooden boards and strips fixed with metal nails, now completely rusted, of irregular shape.

The under beams and joists of the first rows showed a particular blackening given

Figs 19, 20 and 21. Some examples of plaster cladding, carried out in past maintenance interventions to stop parts of the coffered ceiling from crumbling.

by the degradation of protein material spread perhaps as a consolidating agent, over the entire surface and by deposits of "greasy" matter since, in the past, in the south / east corner there had been kitchens.

Fig. 22. Detail of a coffer in the southern sector and of the type of deterioration consisting in a general blackening and browning of the decorated surfaces.

Blackening and channels linked to the seepage of rainwater with the relative migration of tannins to the surface were also visible.

Organic damage caused by fungi or white rot were found, though limited and localized to a few areas, on some joists in the first spans. The attack by xylophageous insects was also limited to a few localized areas.

Intervention methodology

The southern sector was the one chosen as the pilot site, in which the first experimentations and methodological choices of intervention took place, developing and improving more and more over the years of work and to become consolidated practice. The problem that from the beginning required the most attention was certainly that inherent in the decision as to how to deal with the overpainting, both of the beams and of the coffers, but as a first approach to the work, great attention was also always paid to the documentation phases

Documentation of the state of conservation

As a first step, the initial high-resolution digital photographic documentation of the state of conservation was carried out, followed by documentation and graphic mapping.

Mechanical cleaning

The first step after the documentation phase is mechanical cleaning. After removing surface dirt and other loose deposits of various kinds with a vacuum cleaner, brush and toothpicks for the cracks and other difficult points, all the excess layers of plaster on the work surface and all the infills present in the coffers were removed.

Later, after careful inspection of their conditions, any strips and boards in need of reinforcement were removed and their position documented to ensure exact relocation.

Scalpels were used to remove the acrylic paint and plaster on the sleepers. Removal was facilitated using a solvent gel of acetone and ligroin, spread on Japanese paper, with contact times of about five minutes, which caused the swelling of the paint and made removal easier.

Chemical cleaning

The areas that were not affected by repainting underwent a relatively milder intervention, given the delicacy of the original paint without preparation and a protective layer, consisting of the use of surfactants, in the particular case of ox gall. The cleaning was more complex and difficult when it was necessary to repaint.

Given the good result obtained cleaning the original decorations, during the pilot stage, the works director initially decided to recover the original decorative system, removing the repainting of evident lower artistic and aesthetic quality. The main difficulty was to find a safe and fast method which, respecting the original polychromy, could be applied in a controlled manner on the repainting even by an inexperienced operator.

Repainting, on a white background and on a red background, was in tempera in both cases. The white paint was easily removed while the red paint was thicker, more tenacious and had a coarser grain size.

The original colors, although more solid than the repainting, due to the different binder and its greater polymerization, were extremely delicate and easily removable, especially when the mechanical action necessary for the removal of the additional layers was carried out.

To understand its fragility, it is necessary to start with the cleaning of the whites where, with a slight mechanical action, inevitable during solvent cleaning, the original pictorial film below was easily exposed but with it the ease with which it was possible to abrade it. or even partially remove it, given the affinity of the materials and the lack of a protective layer on a pictorial film as thin as the original one.

In the red areas the problems were greater because the material to be removed was much thicker and more tenacious, consequently the mechanical action was more prolonged and more incisive. It was also necessary to intervene with stronger solvents, especially in the finishing phase, but there was also was less visual control, since it is a dark color that darkens even more when wet, blending into the dark color of the underlying wood.

The solvent useful to dissolve the repaintings was water, alone, added, supported, emulsified, mixed, with surfactants, solvents, chelators, etc. In all these ways the water worked discreetly according to the specific action that had to be to applied but the damage to the original colors was mainly caused by the mechanical action, whether it was applied with sponges, cotton swabs or in any other way, which was inevitably for the finishing.

Given the difficulties encountered in the removal of the repainting and due to the long time required to obtain acceptable results, we subsequently opted to maintain this repainting, arriving at executive solutions that will remain almost unchanged for the course of the subsequent works (it should be noted that the southern sector was the one in which the pilot project took place and in which particular problems and the related methodological and technical choices were addressed and defined for the first time).

When it was decided to keep the repainting, the polychromies were cleaned with chelating gel PH 7.5 applied with a brush, with contact times ranging from a few minutes to about ten, depending on the toughness of the dirt on the repainting, with interposition of Japanese tissue paper. The subsequent finishing of the cleaning took place with the same liquid solution and then with a solution of water and ox gall in buffer.

Even on the beams, where the repainting was not removed, the cleaning phase involved the application of a chelating solution on Japanese paper. After removing the Japanese paper, a pad cleaning was carried out with the same liquid chelator used for a first finishing. After drying, a further finishing was carried out with a surfactant such as ox gall.

A methodological alternative was proposed both on the coffers and on the beams, used depending on the case or on the convenience of the individual operator. This second method involved the use of an Ethomeen solution which had the advantage of requiring longer time to work than the chelating solution, and therefore with generally more controllable action even by inexperienced operators.

The removal of any layers of dark protein matter on the surface was also carried out. In this case, after applying Japanese paper, a solution of ammonium carbonate at pH 7.5 was used with contact times of about 10 minutes and removal with a swab with the same solution applying a light mechanical action with a scalpel if deemed it necessary.

Disinfestation

After having carried out the dry removal, with a scalpel and brushes, of the residues of fungi and white rot, a brush was used on those same areas to apply benzalkonium chloride at 4% in water and alcohol in a 1:1 ratio to block the pest action. Subsequently, permethrin-based anti-woodworm repellent was applied over the entire ceiling by brush.

In conclusion, Paraloid B72 was spread at 5% or 10% in acetone on all areas worn by the attack of xylophageous insects and on the parts where the fungus had made the surface spongy and structurally weak. The application was made by brush and injection in case a deeper treatment is required.

Grouting and fillings

As usual, between the cracks and joints, if in the presence of material leaking from the false ceiling, the possible fall of inert material is buffered by inserting the filling cotton, consolidated with pigmented Gelvatol, in water and alcohol.

At the beginning of the works, during the pilot project, Balsite had not yet been introduced as a grouting material, so many of the gaps were closed with only bi-component resin of the Araldite type, sometimes adding sawdust to the mixture. Subsequently, the technique was developed to replace the sawdust with inert pigment most of the time, in order to create fillings of a similar color to the pictorial fabric in which they were inserted. The last step was the introduction of the bi-component Balsite epoxy resin, also pigmented, as a final finish at the level of the grouting.

In the presence of plaster fillings, these were treated with borders and finishes in the gaps in the surface with putty composed of plaster of Bologna and *colletta* glue, as it is similar to the original material, thus respecting the principle of compatibility between the materials.

Preliminary painting for retouching

As usual, preliminary painting of the esthetic restoration were done by brush on the entire surface, with 40% Lefranc & Bourgeois matte paint in white spirit.

Pictorial retouching

Also in this case, the first methodological and executive choices of pictorial retouching carried out in this sector at the beginning of the work were followed by changes and variations, up to, over time, the general conditions described in one of the initial paragraphs of this paper.

Initially, in the areas of the coffers, this was done by reintegrating only the backgrounds where there were traces of the original color or repainting, to then go into some reconstruction if the repetitiveness of the decoration itself allowed it. Retouching was generally performed by glazing, trying to achieve a tone similar to that of the original whole. The reconstruction of the missing decorations over time had been particularly requested by the Commissioning Body, especially for the repetitive ones, and therefore, being easily understood, it was difficult to come across errors or free interpretations.

As far as the beams were concerned, the Koranic inscriptions on the sides of the beams were reconstructed as much as possible, as was then usual according to the methodology subsequently followed in the other sectors, with the help of the Yemeni responsible for ancient inscriptions if necessary.

Also, for the underbeam, the reintegration was carried out by "closing" the repetitive decorative elements and background backgrounds, reducing the various stains and dark areas.

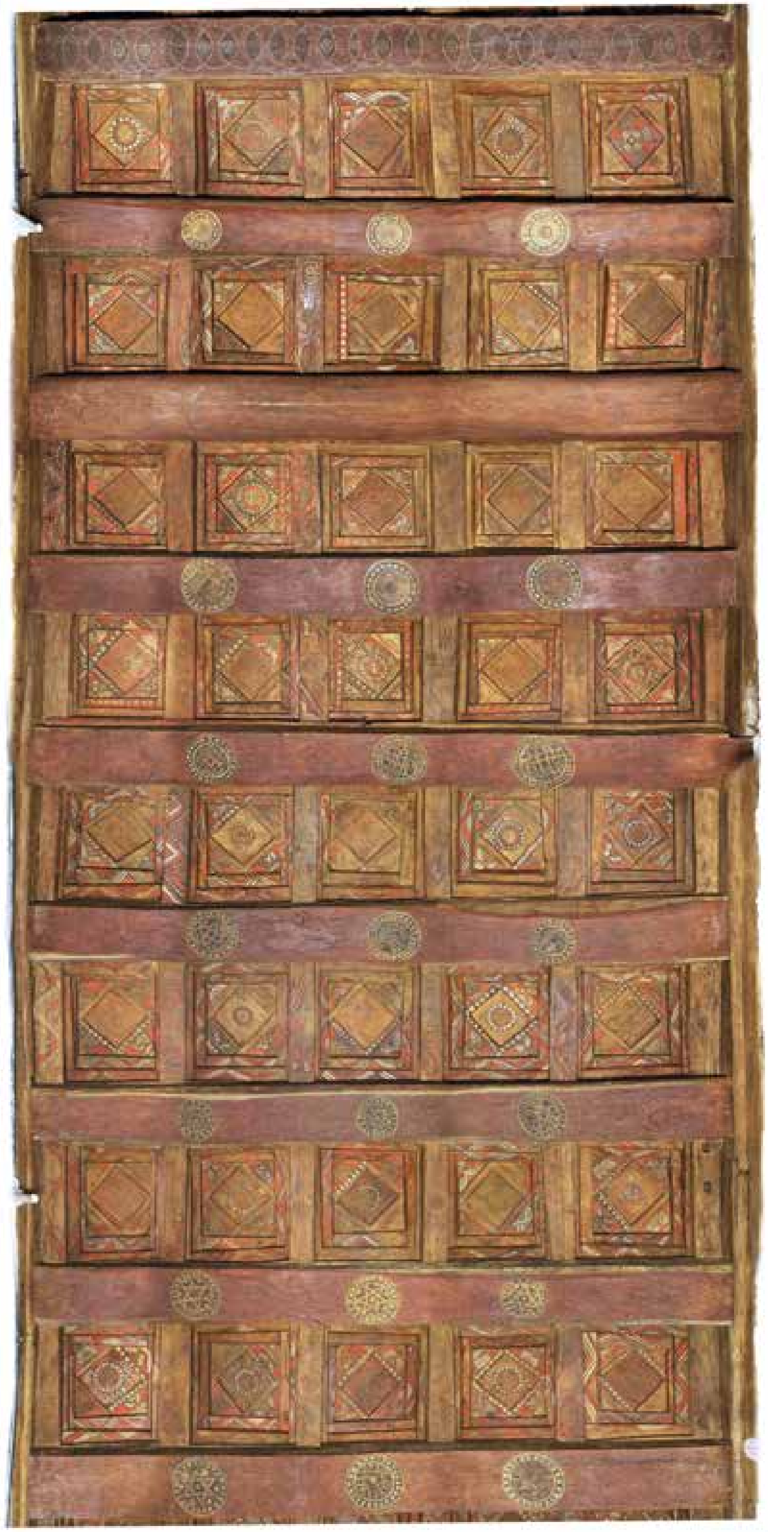
Balancing of the exposed wood parts, light or dark, both of the original strips and of the new additions, was done with watercolor glazes. The chromatic integration of the new wooden inserts, adequately treated with woodworm material, was instead performed with a mordant color.

Final painting

The final varnish followed the normal methodology, with a brush application of Regal Varnish matte paint at 40% in white spirit.

Figs 23, 24 and 25. Sequence of the restoration of a beam in some in its phases. From top: the state of affairs, cleaning and pictorial retouching.

Figs 26, 27 and 28. Sequence of the restoration of a beam in some of its phases. From top: the state of affairs, cleaning and pictorial retouching.



Section 2 - Chapter 6

EAST WING

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

The east wing, of all the *riwāq*, is the wing that appears to be the most extensive as it occupies the entire length of the area, along the outer perimeter wall of the mosque. The *riwāq* consists of three aisles. Each aisle has a ceiling formed by a row of five carved, painted and gilded coffers. In this sector the coffers consist of four levels and, proceeding from the uppermost, we will have:

1. the square panel, carved, painted on the bottom and gilded in the protruding parts of the carving;
2. the four triangles, also carved, painted and partly gilded;
3. the first and only series of frames, which presents carvings of golden pine cones inserted in niches with a blue background;
4. the last level relating to the under-beams that divide the coffered system in a clear geometric way. The under-beams also have a floral carving painted blue on the bottom and gilded in the protruding parts.

All the levels of the coffers just described are in turn separated and defined by narrow frames decorated with a series of small white three-layer merlons alternating with green and blue merlons, punctuated by small red triangles in the empty spaces of the upper border. The characteristic of these frames is to be composed of a softer wood species, a conifer, compared to the rest of the structure, so they are more damaged as they are more subject to xylophageous or fungal attack.

The rows of coffers are divided by massive but tapered beams that fit in and balance the general coffer system. These beams do not have decorations on the two side faces but only on the lower one, where a bas-relief carving predominates, also painted and partly gilded.

Of all the sectors, the eastern one is certainly the most uniform, since it is characterized by the same decorative apparatus throughout its area without particular exceptions. Being the most recent one, the east *riwāq* has not undergone any particular structural or maintenance interventions which, in the other *riwāq*, has often led to a significant variation in the decorative layout.

Unlike the other wings, the pictorial material of the decoration is used here in a limited way. The reddish color of the wood surface prevails together with the gilding, while the pictorial material, mostly blue, is confined to defining the backgrounds in such a way as to bring out even more the refinement and elegance of the carvings.

The types of carved decoration are quite varied: branches, pine cones, leaves and rosettes. Gold is used lavishly, never exaggerated but in perfect balance with the surrounding shapes and spaces, while the tones of the polychromy range from red to blue. Along the walls are boards ("sleepers") that have been inserted and bear inscriptions taken from the Koran, in Kufic script, carved in relief and painted.

The ceiling of this area can be said to be characterized by about 35% of uncarved or painted wood, about 20% of carved wood, and the remaining 45% decorated with a polychromy based on tempera, gold leaf on a double profiled coffered structure central rosette also carved and gilded.

Figs 1 and 2. Typical detail of the ceiling in the east *riwāq*, before and after the intervention.

The problems of decay

The state of conservation of the wooden structure, if compared to the other sectors, was generally good. It was in fact one of the best-preserved ceilings of the mosque, also by virtue of its more recent construction. Naturally there were, as in the other ceilings, attacks of xylophageous insects that developed in a particular way on all those narrow dividing frames between the coffers, decorated with geometric motifs. This was mainly due to the fact that these elements were made with wood species belonging to the class of conifers, a much softer wood and prone to biological attacks, compared to the hardwood wood used for the supporting structure. Among the biological attacks there is also the formation of white rot as a result of wet and dry cycles, caused by periodic seepage of water, coming from more or less continuous infiltration over time in different points. This particular type of biological damage, neglected over time, in addition to giving the surfaces a very dusty appearance with almost total loss of polychromy and a general graying of tones, caused structural weakening of the frames of the lower border, immediately below the point support of the joists, on which the structure of the coffers was built.

Fig. 3. An insect nesting area is visible in the photo.

Fig. 4. Detail of the nest removed from the east *riwāq*.

Figs 5, 6 and 7. The photos highlight typical situations of deterioration of the eastern *riwāq*, in particular the attack of xylophageous insects on the narrow frames that divide the elements of the coffers.

The border of the innermost frame that profiled the elements of the coffered ceiling seemed initially to have remained more intact since it still had an intact polychromy but, in fact, in many points immediately below the same color, the cavities formed by insect attacks made the wooden support spongy and structurally inconsistent, putting at risk the adhesion of the pictorial film, now close to disintegrating even on these elements.
Some coffers, fortunately few, had completely dilapidated parts, mostly caused by old infiltrations of rainwater from the top of the ceiling. These parts alone will be disassembled and treated on the bench for immersion consolidation, then reinforced and replaced in situ.

There was a widespread blackening and the presence of soot, in particular on the under-beams and on the lower part of the coffers, with very thick deposits and firmly cohesive to the surface. There was also a pigmented organic layer on the entire surface, now completely blackened, perhaps applied as a final and protective varnish.

The color change of the wooden support in this sector varied depending on the proximity of the aisle to the windows overlooking the internal courtyard, changing from darker and browner shades to lighter and reddish ones. Precisely because of the light and different environmental conditions from aisle to aisle that caused a chromatic alteration so visible in the overall reading of the entire east wing.

Another problem that appeared quite evident to us at a first phase of visual analysis was the presence of considerable grime in several points of the ceiling and on the beams, due to impregnations or real washouts, caused by rainwater poured from the roof and probably loaded with plaster. and water-soluble material present in the fill used above the ceiling.



Figs 8, 9 and 10. Some examples of badly damaged coffered areas due to water seepage and percolation.

Also, in this sector the whole ceiling structure had white spots and stains, if not whole sectors covered by the gypsum-based material used during the maintenance interventions of the past, mainly located on the boards of the sleeper with its Koranic inscription and on some sub-beams. In particular, the sleeper's structure was largely hidden by plaster but, although covered, was still generally intact except for some missing profiles and small gaps on the Kufic letters.

The polychromy of the ceiling is characterized by thin layers of fine-grained color,

Figs 11, 12, 13 and 14. Beams and details showing the covering of the original decorative motive with white plaster-based paint.

spread directly on the wood surface. It was presented with a good degree of conservation in the blue and red backgrounds at the top of the coffers to such an extent that it was assumed that it would be restored at a later time. In fair condition, the blue color in the niches of the pine cones and in the carvings of the sub-beams, as well as the red profiles of the triangular elements and the white, blue, green decorations of the frames of the coffered elements, while the red profiles of the pine cones have been completely lost. and the motif of the dividing joist between the coffers.

The typology of the layers of dirt present was rather simple to identify and remove. It consisted of greasy dirt and organic residues of various kinds (cobwebs, nests of insects or birds, guano) and a layer of pigmented organic material, of a reddish-brown color, bound with a protein glue that was easily removed once swollen in water.

On the other hand, it was not easy to fine-tune the cleaning of the pine cones and the blue cavities on which they rest. Many of them showed whitish efflorescences, which laboratory analyzes have confirmed to be saline.

Various situations were also been identified for the gilding. It was well preserved in the upper portions of the coffers, in fair condition in the decorations of the sub-beams, badly abraded or partly repainted with a yellow pigment and covered in several places by saline efflorescence in the pine cones.

Another problem was the presence of dark spots on the polychromy caused by migrations of the wood tannins, a phenomenon always caused by the seepage of rainwater coming from the roof.

The only real serious deterioration of the sector was located in the third aisle of this wing and more precisely in the part between beams 23 and 29, where the subsidence of the foundations of the minaret towards the west had caused the emergence of the heads of the beams inserted in the masonry. This slippage also caused the displacement of the board corresponding to the sleeper, placing it in an unstable manner on the splayed masonry. In addition, in the vicinity of the collapsed beams, on the wall opposite the minaret, the boards of the sleeper were missing, fallen or broken precisely due to the lowering of the beams. In this area, static calculations were immediately necessary in order to plan a correct and safe recovery intervention.




Figs 15, 16, 17 and 18. The photos show one of the few areas in the east that required external intervention removal of the outer roof.

The methodology of intervention

The general phases that characterized the restoration work in the eastern sector can be summarized as follows:

Documentation of the state of conservation
As a first step, the initial high-resolution digital photographic documentation of the state of conservation was carried out, followed by documentation and graphic mapping.

Mechanical cleaning
After performing the appropriate preliminary tests to identify a cleaning system for the entire surface, mechanical cleaning was undertaken with a vacuum cleaner, with soft bristle brushes and wooden sticks to remove incoherent dirt and remove dust from the cracks of the elements of the coffered section. Subsequently, the surface was descaled to remove the thick layer of plaster on the sleeper and the numerous splashes present around the heads of the beams. Furthermore, the black molds present on the polychrome frames of the coffers and on the frames of the overhead beam were also removed with a scalpel, where the original decoration, badly damaged, was almost totally missing. The mechanical cleaning phase ended with a further cleaning with a vacuum cleaner to remove the residues produced by the previous operations.

Figs 19 and 20. Some cleaning pieces with the removal of the white rot.

Preconsolidation
In this sector, a preconsolidation phase of the narrow polychrome frames that delineate the coffered elements was necessary, since they were particularly deteriorated due to fungus or white rot. This biological attack had determined a complete alteration in the solidity of the wooden structure giving rise to a spongy consistency. This caused particular problems in the chemical cleaning phase, since the wood surface was so badly damaged it tended to react to the solutions used, both liquid and thickened, creating halos and stains that are difficult to remove in subsequent phases. Consolidation, by limiting the absorbency

of liquids, prevented this drawback in the subsequent cleaning phase. This was done with Paraloid acrylic resin diluted 5% in acetone, applied with a brush or by injection for a deep treatment, depending on the degree of deterioration of the treated surface.

Most of the gold leaf decorations also required a preliminary fixing intervention in addition to the other restoration operations. Fixing was localized by brush with Paraloid B72 at 3% in Acetone.

Chemical cleaning

The polychromy cleaning of the coffers, given the type of dirt previously described, was carried out substantially with surfactant solutions, in particular bovine bile at low concentrations in demineralized water gave good results on most of the surfaces. However, given the different types of dirt present and the different state of conservation of the structure of the elements, the intervention was often diversified, operating in a specific way, especially in the finishing phase, depending on the case in question.

First of all, we established that for the areas of unpainted exposed wood, a treatment with hot water and high absorbing synthetic PVA sponges of the "blitz fix" type was sufficient, as it allowed removal of that pigmented layer of organic origin uniformly present over the entire surface. The sides of the beams on the other hand, those affected and compromised by the seepage of rainwater infiltrated from the ceiling, which caused numerous and evident stains surrounded by grime of a rather dark color, required, following the drying of the first general intervention with hot water , a second and subsequent finishing phase, which therefore took place in a localized way, to ensure uniformity of the intervention itself, which then facilitated, with the accompaniment of tones, the subsequent intervention of chromatic restitution. In areas with strong blackening, 1% Coccocollagen in a gelled solution was generally used with the interposition of Japanese paper and subsequent rinsing with demineralized water.

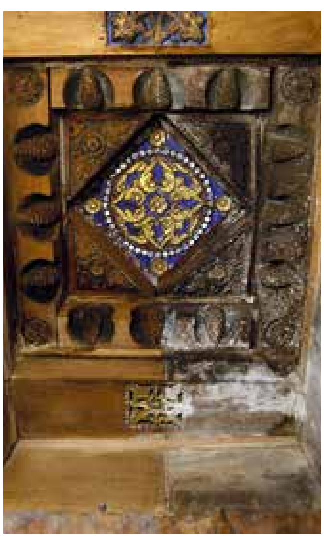
Even the cleaning of the narrow polychrome frames that were particularly blackened required a differentiated and specific finishing intervention. On these areas, after cleaning with gall, we proceeded in a localized way using a chelating solution at pH 7.5 or pH 8.5 depending on the cases, limited to the areas with more dirt accumulation. This made it possible to remove the patina of dirt, which was very cohesive, thus revealing the original chromatic rhythm of the decoration.

The gold leaf of the underbeams was cleaned using a chelating solution at pH 7.5 and with a subsequent dry removal phase of the dirt. Cleaning the sub-beam notches was relatively simple with water, a soft-bristled brush and a blitz-fix sponge.

The gold leaf on of the underrun was cleaned with a chelating solution at pH 7.5 and with a subsequent phase of dry removal of the dirt deposited inside the more minute niches and where necessary, a final cleaning was carried out with a cotton swab and chelating solution.

The cleaning of the gold of the pine cones, the floral designs and the flowers inside the coffers was generally done with ligroin since the dirt was not particularly stubborn and its removal was relatively simple. If, on the other hand, there was a strong adhesion of the coherent layer, the chelating solution at pH 7.5 and a cotton swab was used, without applying a particular mechanical action but only with small delicate touches to remove the surface deposit.


Figs 21 and 22. Under-beam cleaning blocks.



Figs 23, 24 and 25. Cleaning blocks.

Disinfestation

Also in this case, a localized biocide treatment was carried out in the areas affected by attack of white rot, with 4% benzalkonium chloride, while the woodworm repellent was applied by brush on the entire surface with a substance based on permethrin.

Grouting and fillings

The closing of the cracks present between the elements of the coffer was done with the insertion of cotton hardened with Gelvatol resin, adequately pigmented to the general tone of the structure, so as to appear aesthetically as empty areas of darkness, creating continuity between the elements of the coffer and to avoid the fall of inert material from the false ceiling.

The grouting of the lesions, cracks and gaps in the substrate was done with bi-component epoxy resin of the Araldite type for deep areas and finished flush with bi-component Balsite resin. To obtain a color similar to that of the wooden support, stable powder pigments were added to the mixture.

Preliminary painting for retouching

As a preliminary operation to the first painting, the background tone of the non-decorated wooden surfaces was balanced, in order to guarantee a unified vision of the whole and to be able to work more precisely during the phase of pictorial integration of the polychrome decorations. This operation took place with the drafting of a pigmented collection. Taking into consideration also the shades of the contiguous sectors, two different shades were prepared: a dark tone (10 parts of burnt umber and 7 parts of natural umber) for the darker original parts and a light tone (10 parts of burnt umber and 5 parts of natural umber) for the light and intermediate areas. In some cases, a neutral or non-pigmented collection was applied as a means of filling the characteristic pores of the wooden material, in the soffits and joists and in the areas that had the right neutral tone.

The subsequent preliminary painting to the aesthetic restitution phase took place with the use of opaque effect paint produced by Lefranc & Bourgeas diluted to 30% in white spirit.

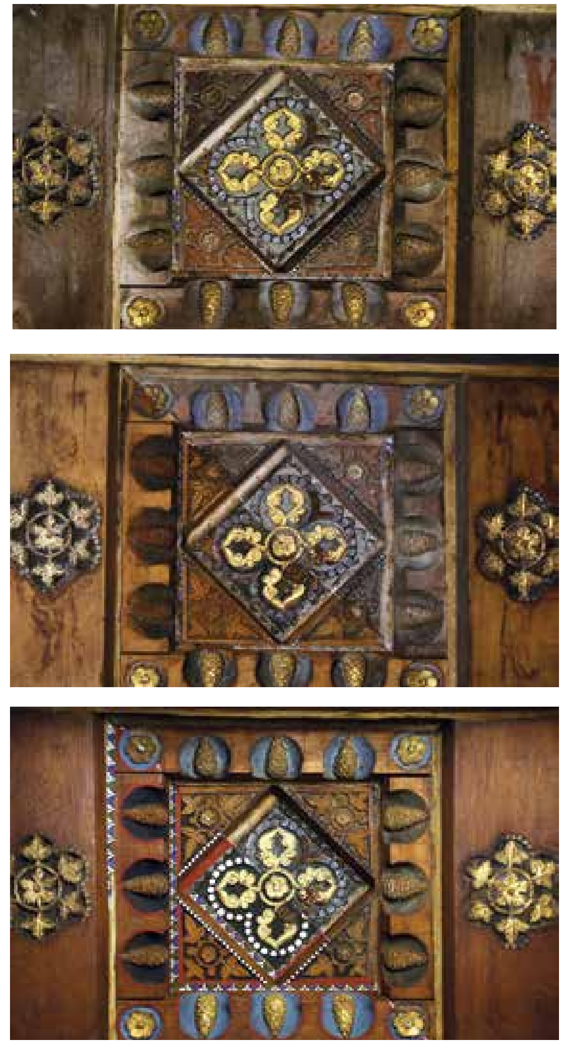
Pictorial integration

The retouching of the polychromy was done with varnish colors as these colors allow the different shades of the decorations of the drawers, beams and joists to be uniformly tinted. Given the low polychrome percentage of this wing, with the presence of a single decorative pictorial model made up of numerous and minute details, it was decided to reintegrate by completing the motif more than what was chosen in the other sectors, in particular all repetitive decorative modules such as white dots and bands. This choice was made as a little accentuated retouching would not have transmitted a good visual result to a view from below.

Final painting

All the wooden surfaces were treated with a brush coat of mat regal varnish diluted 40% in white spirit as a final protective varnish.

Figs 26, 27 and 28. In sequence the restoration intervention on an underbeam in some of its phases, from above the state of affairs, cleaning and pictorial retouching.



Figs 29, 30 and 31. In sequence the restoration intervention on a coffer in some of its phases, from above the state of affairs, cleaning and pictorial retouching.

Figs 32 and 33. In sequence the restoration intervention on a coffer in two of its phases, cleaning and pictorial retouching.


E1T31


E1T9

Section 2 - Chapter 7

WEST WING

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

The west wing, of all the sectors, is the one that occupies the smallest area, as it develops only in the central part that runs along the western wall, while the initial and final spans belong, by reason of structural and typological continuity, to the north and south sectors. The west sector is made up of three aisles, with six rows of coffers on four levels, as in the east sector with which it shares many similar elements. The coffers are separated by under-beams and load-bearing beams as is characteristic of the entire ceiling of the mosque. The beams here are sometimes covered on the three exposed faces with wooden boards of different types with respect to the load-bearing beam inside. Both the structure of the coffering and the arrangement of the beams are fairly regular throughout the wing.

Beams, under-beams and coffers are all pictorially decorated. The only gilded carving is found on the upper closing panel of the coffering, just as it was in the eastern sector. The tiles present here are almost identical to those present in the eastern sector.

Even the typology of the decorations in the coffers resembles in many details, in pictorial rather than intaglio style, that of the eastern sector. The beams, on the other hand, are of the same style, with a decoration typical of the wing with elegant and very minute details, consisting of blue arched motifs and floral elements on the two lateral faces and various geometric and/or floral motifs on the lower face. Also in this case, the palette is limited to a few colors, such as blue, green, white and red, with the use of black substantially for the definition of some contour lines. The gilding is present only in the cantilevered floral elements of the carvings on the panel closing the coffers.

It is likely that everything that appears to us today as exposed wood was actually once painted with a red background color, as is the case of the upper triangles, and as evidenced by traces of color on the same reddish surface of the wood.

Figs 1 and 2. Detail of two areas of the ceiling in the west wing that reproduce the decorative motif typical of the sector.

The problems of decay

The ceiling was in fair condition overall. From the structural point of view in all the aisles there is a slight tilt toward the load-bearing wall and some beams had cracks, most of which were of not serious enough to endanger structural stability.

On the other hand, what immediately struck the observer when entering to inspect the sector before the intervention, was the serious state of decay of the first spans of each aisle, i.e., the first five rows of coffers for the first and third aisles, and the first seven in the second aisle.

The ceiling was, in fact, in very bad condition, almost entirely covered by layers of foreign matter, even preventing a real and precise analysis of the actual state of the wooden surface below. In the first place there were overlaid layers and large plaster infill panels, the latter probably used in rough maintenance interventions to replace in some way the missing parts of the coffers or to support the unsafe elements of the coffering and perhaps, as it can be deduced from some morphological details of these infill, to prevent the nesting of insects and birds. In fact, there was also a large amount of deposit material deriving from the nesting of birds, especially in the first three rows of coffers, consisting of thin twigs, feathers and guano, which formed a compact mass adhering to the support.

The prolonged presence of this type of deposit over time certainly favored rapid and serious biological deterioration, creating a micro-environment suitable for the proliferation and nesting of insects and other micro-organisms, such as molds and fungi, thus creating further decompensation in the wooden structure of the coffered system. The formation of fungi, molds and white rot inevitably led to the detachment of the color, which in these areas had become powdery at best, but often presented the extreme situation of large gaps. The polychromy of the coffers and beams in these first rows of coffers will now inevitably be compromised, non-existent and irretrievable.

Infill and plastering had also been used abundantly on the beams. Probably, also in this case, the work had been done in the past, as for the coffers, with the aim of restoring

Figs 3 and 4. Some areas of the western sector that had been completely covered with acrylic paint and gypsum-based plaster.

Figs 5 and 6. Some areas of coffers freed from the layer of white plaster reveal numerous unsafe elements.

Fig. 7 and 8. Detail of one of the many coffers damaged by nesting birds.

Figs 8, 9 and 10. Some details of beams affected by fungal attack and formation of white rot.

or at least protecting the structural integrity of elements that were at risk of collapsing. Several transverse fractures were found on the beams following the removal of the infill panels and of the extra layers of plaster, which most of the time required opening the ceiling from the outside, according to the procedures described in chapter 3 of this section.

In general, although defined as satisfactory, the conservative state of the entire wooden structure of the west wing was uneven, alternating well-preserved areas with others in poor condition and with the extreme case of the first rows of the coffered ceiling as previously described. The most widespread factor of degradation the biological decay caused mainly by attacks of xylophageous insects, which had eaten away the boards covering the sides of the beams and in all those decorated frames separating the main elements of the coffering. In this sector, this phenomenon is also largely due to the use of a much softer wood species predisposed to a biological attack of this type compared to the wood used for the other ceiling elements of the mosque. The structural weakening of these elements, which have become spongy and inconsistent, led to further failure with the collapse of several coffers, requiring the opening of other portions of the sector from the outside in order to carry out an adequate and precise intervention.

As for the beams, some cladding boards have been lost, possibly fallen or removed over the years as completely deteriorated, others were in an advanced state of decay with cavities affecting the board itself in all its dimensions.

Figs 11 and 12. Detail of some roofing of the beams damaged by attacks of xylophageous insects.

Fig. 13. Detail of a coffer in which the combination of various degradation factors caused the constituent elements to collapse.

Also, the sleeper at the base of the ceiling, carved with Koranic inscriptions, consists of wooden boards made of a soft wood species and has been attacked by xylophageous insects, like the other elements of the same wood family in the sector. Some panels were completely excavated and deteriorated, now illegible and irretrievable both from an aesthetic and structural point of view.

There are, albeit to a lesser extent and limited to a few points of the ceiling, infiltrations of rainwater due to imperfections in the slope of the ceiling which led to the formation of pools of stagnant water. This seepage caused dark brown stains to form on the surface, generating molds and fungi. There was also some blackening caused by the past presence of oil lamps hanging from the ceiling.

The technique of execution of the polychromies was similar to that of the other sectors, a thin coat of fine-grained tempera, applied here, however, on a reddish base that is not always visible. The state of conservation of the decorations is satisfactory in the coffering, if we exclude the more specific case of the first rows of the aisles and of the painting done on the narrow frames between the elements of the coffering. The decoration of the beams is more incomplete, especially if roofing boards are present. As previously mentioned, the use of a softer wood species that compromised the state of structural conservation also affected the state of conservation of the aforementioned pictorial film.

Figs 14, 15, 16 and 17. Details of the sleeper band obscured by the attack of xylophageous insects.

A layer of pigmented protein material, of a reddish-brown color, was present more or less uniformly on the entire surface and sometimes penetrated into the porosity of the wood, similar in color and composition to that found in the eastern sector. This last protein film altered the polychromy which consequently appeared more purplish, especially on the beams. With cleaning, in fact, the original underlying paint turned out, for a good percentage, to be red color, with an organic binder.

A particular case was represented by the first ten rows of coffers of the first aisle (sector 01), characterized by a wooden composition not carved in the tiles and a double coffer structure profiled with a predominantly white / blue tempera-based polychromy. This is a repainting, which will be preserved in this restoration, under which there is the original decoration.

In general, we can say that the western sector was characterized by a fairly good state of conservation, both as regards the wooden structure and the conditions of the polychromies, although there are several areas in rather critical conditions.

The methodology of intervention

Documentation of the state of conservation

As a first step, the initial high-resolution digital photographic documentation of the state of conservation was carried out, followed by documentation and graphic mapping. The


Figs 18 and 19. Example of the rows of coffers in the first spans of the west sector 1.

documentation phase followed with even more precision the areas in which the opening of the ceiling was planned, documenting the operations step by step and providing fundamental guidance in the reassembly of the coffers, indicating the exact location of the various elements.

Mechanical cleaning

As a first intervention, according to the usual methodology established and applied also for the other sectors, mechanical cleaning was carried out, i.e., the removal of all those overlaid layers and plaster infills that occluded the view and did not allow the precise analysis of the artifacts, especially in the first spans of the sector, on the sleeper and on the perimeter areas. During this operation, molds and fungi were also removed, in order to prepare these areas for the subsequent biocidal intervention.

Pre-consolidation and consolidation

Given the particular condition of detachment and pulverization of the painted surface, it was necessary here, more than in other sectors, to apply a fixative to the color, so that it could be treated with greater ease during the subsequent cleaning phase.

This was done using Klucel G resin, diluted 4% in ethanol, applied with a brush with Japanese paper interposition. Where possible, where the color was thicker and disconnected, we intervened with injections of the same resin at a lower concentration to facilitate its penetration under the color flakes. In preliminary tests, Aquazol 200 was also tried, but was deemed unsuitable as it caused noticeable whitening and yellowing, due to the migration of tannin to the surface.

Paraloid at a concentration of 5% in acetone was used to consolidate the gold leaf of the carved elements on the tiles. The wooden structure was also generally reinforced with the same Paraloid resin in varying concentrations, generally no more than 5% in acetone. However, given the particular fragility of many wooden elements with a spongy consistency and the presence of many cavities, also extended over large surfaces, the Paraloid treatment alone would have proved useless in restoring structural strength to the support. Furthermore, not wanting to use acrylic resin indiscriminately on large surfaces, we opted for the injection of bi-component epoxy resin of the Balsite type, diluted in alcohol as needed. This methodology made it possible to restore the structural solidity of the wood to a good extent, filling the cavities created by previous attacks of xylophageous insects.

Chemical cleaning

After protecting the painted surface and the consistency of the wooden support, it was possible to carry out the subsequent solvent cleaning operations with relative tranquility. In developing the best cleaning methodology, various tests were carried out with chelating solutions and surfactants. The main objective was to remove that red / brown layer of protein origin present more or less uniformly over the entire surface. In particular, the cleaning focused on the coffers, where the polychromy, largely well preserved and in better condition than that on the beams, was blurred and grayed by this layer.

Figs 20, 21 and 22. In sequence the restoration intervention in some of its phases, seen from above: the current state, followed by the dry-cleaning phase and finally the chemical cleaning and structural rehabilitation phase.

The coffers were generally cleaned with surfactants, in this case ox gall was used, especially for the red and blue colors. Chelating solutions at ph. 7.5 were used to clean the gold leaf of the carvings present in the panels of the coffers. The use of surfactants, especially coccocollagen, also proved very useful in the finishing phase for the removal of

Figs 23 and 24. First cleaning phase which involved the removal of the numerous bird nests.

all those dark spots caused by highly degraded protein material and by the surface migration of tannin.

The method described above was also followed for cleaning the beams, although in this case longer contact time was required for a more incisive action, especially on areas of exposed wood without polychromy, where the protein layer had been absorbed through the porosity of the material.

Cleaning thus restored the best view of the different decorations on the ceiling.

Disinfestation

Pest control treatment was an important operation in this sector to ensure the stability of the intervention in the future. In particular, pest control treatments were performed in all areas where the ceiling was removed, working from above, with special attention to

Fig. 25. Solvent-based cleaning on the band of the Koranic inscription.

Fig. 26. Solvent-based cleaning on the dehumidification of an under-beam.


Figs 27 and 28. A photographic comparison between the first and final part of the restoration on a portion of the under beam.

the first spans of the sector. Subsequently, in a localized way, benzalkonium chloride was applied by brush, in all those areas affected by the growth of mold and fungi or white rot.

Woodworm treatment was then performed on the entire surface with permethrin-based material, as in all the other sectors of the mosque, paying close attention to soak material in woodworm repellent, especially those elements characterized by soft wood species belonging to the class of conifers.

Grouting and fillings

The grouting and filling of the cracks between the coffered elements was handled in the same way as in the other areas of the mosque.The fillings made to prevent material of various origins from falling through the openings between the wooden elements of the coffering consisted of cotton inserted in depth and later solidified with pigmented Gelvatol.

The grouting was done using two different bi-component epoxy resins, Araldite and Balsite. The first was used for depth and sublevel fills, the second for flush finishes. A common practice was the addition to the bi-component resin of stable powder pigments to give the grouting a color and tone similar to those of the artifact, thus facilitating subsequent pictorial retouching.

Preliminary painting for retouching

The preliminary painting to the pictorial integration phase was done using the usual method with Regal Matt paint at 30% in white spirit on the entire surface.

Pictorial integration

Also in this sector the modes of pictorial integration and final aesthetic restoration were preceded by long discussions and reflections, even more so than in this area of the mosque where the gaps were numerous and very extensive. However, the repetitive nature of the same decoration, especially on the beams, would have easily allowed a more consistent reconstruction of the pictorial fabric than was actually done.


Figs 29 and 30. Example of integration of the Koranic inscription band with a shaped wooden piece.


Figs 31 and 32. Example of integration of the Koranic inscription band with a shaped wooden piece.

Fig. 33. Detail of the western sector at the end of the intervention.

Fig. 34. Detail of the western sector at the end of the intervention.

The main problem consisted of the decorative typology, with its many small and minute details, which, if not reconstructed, would hardly have succeeded in transmitting to the observer located several meters below the enormous aesthetic qualities that this decoration possessed and that it certainly managed to convey in the past. The compromise reached between the parties involved and the specific choice made in this case consisted of a partial reconstruction of the decoration which, in the points where the it was still visible, even if fragmented, was reconstructed as much as possible in tone with the hatching technique, leaving only the reddish background color with a neutral background.

Section 2 - Chapter 8

THE PALIMPSEST

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

A completely atypical area compared to the general coffered ceiling structure of the Great Mosque can be found in a rather restricted area located in the northwest corner, in the initial spans of northern sectors two, three, four and five. For reasons of structural continuity of the ceiling they have often been merged with the northern sector but due to their particular structural and aesthetic qualities they can very well constitute a small sector in their own right. For this reason, it was decided to devote a specific chapter to this sector, dividing it into four separate zones.

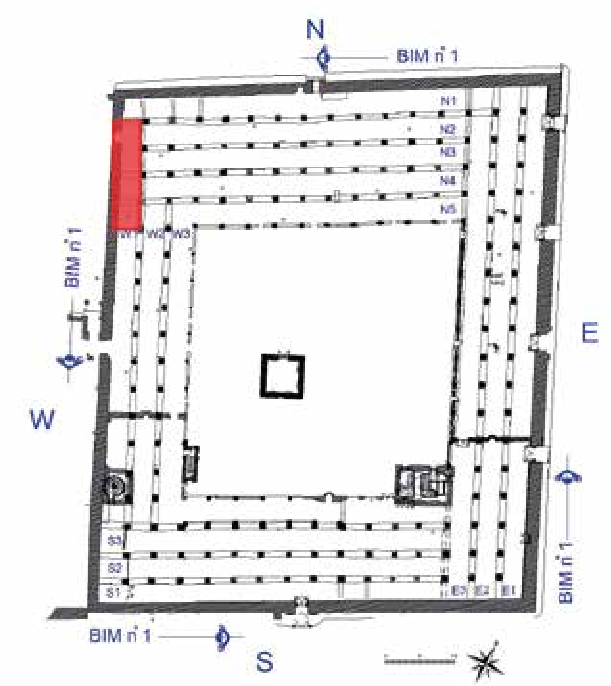


Fig. 1. In the general plan of the Mosque, the first spans of the northern sectors in which the area in question is located are highlighted in red.

What immediately characterizes the zone is the presence of numerous finely carved wooden elements with geometric and floral motifs, of a quality rarely found elsewhere. Upon closer inspection, however, it is clear that the various elements that make up the template have been assembled in the various spans in an arbitrary way, not always respecting the principle of symmetry, using salvaged elements certainly designed for other buildings. However, despite the numerous inconsistencies found, both from a structural and decorative point of view, there seems to be a basic compositional model that may have inspired the previous builders or that they tried to follow.

Starting from the top, the structure is always made up of large central elements, which we will call “capping structures”, the larger of which are rectangular in shape, while the smaller ones are square. These capping structures may contain simple decorations with very dense carving or hexagonal or octagonal tiles, 15-20 cm deep, carved with jutting floral elements, closed at the top by other tiles very similar to those that close the top of the coffers. The structure and type of the tiles is not always the same, but varies depending on the shape of the closing cap. The first version, found in northern aisle 2, features a single large rectangular capping structure. This structure contains numerous small hexagonal lanterns with carved tiles and jutting elements with floral motifs. The second version, in in northern aisle 3, consists of two originally square caps of approximately the same size. This section was particularly striking for the brilliant blue enamel paint applied in an earlier maintenance job. The first cap contains no tiles while the second has tiles in a star motif, a shape obtained by interlocking projecting elements with curved line. The third version, corresponding to sector N4, consists of two square caps of similar size, without tiles, but with carvings on a flat surface. The last version consists of two small rectangular caps, one with octagonal tiles and the second containing circular tiles set in hexagonal frames.

Each capping structure is supported by a double frame, most often composed of niches and three-dimensional plastic elements carved with floral motifs. Also, in this case the element is not repeated in the same way in all sectors and, in particular, the projecting carved elements that divide the niches do not always exhibit the same design.

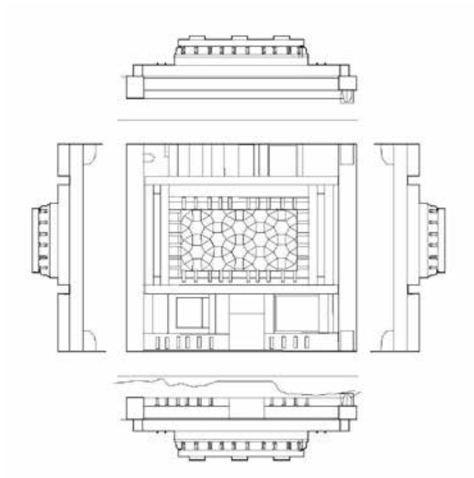
At the junction of the capping structure with the walls, there are vertical panels, some painted and others carved; these latter, clearly recovered from openings that had been closed, are reused here to frame the closures of the ceiling structures.

On the east wall, at the base of the template structure, there is a long vertical wooden band with painted Koranic inscriptions, as if to recall the panels of the sleepers that characterize a large part of the ceiling of the mosque.

All the capping structures are divided by beams perpendicular to the walls and different from each other in shape, size and decorative motif, a feature that still confirms that here again recycled material was used.

State of fact

From the structural point of view, since these panel templates were clearly assembled from elements that has come from another building and, in all probability, were not parts of the same body, many flaws and defects of the various compositions could be observed, and




Figs 2, 3, 4 and 5. External structure of the upper "capping structure".

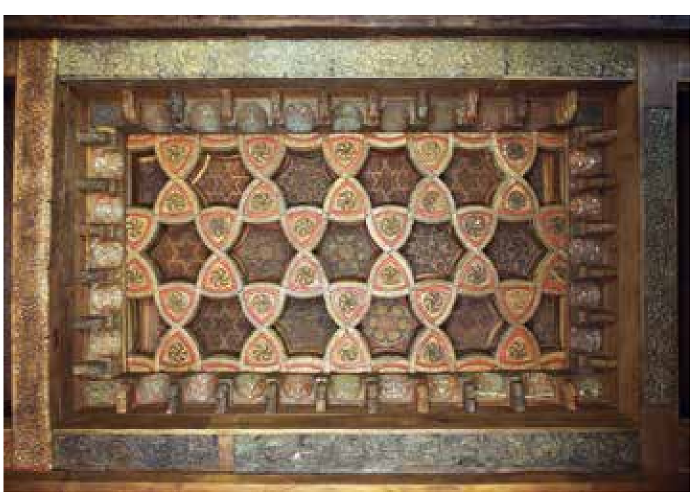


Fig. 6. A detail of the coffer palimpsest following the structural restoration and the cleaning intervention.

Fig. 7. A detail of the coffer palimpsest following the structural restoration and the cleaning intervention.

Fig. 8. Detail of one of the "end caps".

Fig. 9. Detail of a side decoration.

Fig. 10. Detail of what originally must have been a decorated and carved capital.

Fig. 11. Detail of a small decorative element placed under one of the secondary beams.

Fig.12. Detail of a carved wooden window, here reused as a horizontal roofing element.

some may have already been present from the outset, given the carelessness of the assembly, while others were likely caused by the natural movements of the wood that occurred over the centuries, by the sagging between the joints and the supports on the masonry, often inexpertly remodeled and buffered.

With reference to the pictorial surface, in general, the analysis of the decay does not reveal anything different from what was found in the other sectors of the mosque.

The perimeter areas were in fact affected by scanty roofing and plaster cladding, even of considerable thickness, with consequent splattering on all the neighboring areas. Sometimes the infills had been applied in order to fill some gaps and gaps in order to limit the detachment of wooden elements or to reinforce and close large cracks that could have caused material to fall. In some cases, in particular on the horizontal elements, the visible plaster was that spread outside over the roofing that had dripped through the openings and slits present between the various elements of the poorly positioned panels.

As in the rest of the coffered ceiling, there were many stains related to the seepage of rainwater from the roof and the consequent release of tannins from the wood. Some areas then experienced prolonged stagnation of pools with consequent deterioration of the wooden material and formation of white rot.

The whole surface appeared heavily blackened, a fact probably caused by a layer of proteic matter that had already been seen in other areas of the mosque ceiling.

The signs of attacks by xylophageous insects were not very common, given the good characteristics of the type of wood used here.

A very special case is certainly represented by the second panel in wing N3 where, in the Seventies, a first intervention of maintenance had been carried out by Egyptian workers. This intervention consisted mainly of simply applying a thick layer of bright enamel paint, particularly a blue background coat with purple accents that was extremely difficult to remove.

Carpentry and restoration of the wooden structure

After securing any parts at risk of detachment and numbering all the ceiling elements so as to correctly reassemble them if they should have to be completely dismantled, the entire existing situation was photographed and described in detail

Many parts of the decorative panels were disconnected and had been rearranged in a disorganized manner. The intent of the reassembly was to restore an area that appeared disorganized in many of its aspects and composed of elements not intended for the places in which they were inserted, but having been made to fit. We wanted to recreate an order and a structural symmetry, while always remaining, as far as possible, respectful of the original design.

The disassembly was done from above with the removal of the external *qaḍāḍ* and of the entire roof covering, according to the methodology already outline previously and ap-




Figs 13, 14, 15 and 16. The images show the two upper caps and some details of the areas affected by the past maintenance intervention.

plied for the disassembly of the coffered ceiling. The opening of the ceiling then provided the possibility to design and subsequently carry out an effective operation of carpentry to support the ceiling and thus relieve the original structure of most of the weight, while also relieving everything on the external walls to ensure better conservation over time of all the wooden elements of which it is constructed and above all facilitate simple intervention if the need should arise in the future.

This operation involved the installation of a system of crossbeams, perpendicular to the masonry, and longitudinal, parallel to the load-bearing walls, on four levels, duplicating the structure of each of the panel templates from the outside:

- The first level consists of a pair of longitudinal wooden beams inserted on the top of the walls and which has the task of distributing the weight of the whole system on the load-bearing walls.
- The second level is made up of transverse wooden beams of different lengths which have the task of supporting the entire weight of the system, transferring the forces to the first level and thence to the masonry. Two pairs of beams were thus inserted in the paneled areas in place of the original load-bearing beams. These double pairs of beams run the entire width of the area, from wall to wall, so that each panel has an autonomous and independent supporting structure. At each of the capping structures,

shorter beams were installed, linked to the third level, as support for the branches used to cover and enclose the ceiling.

- The third level consists of four sets of two pairs of longitudinal beams placed on the sides of the capping structure of each of the four panel templates. The length of each pair of beams is equal to that of the area of the panel it encloses.
- The last level consist of a system of separate crossbeams, placed above the capping structures as additional support for the structure and as a support for the branches for the new roof covering.

This truss system that duplicates the panel structure, caging it, has been designed in such a way that each paneled section has its own autonomous supporting structure, so that, if it should be necessary in the future to reopen the ceiling for maintenance, each section can be dealt with independently.

Also, in anticipation of possible future maintenance, all the elements of which the section is composed have been left mobile, so that it can be easily disassembled even from below and can thus be repaired without necessarily having to operate from the outside.

Furthermore, like all the coffered areas that were opened and disassembled from the outside, about twenty centimeters of empty space was left between the original ceiling and the new load-bearing structure, both to ensure good ventilation of the system and to facilitate possible disassembly of the individual elements from below.

As regards the wood restoration more specifically, the operations and works performed were not very different from the usual methods applied in other sectors.

Reassembly of all the elements that were fractured or had disconnected parts was then made, and reconstruction of the missing wooden parts was carried out. A few joists or other particularly degraded elements, after disassembly, were reinforced with additional wooden supports and Araldite from the back before being repositioned. The wood used for the additions was always treated with a woodworm repellent by immersion, for small pieces, or with three coatings on the surface of the same woodworm repellent. An aliphatic glue and, in rare cases, bi-component resin of the Araldite type loaded with sawdust was always used for gluing the moving parts and the new additions to the originals.

Works of restoration

Also in this case, despite the particularity of the construction of many of the elements composing the paneled zones, the methodology followed and the materials used do not differ from those used in the other zones and described previously, also considering that the agents of deterioration were the same and the general conditions were similar.
In general, therefore, the intervention was carried out as described below:

- Initial photographic documentation, in digital high resolution, of the original structure and its state of conservation.

Fig. 17. Removal of the roof covering.

Fig. 18. Phase of the structural intervention in an intermediate stage of reassembly of the upper cap.

Fig. 19. Detail of the interlocking system of the renovation.

Figs 20 and 21. The pictures show the system of wooden beams supporting the wooden structure.

- Graphic mapping of the state of conservation.
- Following restoration of the wood portions, high resolution photographic documentation was made of the work and the panels were reassembled and the new structure photographed.
- Removal of the paint and plaster coating the lower perimeter areas of the ceiling, particularly around the beams and on the boards bearing the Koranic inscriptions.
- Mechanical cleaning with a vacuum cleaner and soft brushes to remove loose dirt and remove dust from cracks.
- Execution of preliminary tests for the identification of a system for cleaning and consolidating the entire surface, both painted and wooden parts, and relative photographic documentation.
- Localized fastening with synthetic resins of all the polychrome parts and of the gold leaf or where the constituent materials had lost cohesion. For the polychrome areas, Klucel G from 2% to 4% was used in demineralized water with the interposition of Japanese paper, in order to protect the surface from the possible abrasive action of the brush. 3% Paraloid acrylic resin applied with a brush was used for the areas with gilding.

Chemical cleaning

This operation essentially involved the use of surfactants. For the exposed wood areas, a solution with surfactants of the Tween 20 type gave excellent results. For the lower decorated areas the chelating solution at pH 7.5 was used. This same chelating solution was also used for cleaning the gold and for the hexagonal frames of the upper closing cap. Removal of the blue enamel overpainting present on the panels corresponding to the three northern sectors was done with solvengel in benzyl alcohol finished with a pH 9 chelating solution. The use of a pH 9 chelating agent ensured a better finishing in cleaning of the original decorations and wood parts which, otherwise, would have presented a slight blue halo created by the absorption of the wood of the repainting removed by the solvengel.

- Disinfestation on the entire surface with permethrin-based woodworm repellent.
- Treatment of areas that have suffered a biological attack, specifically white rot, with Biotin T applied by brush or nebulization.
- Treatment of all iron elements. These elements were cleaned by mechanical action with abrasive papers and brushes and subsequent application of tannic acid and application of a protective solution based on acrylic resin.
- Grouting the cracks in the substrate and the deeper cracks between coffers and frame strips with Balsite bi-component epoxy resin, while Araldite bi-component epoxy resin was used for the larger cracks. To obtain a color similar to that of the wooden support, a stable powder pigment was added to the mixture of the latter resin.
- Preliminary to the pictorial retouching, a base coat of matt effect paint produced by

Figs 22, 23, 24 and 25. The photos show some cleaning blocks.

Lefranc & Bourgeas was applied, diluted at 30% in white spirit.

- Chromatic integration of all wood areas was achieved with glazes of varnished colors.
- Pictorial retouching of the polychrome areas was done with varnish colors using pictorial hatching as an executive technique.
- Final varnishing with matt varnishes.
- Graphic mapping of the intervention was then carried out.
- Final photographic documentation of the intervention was performed.


Figs 26 and 27. A comparison of photos before and after restoration.

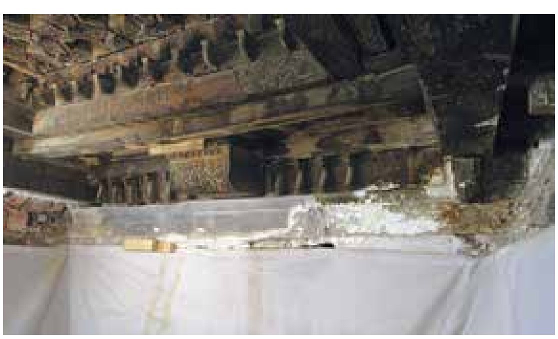

Figs 28 and 29. A comparison photos before and after restoration.

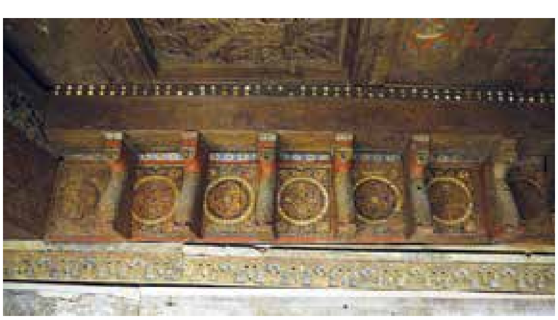

Figs 30 and 31. A comparison of photos before and after restoration.


Figs 32 and 33. A comparison photos before and after restoration.


Figs 34 and 35. Top: one of the upper capping structures prior to restoration.
On the right, the same element which, once removed, reveals larger size than previously appeared.


Figs 36 and 37. Top: the upper “capping structure” reassembled in the final structure.
On the right, the sector after restoration.





Figs 38, 39 and 40. Top: two details of the lateral decorations prior to restoration.
On the left a detail of the decoration after restoration.

Section 2 - Chapter 9

THE DOMES

RENZO RAVAGNAN – THE ITALIAN-YEMENI TEAM

In the first aisle of the north wing, where the *miḥrāb* is located, the typical coffered structure of the Mosque ceiling is interrupted by two spans containing a particular and very elegant composition of five domes, effectively emphasizing the importance and holiness of the area they surmount. The main dome, which occupies the central position, is flanked by two pairs of smaller domes. Their wooden composition is called "basket", with the truncated caps in the upper part. The central dome is closed at the top by a large alabaster slab, smooth and octagonal in shape, while three of the four lateral ones end with rectangular skylights, closed by finely worked alabaster slabs in bas-relief with floral motifs, all unfortunately deteriorated, broken and coated on the outside with *qaḍāḍ*. The skylight of the fourth, the one located to the south, on the right side of the central dome, is devoid of alabaster, replaced by two wooden planks placed side by side and decorated, probably because the original alabaster, now lost, was irremediably damaged.

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Fig. 1. General view of the domes.

Colors, materials and decorative motifs have the same characteristics that can be observed throughout the north sector, adapted to the specificity of a domed structure, composed of numerous overlapping triangular strips that form concentric painted bands. The decorations present on the circular bands of the wooden cap of the domes can be identified in four main types:

- Red/burgundy background bands and white or yellow circular motifs.
- Ocher yellow background bands with black circular motifs.
- Bands with a blue background, adorned with a series of small rosettes made up of six white petals organized symmetrically around a red heart.
- Bands adorned with a series of small three-tiered merlons, white on a blue background, and punctuated by small red triangles in the spandrels.

Figs 2 and 3. Detail of the wooden canopy, before and after restoration.

The basic horizontal supporting surface of the domes consists of a series of subbeams that divide the surface into triangular and rhomboid shapes. The decorative layout is not uniform over the entire surface, on which one can distinguish on the one hand the repainting relating to the second level, characterized by the typical red/burgundy background with yellow ocher medallions, and on the other very floral motifs, elaborate and elegant, related to the first level of painting.

Figs 4, 5 and 6. Details of the under-beam system of the support surface.

Even the supporting beams have, in terms of material and types of decoration, aspects that are very similar to the entire north sector. The only peculiarity is the presence of two circular beams smaller in diameter than the usual measurements found in the sector, placed under the central dome, where the axis is slightly tilted in respect of the perpendicularity of the vertical wall. They were probably added in a maintenance intervention, as a further support to the dome, which was in precarious conditions evidenced by the southern surface of the cap which is slightly sunken. These beams also have a common decoration, in particular the aforementioned red/burgundy background color with yellow circular medallions, the surface of which is in turn decorated with an intertwining of black lines. This suggests that the two new beams were inserted at the same time as the repainting of the second level of decoration.

The problems of decay

What was immediately striking was the damage created by a conservation intervention, during which two new load-bearing beams were inserted under the central dome, and a large quantity of lime, gypsum and sand-based mixture was used to plug the openings. between the same beams of the central cap. This mixture was then widely used in various points to stem sagging of the concentric bands of the caps.

Regarding the state of conservation, the real critical points were the skylights, which,

Figs 7 and 8. Details of the large plaster infill found in the central dome.

having been in bad condition for some time, had been remodeled and blocked with various buffers in an attempt to fasten the elements; precisely because of these clumsy attempts, however, some elements had been irretrievably lost. The northern right-side dome was devoid of the skylight altogether, and it had been replaced by a coarse and uneven layer of plaster which thus filled the gap.

Other faults were present in a few localized points and related to imperfections at the joints of the wooden elements, deriving from normal deterioration and movement of the structure. These failures were visible on the first upper bands of all five caps and on the south side of the central dome cap, where a slight breakthrough was clearly visible.

Fig. 9. Details of the skylight of the NW dome which highlights the precarious state of conservation. The wooden boards showed serious disconnections and large plaster infills.

Fig. 10. Details of the skylight of the SW dome. Also in this case, in an attempt to restore the wooden structure, large plaster walls were built which over time which had become unsafe and at risk of collapsing.

Fig. 11. General view of the central dome during restoration.

Regarding the state of conservation of the pictorial film, no variables were found compared to the rest of the northern sector.

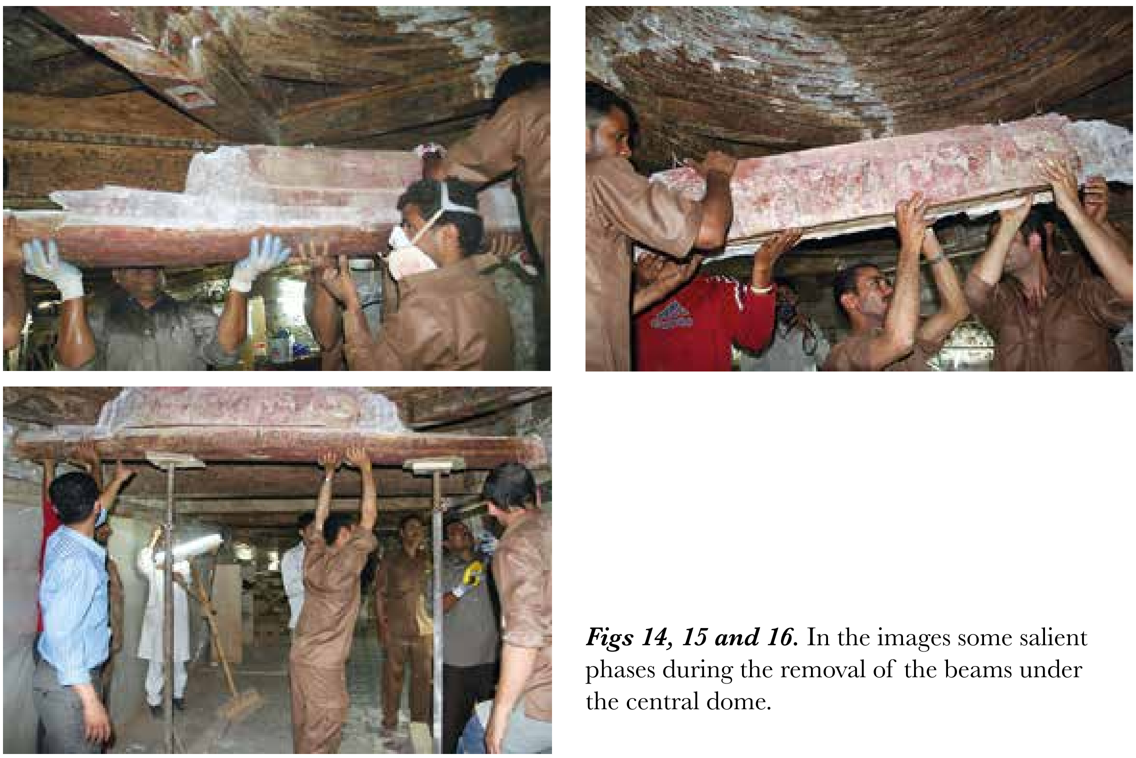
Figs 12 and 13. Detail of the elements that make up the wooden cap.

Intervention methodology

As for restoration of the decorations, given their nature and the state of decay similar to those of the first aisle and, more generally, to those of the entire north wing, please refer to what has been detailed in chapter 3 of this same section (North wing, Intervention methodology, p. 247). In this context, we want to consider a specific intervention carried out on the domes and illustrate the reasons behind the methods chosen for the intervention itself.

A first reflection arose when it was decided to carry out the rehabilitation of the whole system of the domes. It was clear that it would be necessary to act from the outside, opening the roof and freeing the entire structure, so as to be able to proceed in a precise and targeted manner and make the result more effective and lasting over time.

The greatest difficulties came from having to decide whether or not to remove the two beams inserted later, to which we referred in the previous paragraph. Considering that the framework would have been restored from the outside with major carpentry work, these two beams would no longer have carried out the support task for which they had been introduced, and would have created an esthetic disturbance within the harmony and equilibrium of the original system.



Figs 14, 15 and 16. In the images some salient phases during the removal of the beams under the central dome.

As already mentioned, however, the typology of the decorations that the two beams presented suggested that they were contemporary with the creation of the second level of painting, thus giving the two beams a historicized character as well as historicizing the other elements of the area in question.

In its truest meaning, restoration is not just an art, but a way of dealing with damaged property that differs completely from any repairs it may need. It is an attempt to preserve and restore the works to their original state, without completely erasing the effects of time or renewing the object or making inappropriate additions that risk distorting the original work. The choices are therefore determined by the way in which we investigate the object under study, in an attempt to understand the intent of those who conceived it, and it is this road that needs to be taken to study the materials, their production in the historical context, and then to diagnose its deterioration. The process, after careful consideration of different points of view, must make a critical evaluation of the task at hand and, decide whether to allow changes to be made.

Starting from these assumptions, and from the need to adapt to many different situations, we resolved to remove the two beams, favoring an esthetic-functional restoration in the most special and important point of a vital place of worship that still today fully carries out its religious function and community service.

The main purpose of the removal of the two beams was to recover the historical-artistic significance of the domes, while ensuring the maintenance of their physical integrity, that is what Brandi defined as the "re-establishment of the potential unity of the work of art." From an executive point of view, what is certainly most interesting is the structural rehabilitation carried out externally. In this case, for the excavation, the collaboration of the team of archaeologists was also necessary, as supervision of those in charge of laying the plaster was crucial.

Having freed the frame from its external covering and performing a first cleaning, the wood surfaces were found to be badly damaged by insect attacks, xylophages and fungi. This led toan initial disinfestation, which was subsequently repeated.

Consolidation

However, safe operation required that all the wooden components be intact, so any dilapidated and irrecoverable boards had to be replaced.

Later, the perimeter walls were restored, with niches built to house the heads of the metal beams that would go to support the original wooden beams. Two pairs of perpendicular beams were inserted into the wall for each dome in a lateral position at the base of the dome cap. In addition, between the space of the heads of the beams, parallel to the line of the wall, three wooden beams measuring 14x8 meters were installed, to make the structure more efficient. The wooden beams and the metal beams were connected near the north wall and the dividing wall between the first and second aisles, in order to ensure that the weight was discharged and evenly distributed over the entire length of the load-bearing walls.

Above this system of beams and crossbeams, a double wooden frame was also installed diagonally to support the tie rods meant to support the original load-bearing beams.

Having secured the structure of the domes in this way, it was possible to proceed with the removal of the two beams below, which were then restored and handed over to the Mosque museum to be exhibited to the public.

At the conclusion of the works, the external roofing was restored according to the usual methodology, following the shape of the domes with the last *qaḍāḍ* layer.

The alabaster plates

To close the skylights of the domes, alabaster plates were inserted in a simple wooden frame that secured them in their position. The only exception is the south dome on the right side which features two painted wooden panels to replace the original alabaster.

Fig. 17. Detail of the external structure of the central dome.

Fig. 18. Detail of part of the external wooden structure built to support the dome.

This constructive element certainly originally allowed the intense light characteristic of Yemen to filter, thus illuminating the internal area of the *miḥrāb* and creating a very special mystical effect.

While the large alabaster slab of the central dome has a simple smooth surface, the alabasters of the smaller domes feature refined bas-relief engravings depicting a weave of floral motifs, according to the usual typology of Middle Eastern art. Note that the slabs, although at first glance they appear similar, are all different from one another, both in terms of size and type of engraving.

The alabaster: problems of decay

The state of conservation of the alabaster slabs appeared very problematic from the beginning. Only one of the four was still intact, i.e., the one on the north dome on the right side, while the others were reduced to fragments of various sizes and showed signs of improvised maintenance.

The slab of the north dome on the left side was fractured in the center. In the past, attempts had been made to repair this fracture by means of a plaster pad on the outside and the insertion of metal staples, which, having completely rusted, had become a further obstacle to conservation.

The slab of the south dome on the left side also had a large triangular gap in the center, filled with an additional smooth slab of alabaster resting on the upper face.

The slab of the central dome was the worst preserved. It was in fact divided into countless fragments of various sizes and dimensions, some of which are now lost.

The internal surfaces of all the alabaster slabs were also completely blackened by a thick dark brown layer of protein origin, probably deriving from the fumes of oil lamps that we know had been placed for years just below the domes as testified by the numerous metal hooks placed on the beams and under-beams.

Fig. 19. Detail of the alabaster of the NW dome.

Fig. 20. Detail of the alabaster of the SW dome.

Fig. 21. Detail of the alabaster of the central dome.

Fig. 22. External view of the alabaster of the central dome.

Fig. 23. Detail of the alabaster of the NE dome.

Fig. 24. Detail of the painted wooden board of the SE dome.

Fig. 25. In the image, the particular *qaḍāḍ* structure found during the excavation above one of the side domes.

Intervention methodology

Removal of the external covering for restoration of the wood structure made it possible to remove the alabaster slabs with relative ease, so that they could be repaired more effectively in laboratory. The only alabaster not removed is that of the north dome of the left side, because on the outside, during the excavations, the ancient closure with *qaḍāḍ* came to light which, although not entirely original, represents an important testimony of the ancient building systems. Therefore being an ancient element and historicized, we opted to preserve it, leaving it unchanged in its original position. As a result, remediation was carried out on the spot. The cleaning of the alabaster slabs followed three main phases:

- dry cleaning with brushes, scalpels and wishab sponges for the removal of powdery deposits and accretions of plaster or mortar;
- first chemical cleaning with ammonium carbonate compress for an average contact time of 30 minutes, necessary to remove the dark brown stain, deriving from the fumes of oil lamps;
- finishing of the chemical cleaning with strong cationic ion exchange resins, for the

removal of those residues that the previous cleaning phase had not been able to remove.

- The result obtained by cleaning and by the effect of the ion exchange resins was surprising, as the slabs were restored to their original whiteness.


Figs 26 and 27. Detail of the alabaster strips during the intermediate cleaning phase.

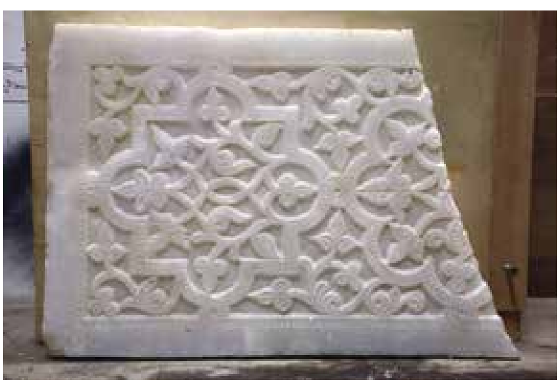
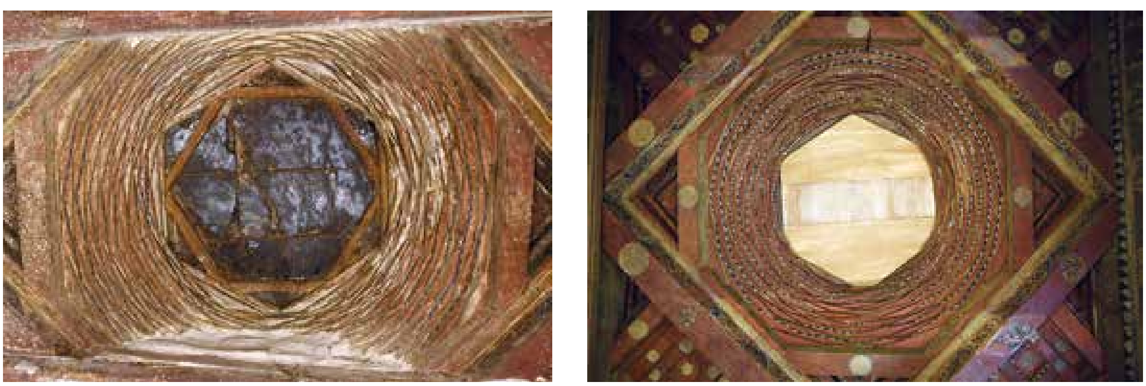


Fig. 28. Detail of one of the alabaster slabs after cleaning.


Figs 29 and 30. View of the NW dome before and after restoration.

Figs 31 and 32. SW view of the dome before and after restoration.

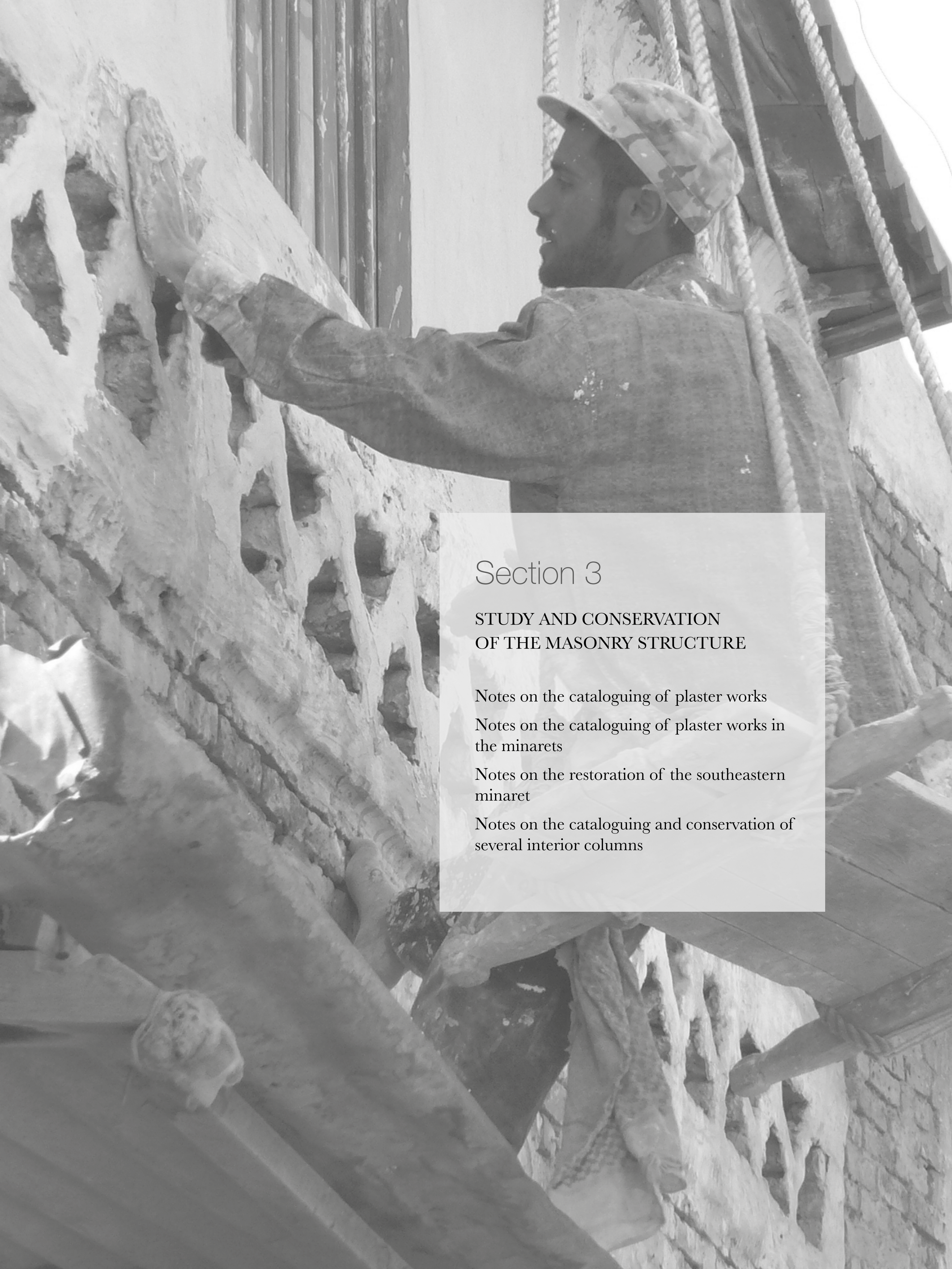


Figs 33 and 34. The central dome before and after restoration.

Fig. 35 and 36. View of NW dome before and after restoration.


Fig. 37 and 38. View of the SE dome before and after restoration.


Figs 39 and 40. Detail of the Quranic inscription situatated below the domes.
This is a rare example of gilded letters.



Section 3

STUDY AND CONSERVATION OF THE MASONRY STRUCTURE

Section 3 – Chapter 1

STUDY AND CONSERVATION OF THE MASONRY STRUCTURE

STEFAN WIDMER, MAURIZIO MERLO, FABRIZIO TONELLA

NOTES ON THE CATALOGUING OF PLASTER WORKS

In the course of our detailed study of the building, the history of its restorations and the works of maintenance carried out through the centuries, we made extensive examination of plaster samples. Microscopic analysis was done to determine the composition and approximate date of these samples.

Samples were taken from the walls at different heights, as well as from the columns and minarets. This was done by chiseling through the modern coating of paint and plaster surfacing. For every "window" opened in this way, we prepared a report sheet defining the type of wall, type of plaster and superimposed layering of paint or superficial plaster, Petrographic studies were made of some samples, as well as observations under the optical microscope, for a macroscopic description of their composition.

We are including in this section only a few of the 270 tables produced, as they are the most significant from a historical standpoint. Every assay was numbered and placed on the mapping of each wall and in the file of report sheet. Complete documentation is available from the archives of the Istituto Veneto per i Beni Culturali.

East wing

Most of the plaster works in the east wing were produced using a mixture of fine or medium-grained gypsum and calcium sulfate. Layers of paint and smooth superficial plaster are superimposed, painted with acrylic color.

The external wall on which these layers of material have been applied is a structure in basalt or sandstone blocks, occasionally separated by layers of bricks (as in the case of EEW0432). Between the inscriptions in wood and the wall of stone blocks there is, in some cases, a row of bricks (E1EW0401, E1EW0405), later plastered with a layer of material covered by a general plastering with industrial mortar and acrylic paint used through the mosque.

In this wing, the walls of the arches are composed of bricks and the older mortar which is a compound of fine and medium-grained lime and gypsum coated with acrylic paint. In many cases, on the lateral walls as well as on those of the diaphragm supported by the columns, the plaster is applied in a number of jutting steps directed upward and varying from one to four, of variable width, probably produced for decorative effect. Some of the arches of the aisles entirely lack any ancient plaster finish. These may be zones where the wall was repaired at the same time as the modern industrial plastering was done.

The wall that faces toward the inner courtyard of the mosque exhibits a different stage of construction from the wall of the minaret connected to it in the north corner. Here a single layer of plaster was applied, then covered with industrial plaster and the same acrylic color applied on the outer surface of the entire wing.

Around the access doorways from the outside, the plaster contains a jutting band 23 cm wide. The exterior wall on the east side, toward the north corner, shows some irregularity, which may be due to the later closure of an opening, or to type of material used in construction of the wall or in the layers of paint.

The plaster of the east wing, toward south, is different from that toward north. The former features four “steps” staggered upward (Fig. 1).

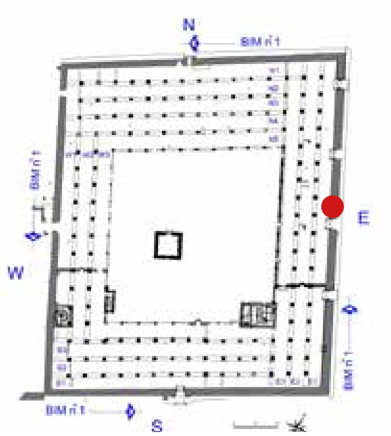


Fig. 1. E1EW0001

One would expect the walls of the entire aisle to have this type of decoration, because the adjacent wall across the aisle, built later to separate the southern section from the northern one, still shows, at the point where the walls meet, the plaster with the four “steps”, now concealed behind bricks.

The decoration is a good quality, fine-grained plaster based on gypsum mixed with small amounts of carbonate and silicate filler.

The plaster on the west wall, though decorated in the same way, seems to differ slightly in the composition. This could be later work done in a more exposed area, more subject to deterioration.

The plaster in the more northerly portion of the aisle shows some discoloration. This is probably more recent, as there are no intermediate layers between the base coat and the so-called "industrial" plastering. The original plaster that covered the surface has been found on the wall of the minaret inside the Mosque (Fig. 2).

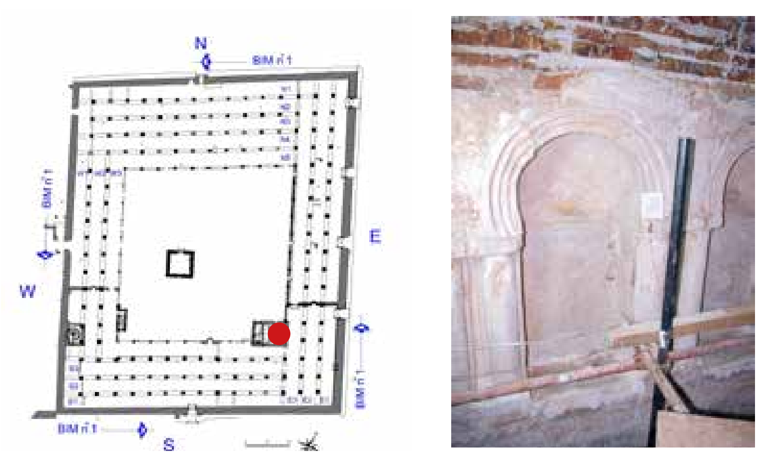


Fig. 2. E3WW0031

The walls of some arches in the east aisles show no traces of ancient plastering. Recent maintenance works are, however, visible, contemporary with the last plastering of industrial material.

The exterior walls, in the sections where these layers of material were inspected, are composed of basalt ashlars and blocks of sandstone, occasionally separated by rows of bricks (Fig. 3).

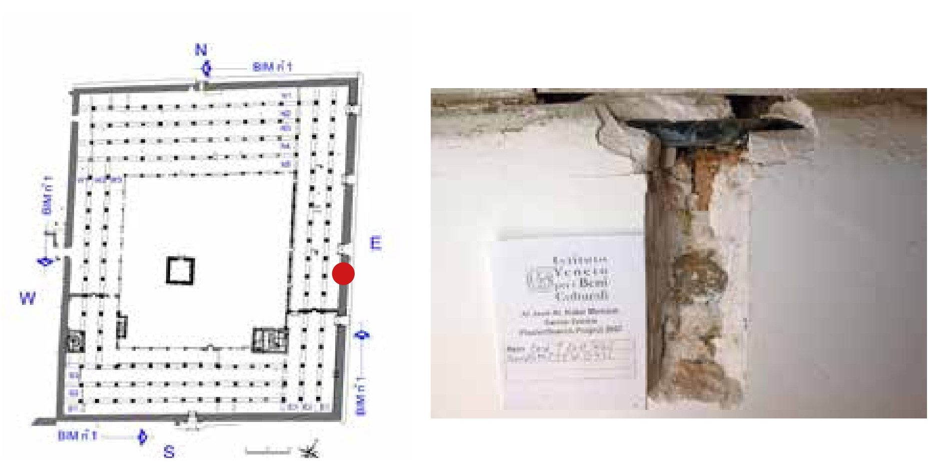


Fig. 3. EEW0432

Between the inscriptions in wood and the walls of stone blocks there is, in some cases, a row of bricks (E1EW0401, E1EW0405), later plastered with a layer of material covered by a general plastering with industrial mortar and the acrylic paint used throughout the mosque (Fig. 4).

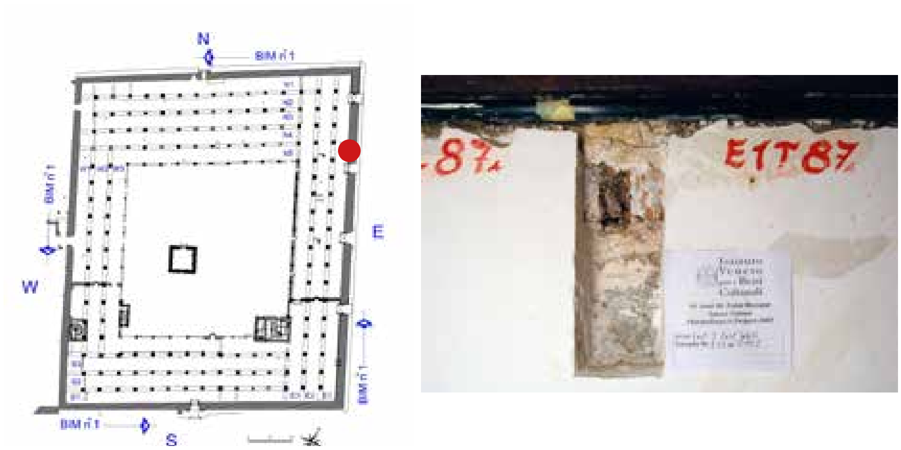


Fig. 4. E1EW0401

Around the access doorways from the outside, the plaster contains a jutting band 23 cm wide (Fig. 5).

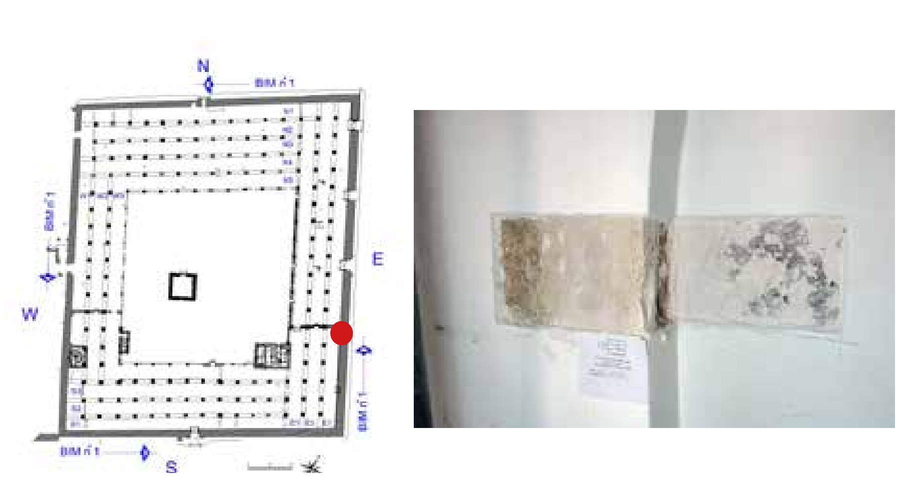


Fig. 5. E1EW0035

The exterior wall on the east side, toward the north corner, shows an irregularity, which coincides with the closure of an opening, both as regards the construction material and in the layers of paint. Here the wall is constructed in limestone blocks with a clay-type mortar covered with the usual industrial plaster, two coats of acrylic paint and one of oil-based paint.

South wing

The south wall of the mosque was constructed in sandstone blocks and brown, sandy mortar. The most internal layer of plaster consists of a reddish lime and gypsum with coarse to fine granularity, and a filler of yellow-gray sand and brick powder. Only one jutting step is visible near the beams. There are three coats of lime on this layer. These are followed by a layer of industrial plaster coated with acrylic paint as in the east wing (Fig. 6).

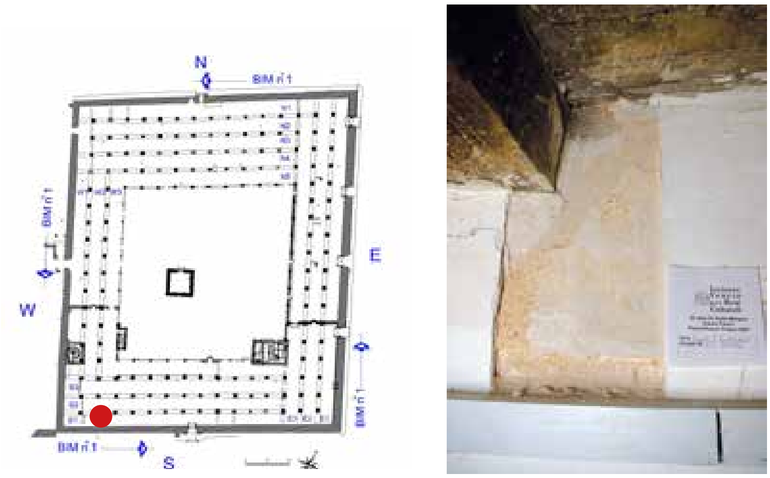


Fig. 6. S1SW0106

Beyond the access door, toward the west, the outer wall is constructed of sandstone blocks mixed with basalt ashlars, with the same type of mortar used on the other section of the wall. The innermost layer of plaster bears incisions and trowel marks. Underneath the beams there is a jutting step as on the other section of wall. The surface of this plaster is yellower than the other, but the layers of paint are identical, as is the usual coating of modern plaster with acrylic paint. Toward the western corner, the plaster been marred by water damage.

The walls inside the aisle, supported by pillars and columns, are built of brick with the same type of plaster and paint as the perimetral walls. The plaster is more than a centimeter thick and also here is applied in steps toward the beams.

The structure of the walls in the aisles includes beams, strips and boards of wood between the bricks, which had been coated with paint and plaster to a thickness of one to three centimeters, sometimes painted with lime but otherwise left bare, before surfacing with the usual industrial plaster. One of these beams (Fig. 7), bears an inscription in black under the plaster.

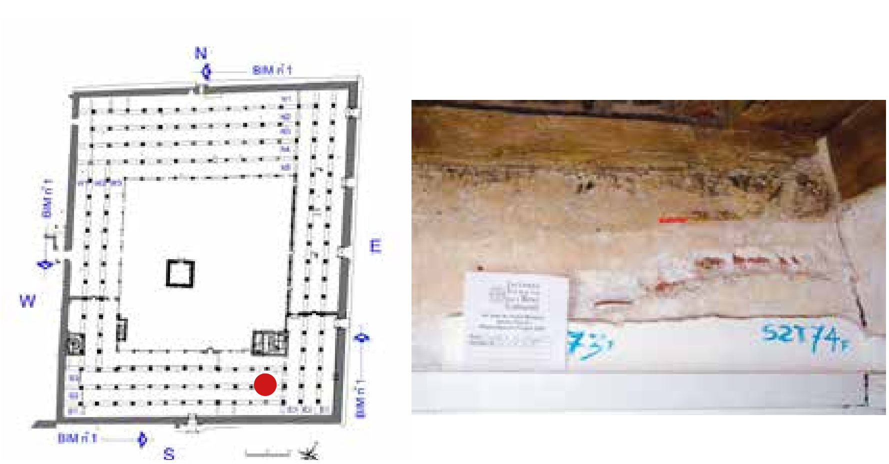


Fig. 7. S2NW0134

The plastering underneath the industrial layer is not always smooth. In the second arcade of the third aisle (Fig. 8), for example, at about 60 cm from the ceiling, the plaster changes from fine-grained to coarse.

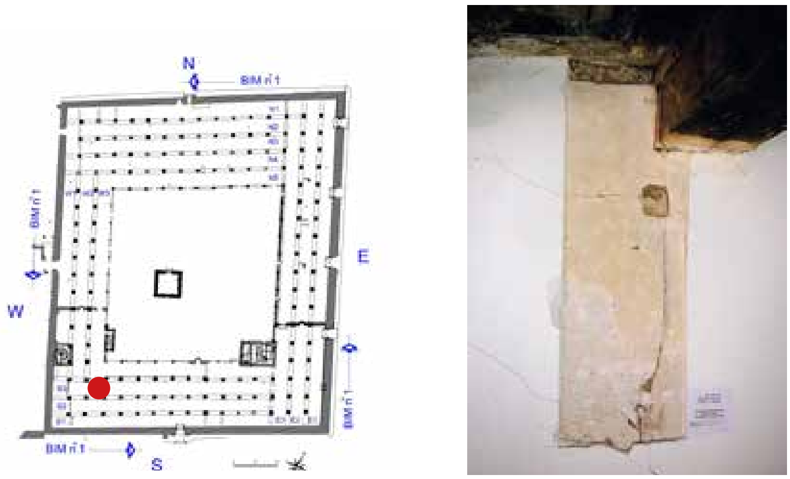


Fig. 8. S3SW0117

In some cases, the older plaster is decorated with a row of circles (S3SW0136B, S3SW0137, S3NW0144). In a few sectors (Fig. 9) between the beams of the ceiling, on the older plaster, there is a decoration painted in white scrolls.

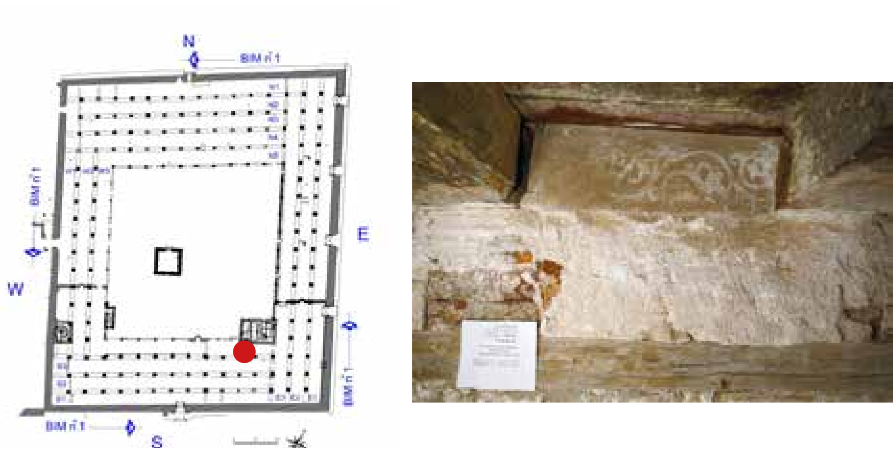


Fig. 9. S3NW0145

The profile of the arches was originally coated, in some cases, with very fine plaster, from 0 to 1 cm thick, and not painted under the industrial plaster (Fig. 10), while in other cases the base layer is from 1 to 3 cm thick, with three coats of lime and gypsum underneath the modern plaster surfacing.

The lintel on the outside of the entrance door on the west wall does not exhibit any traces of plaster under the industrial layer, from which we can deduce that it was left bare or only painted white (Fig. 11).

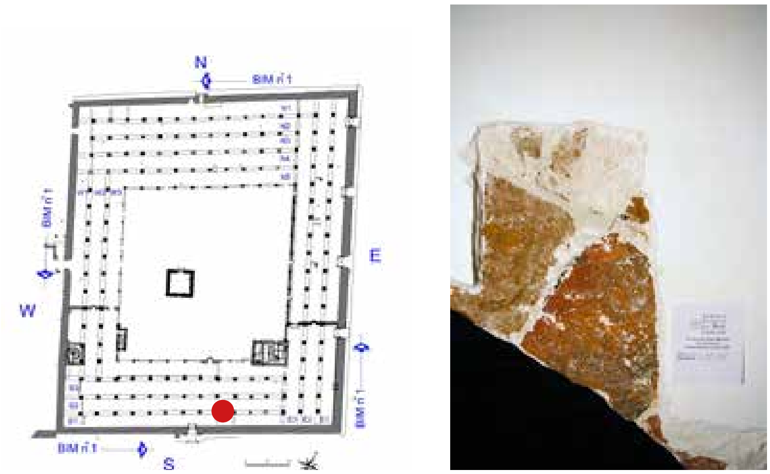


Fig. 10. S2SW0130

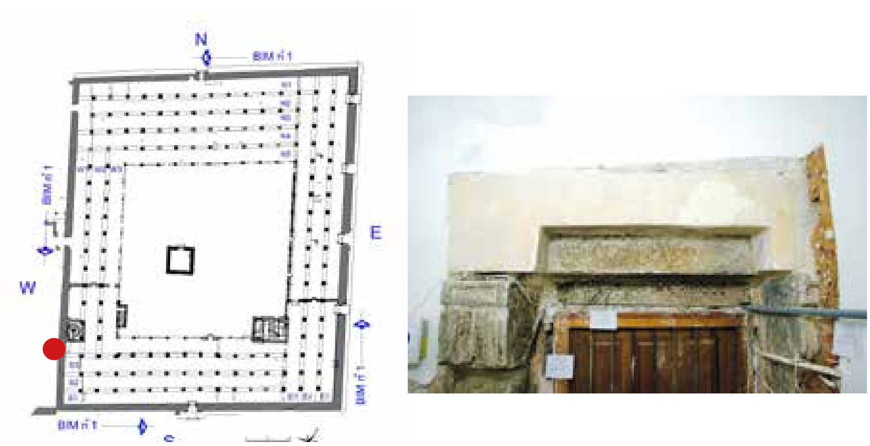


Fig. 11. S3WW0150-Door

Inside the doorway, the lintel was carved, while the basalt capitals were also plastered (Fig. 12).

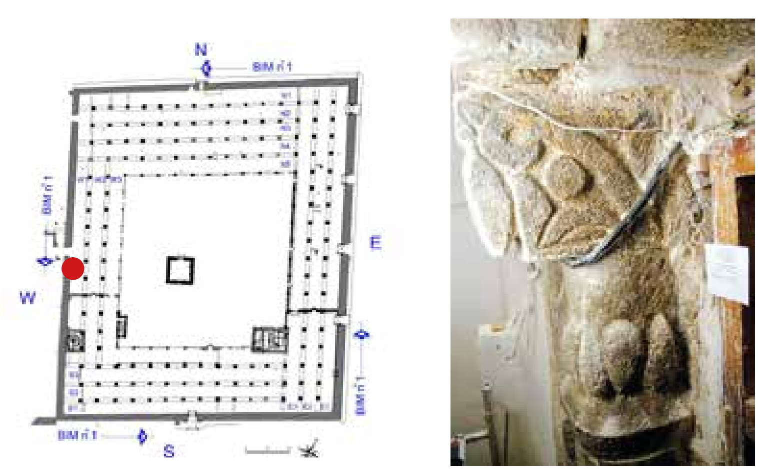


Fig. 12. S3WW0152-Door

It should be noted that the plastering of the south wing has a stepped decoration. This may have been produced in the same period as the east wing, where we find four steps, considering that this sector is higher.

The plaster here is mixed with parts of a reddish material, possibly to integrate some missing parts. In the central aisles, we find traces of color that could be associated with the repainting of the ceiling.

West wing

The perimetral wall of the west wing is constructed of limestone and sandstone blocks with gypsum mortar in the reconstructed portion and bricks with clay-type mortar in the other sectors. The entrance door at the center of the western wall consists of concentric arches in brick, while the surrounding wall is in sandstone blocks, all plastered with reddish lime and gypsum. Two columns alongside the doorway were noticeable for the fact that they had been plastered twice before the industrial surfacing was applied. Beyond the door, toward the north, part of the wall was probably restored, because the masonry in brick here does not show any plastering prior to the industrial surface layer.

In the sector labeled N5SWW0301, a stone counter wall was erected against the brick wall, but the ceiling continues behind this counter wall for 30-40 cm. This oddity is probably due to the restoration work done around 1970. In sector N4WW0306, the second wall consists of bricks and gypsum plaster.

One new finding here was in the area between the minaret and the crossing wall, where we were able to observe the four-step decoration on the plaster. This may be related chronologically to the similar areas found in the north and east sectors (Fig. 13).

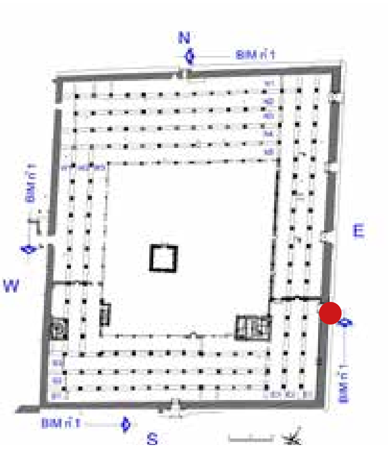


Fig. 13. W2EW0203

A small window and an arch in the east-facing walls of the minaret were found to have been walled over with a filling of sand and ground bricks (Fig. 14).

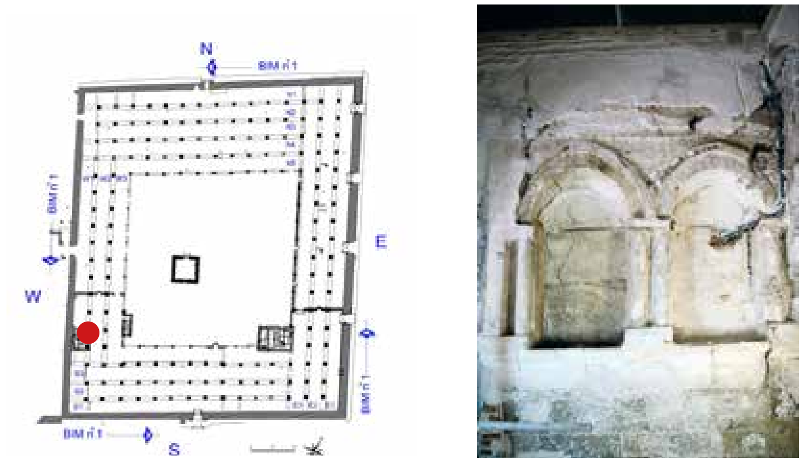


Fig. 14. W1SW0235

The existence of two capitals in the north corner, near the minaret is an interesting finding. They testify to alterations made in time: this facilitates our understanding of the reason for a stucco capital and the subsequent placement of the corner column (Fig. 15).

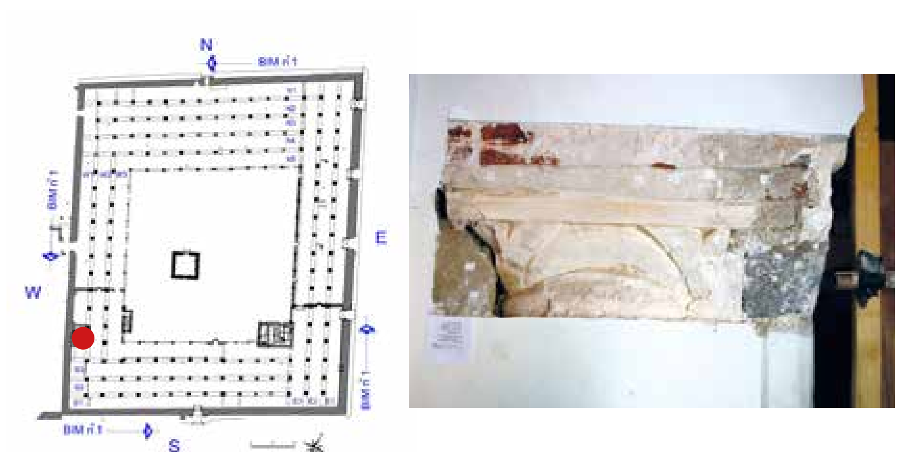


Fig. 15. W2W0205

The plaster of the capital has a reddish color (similar colors were also found in the south sector) like that of the columns found at the west entrance (Fig. 16).

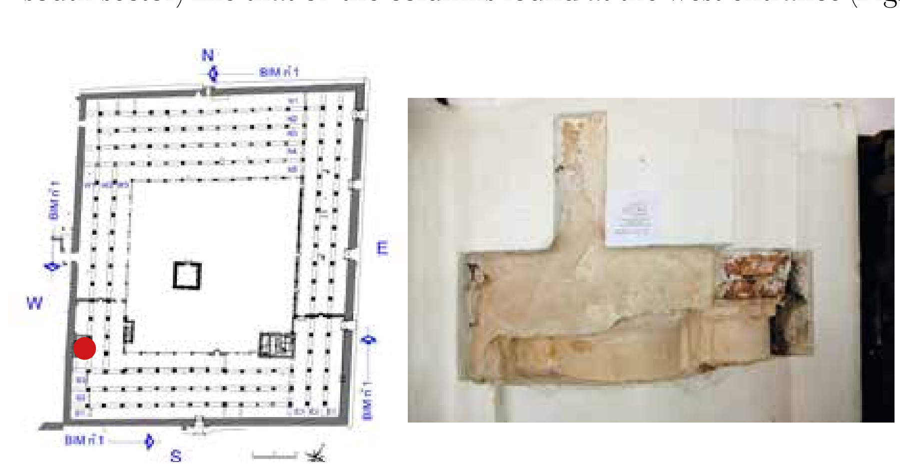


Fig. 16. W1WW0216- Door

The walls of the archways are constructed of bricks with white mortar, composed mainly of lime and gypsum, with medium-fine granularity, and filling in sand and ground brick for a thickness of 2-3 cm. Beneath the ceiling beams we can see four jutting steps. It is entirely covered with white lime and the usual layer of industrial plaster and acrylic paint. The original plaster is preserved only in small fragments on the most northerly archways, beneath the industrial surfacing. In the innermost aisle, near the entrance doorway, we found a wooden plank in the masonry, bearing an inscription (Fig. 17).

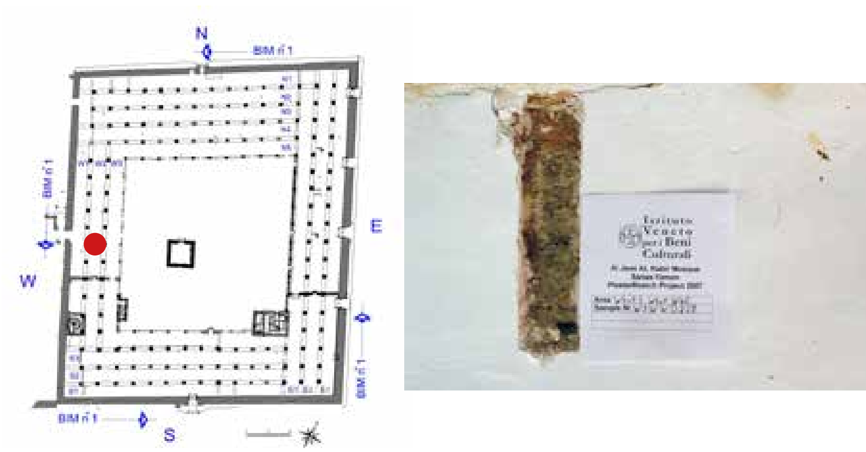


Fig. 17. W3WW0229

An analogous situation was found in the next archway toward the north (Fig. 18).

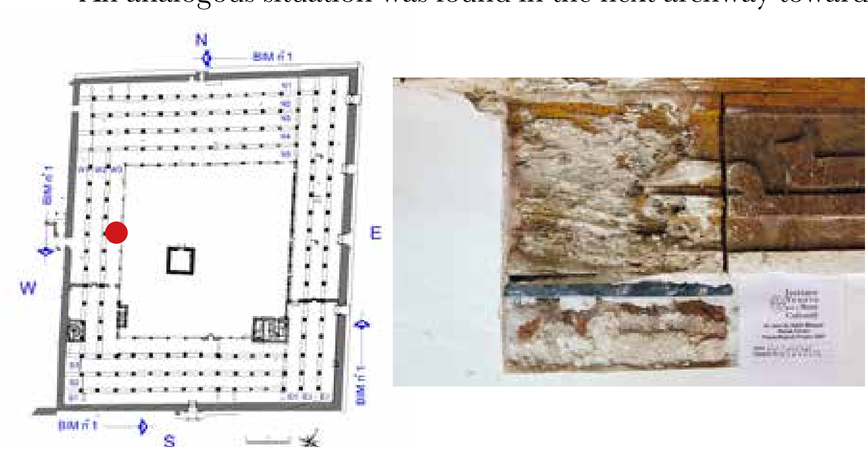


Fig. 18. W3WW0232

In the most northerly section, the walls of the aisles show some peculiarities in the area where it joins the north wing. Assay N5EW0304 (Fig. 19) revealed two types of wall construction: one with bricks and brown plaster over a round beam inserted in the wall, the other in brick with white plaster beneath the beam.

The beam inserted had a layer of decorative painting. It was covered by a coat of lime and gypsum plaster under the industrial plaster surface finish. The plaster continues here underneath the north wall and reveals a number of decorative incisions.

We discovered an arch in the inner courtyard (Fig. 20), that had been walled over, plastered and painted.

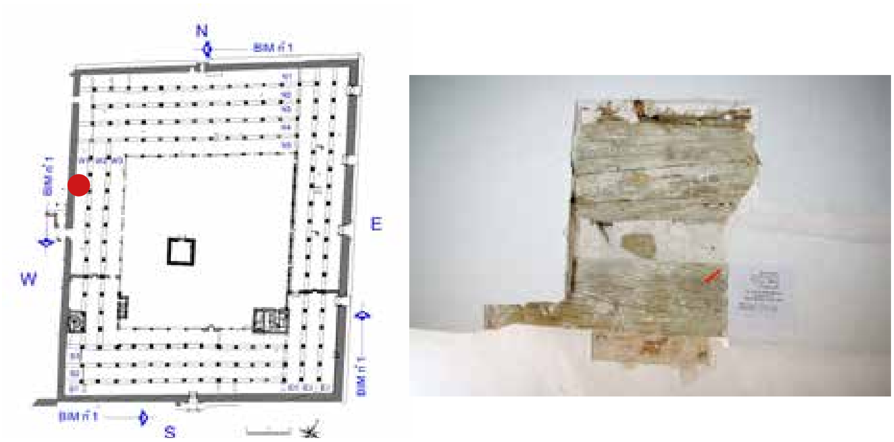


Fig. 19. N5EW0304

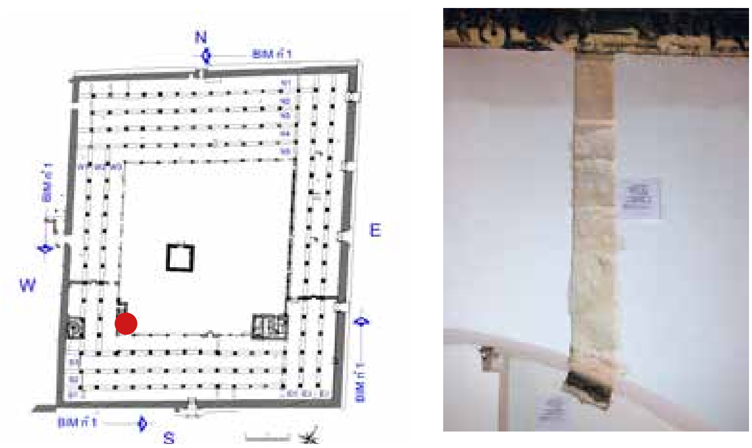


Fig. 20. W3EW0208

The rest of the wall repeats the masonry in bricks and white mortar of gypsum and lime with jutting steps toward the ceiling, painted in three coats of white lime underneath the industrial plaster. There was an uneven spot about halfway up the wall (Fig. 21) due to a crack or joint in the masonry.

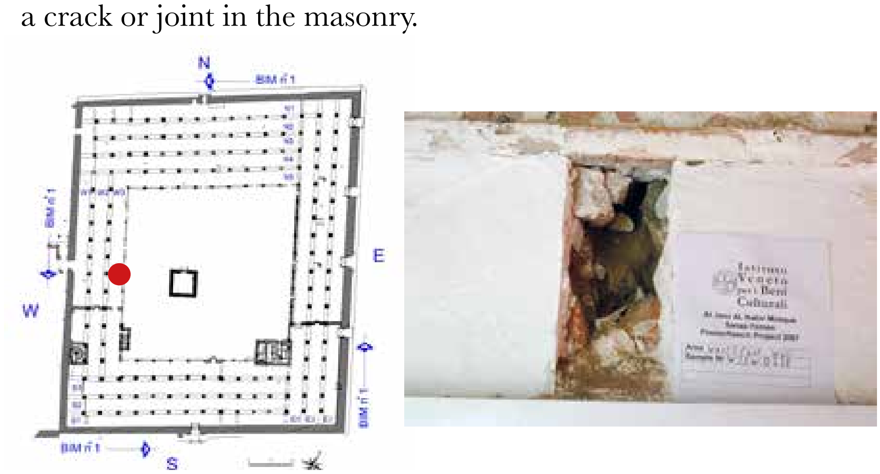


Fig. 21. W3EW0228

During the inspections we also discovered columns and capitals in basalt, corresponding to the southwest door of the building.

North wing

The perimetral wall on the north wing consists of sandstone blocks and basalt ashlars with white mortar, most of which was not plastered under the general modern surfacing. In the western corner where the walls meet, we discovered the system of positioning the ceiling beams, and the different composition of the two walls. The second layer of the western wall (which had been rebuilt) consisted of sandstone blocks plastered with industrial gypsum. Here we discovered a number of carved wooden planks inscribed with gilt lettering outlined in red on a black background. This had been plastered prior to application of the modern surfacing. In other areas (Fig. 22), an inscription on wood measuring 22 cm was found under the plaster.

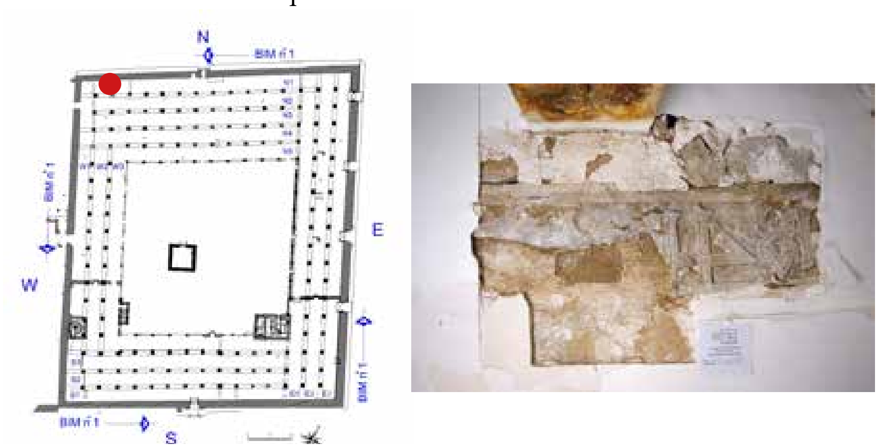


Fig. 22. N1NW0322

In the entrance area, about halfway up the wall, there were more decorated wooden boards and a coat of white mortar. Beyond the door, toward the west, an inscription in plaster is visible, which had been painted red originally, then green and finally silver on a white background. The inscription was later covered over with acrylic and oil-based paints. Toward the east wing ashlars with inscriptions were found (Fig. 23). The perimetral wall in the sector bordering on the east wing contains three rows of progressively jutting bricks at the top (see E3ENW0423, E2ENW0415, E2WNW0416…)

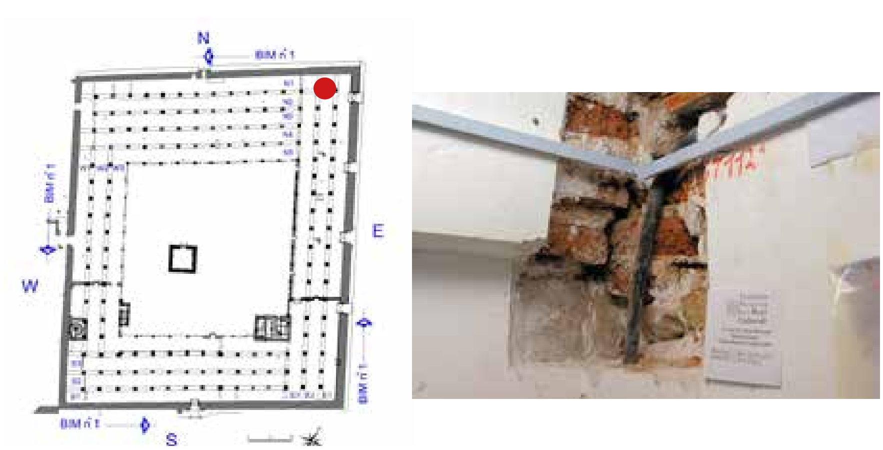


Fig. 23. E3ENW0423

A wall of bricks and plaster carvings was found in the sector of the aisles bordering on the west wing. The beam rests on a carved wooden shelf. Beams have been inserted in this portion of the masonry with and without traces of color that do not seem to have ever been plastered before the modern finish (N1SW0323, N1SW0320, N1SW0319, N1SW0327, N3NWW0344, N3SW0345, N4SW0351) (Fig. 24).

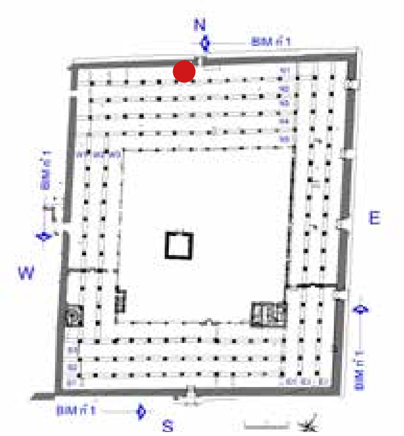


Fig. 24. N1SW0327

The walls of the aisles, above the arches, are composed of bricks secured with white mortar. There are remains of plastering with reddish-white lime and gypsum. Painted boards and beams were discovered in a few sectors (N2NW0342, N3SW0346, N3NW0347, N1SW0335…), including some with floral decorations that were then plastered over (Fig. 25).

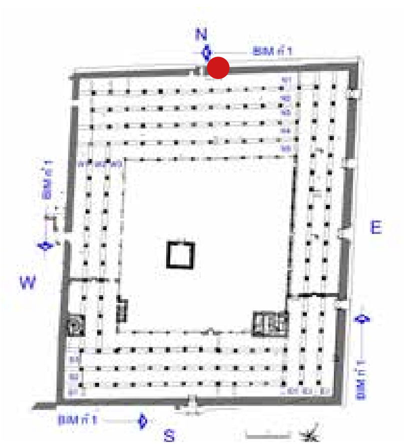


Fig. 25. N2NW0342

A horizontal marking was found in section N3NW0366 (Fig. 26) which could be the imprint of a first plaster step.

Section N2NW0343 (Fig. 27) shows a restoration in brick barely resting on the original wall.

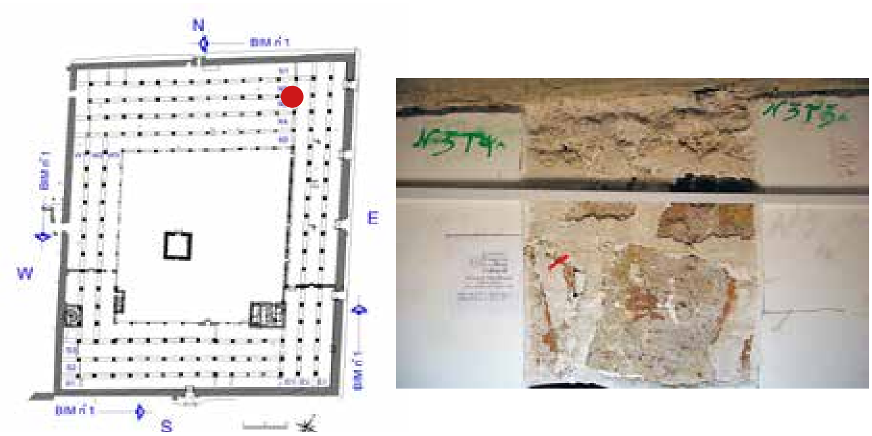


Fig. 26. N3NW0366

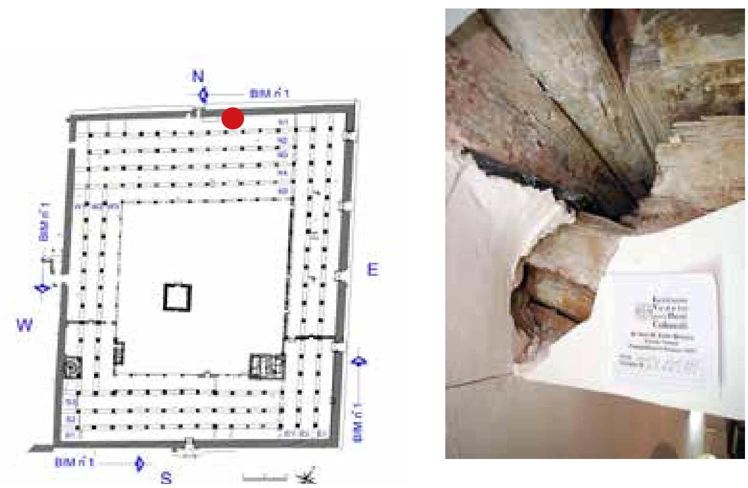


Fig. 27. N2NW0343

Section N4SW0368 in the north-east corner, shows two stages of plastering (Fig. 28).

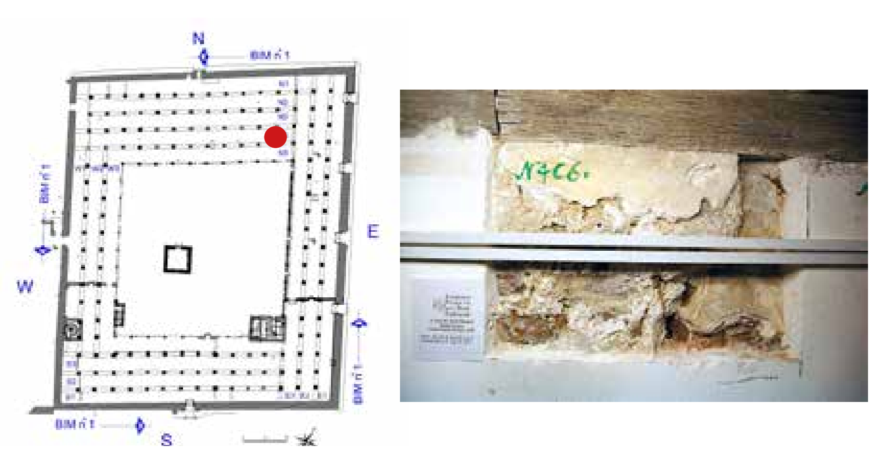


Fig. 28. N4SW0368

After doing this extensive sampling, it was possible to proceed to a conclusive mapping using different colors to indicate different compositions and structures, summarizing the results of the assays made. The areas where mortar was found, where mortar and plaster are decorated with jutting steps, where there is only one step under the beam and where there are painted decorations or inscriptions have been clearly marked.

Conclusions

From the analysis made on samples of material we were able to collect some data on their composition, in general. The mortar is in gypsum, with an average ratio of 5:1 between binder and filler (that is, a small amount of aggregate consisting of limestone-clay fragments, volcanic rock and quartz crystals). The sampling that considers plastering from different period exhibits a continuity in the use of similar materials and workmanship. The analysis made on the masjid of al-'Abbas ad Asnaf, give similar results.

For the future surfacing of the Mosque, depending on the samples analyzed, we suggest using the types used in the east sector (Fig. 1), for their strength and compactness.

Rereading the extensive cataloguing made of the plaster types, it can be seen that the south-east, south and south-west zones were all re-plastered at various times with good quality material and with some decorative plan in mind. The entire north wing, as can be observed from the remains of the plastering still visible, could have been surfaced in the same epoch, but here the subsequent reworkings, which were numerous and very frequent in such an important part of the mosque, were probably so extensive that now only a few traces of the ancient plaster remain. Certainly, such extensive plastering would have been done on the occasion of major maintenance works (special maintenance), probably contemporary with repainting of part of the wood ceiling. There is no doubt that this type of plastering gave the mosque a clean, luminous, uniform aspect.

NOTES ON THE CATALOGUING OF PLASTER WORKS IN THE MINARETS

From our study of the excavations made by the team of archeologists at the site we were able to ascertain that two of the minarets were already in existence at the Great Mosque in the Omayyade epoch of the 8th century. These two minarets were almost identical in appearance and were built at the same time as the wall on the south side. From here, however, the structural history of the two minarets took different pathways, with alterations and reworkings that would give them very different characteristics in the long run.

At the present time, the minarets measure approximately 33 and 31 meters, where the western minaret is slightly lower than the eastern one, while the original structures were definitely shorter, probably to a considerable degree, though we do not currently know their original height. The two structures differ significantly also in specific structural details. In particular, in the eastern minaret, the central pillar of the stairway is square, while the pillar in the western minaret is cylindrical. Despite the difference in dimensions and structural details, the current aspect of the two minarets very likely reflects work done in the Ayyubide epoch.

Assays made on the walls of the minaret toward the southwest revealed, on the inside, brick masonry with yellow-gray mortar and ground brick painted in lime and plastered twice: once with a mixture of gypsum, sand and ground brick, the second time with industrial plaster. On the outside, the masonry is brick with mortar and ground brick and a layer of lime and gypsum plaster underneath the later industrial plaster. On the side facing the inner court, wooden beams were found to be inserted in the masonry.

From section MWEW0601 it could be seen that the wall is built in brick masonry with white mortar and yellow-gray sand with brick gravel. Over the centuries, various coats of lime-based paint in different colors have been applied. The surface color has changed with age to a brownish tint (Fig. 29).

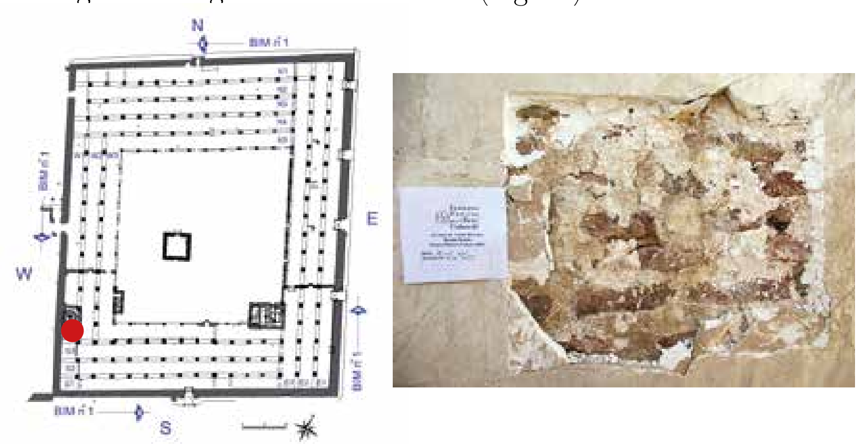


Fig. 29. West minaret, east wall, sample no. MWEW0601.

From section MWEW06 we can see that the masonry consists of bricks with light mortar and inert material consisting of yellow-gray sand and brick gravel. Here again, the entire surface has been covered in succeeding coats of lime-based paint. The surface color has changed with age to a brownish tint (Fig. 30).

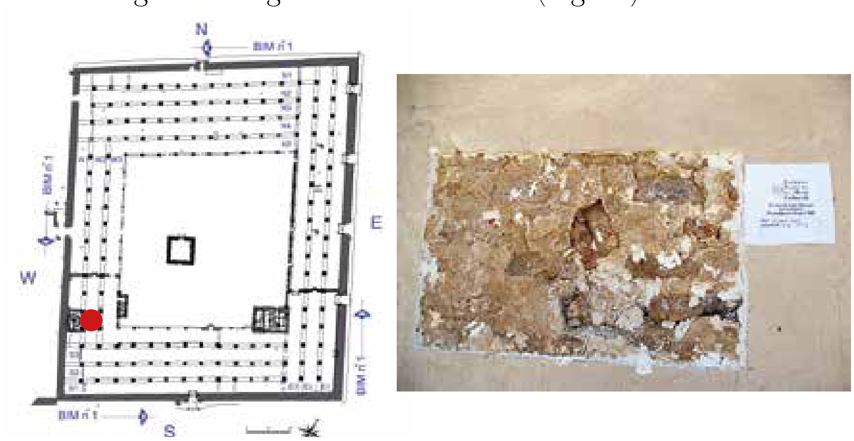


Fig. 30. West minaret, east wall, sample no. MWEW0602.

The wall is constructed in brick and light mortar made with yellow-gray sand and brick gravel. The usual lime-based paint coat it, the color of which has turned brownish over the centuries. In this section we can see a part of what was a star-shaped decoration in brick (Fig. 31).

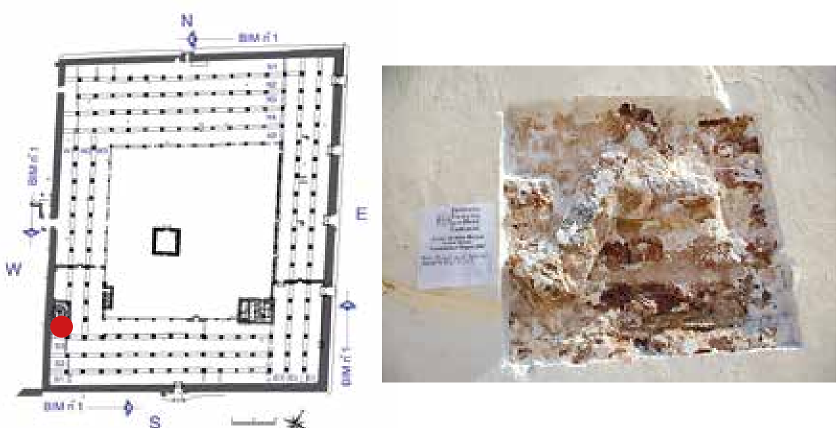
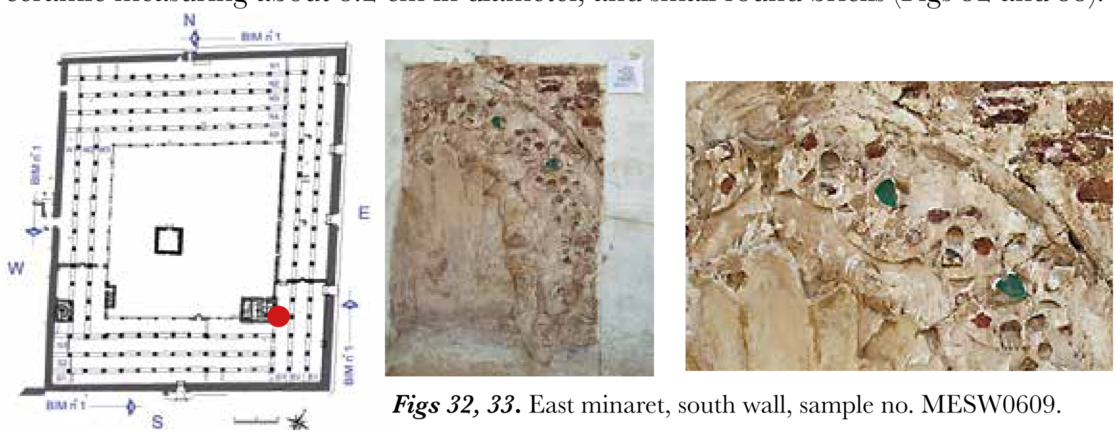


Fig. 31. West minaret, south wall, sample no. MWSW0604.

The minaret on the southeast side has a wall of brick with decorations in plaster molded in a shell shape framed by an ogival decoration set with round elements in green ceramic measuring about 8.2 cm in diameter, and small round bricks (Figs 32 and 33).



Figs 32, 33. East minaret, south wall, sample no. MESW0609.

The first layer of plaster is in yellow-gray sand with ground brick, while a second layer consists of white gypsum and a plaster decoration. It is followed by the usual plastering with industrial material that we have observed on the inside of the mosque.

Section MESW0610 on the south side of the minaret also shows the usual combination of bricks with shell-shaped decorations and ceramic elements embellishing the frame (Fig. 34).

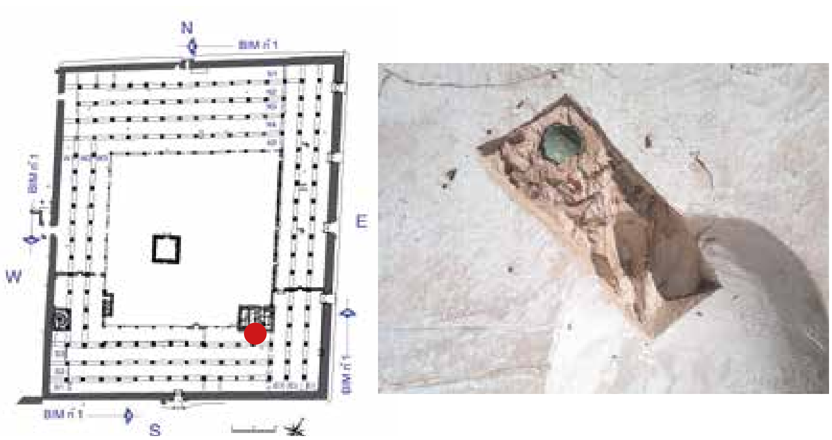


Fig. 34. East minaret, south wall, sample no. MESW0610.

NOTES ON THE RESTORATION OF THE SOUTHEASTERN MINARET

The work of restoration focused on the east minaret as scrapings made there had revealed traces of decoration and Koranic inscriptions, probably dating from the Ayybide reconstruction. Some of these decorations seemed well-preserved, especially the part enclosed in the wall of the new section devoted a library.

The decoration of the minaret consists of an elegant play of colors, the lighter ones created by the mortar composed of lime and gypsum with the addition of filler, alternating with darker reddish ones consisting of bare brick, a typical effect common in Yemeni architecture. Some scrapings on the exterior wall revealed traces of the green ceramic elements applied to the inside of the plaster decorations.

The decorative designs were mainly geometrical and developed horizontally across the façade, alternating in an orderly manner and neatly framed by rows of bricks set in a geometrical pattern or by plaster crenellations. Bands of gypsum-based plaster have been applied to the wall and bear Koranic inscriptions in Kufic calligraphy. Geometrical decorations of various kinds alternate with the inscriptions.

The restoration project included a descialbo process to remove all the layers of mortar applied over plaster decorations and clean the surfaces, as well as structural consolidation of the plastering and plaster decoration, patching of gaps, chromatic color balancing of the surfaces and application of a protective coat of waterproofing.

Fig. 36. Southeastern minaret prior to restoration, detail visible after collapse of the plaster applied over the decoration and inscription in the plaster.

Fig. 35. Southeastern minaret prior to restoration.

Figs 37, 38. Southeastern minaret prior to restoration. Detail of the plaster decoration incorporated into the library area.

Fig. 39. Southeastern minaret prior to restoration. A number of stratigraphic assays were done for cleaning and investigation as to the position, type and condition of the original decorative plan.

Figs 40, 41. Southeastern minaret prior to restoration. The illustrations show a few details of the cleaning assays in which the presence of inset elements in green ceramic can be seen.

Fig. 42. Southeastern minaret, detail of the apertures on the western façade discovered after the first scrapings.

Fig. 43. Southeastern minaret, detail of the decoration uncovered on the western façade after the first scrapings.

Figs 44, 45. Southeastern minaret, detail of the decorations on the west wall after cleaning and repointing the plaster.

Figs 46, 47. Southeastern minaret, detail of the interior decoration before and after restoration.

Figs 48, 49. Southeastern minaret, detail of the interior decoration before and after restoration.

NOTES ON THE CATALOGUING AND CONSERVATION OF SEVERAL INTERIOR COLUMNS

The most important feature of the structure in elevation of the Great Mosque of Ṣan‘ā’ is that it consists of more than di 180 columns which, with the imposing outer wall, support a ceiling of almost 3000 sq.mt.

After the recent works of removal of the plasterworks in various parts of the Mosque, it was possible to observe the structure of the columns more thoroughly. Depending on the epoch of construction, they are of different types and shapes. First, there are the columns in the oldest portions of the Mosque (north and south wings) consisting of elements in solid stone, recovered from earlier constructions. They are of various shapes, thicknesses and consistency, and sometimes have a slightly tilted position. They are often bare, not covered by thick superstructures, but only painted over with acrylic paints or modern white enamels.

Figs 50 - 61. Additional examples of columns found inside the Mosque.







Figs 62 - 73. In the images some types of capitals.






The other major category of columns are those of most recent construction, located in the east wing and in other zones to the west or in isolated positions in the north and south wings. They consist generally of a nucleus in hard stone (black basalt) consisting of more or less voluminous ashlars stacked and roughly finished. The regularity of the cylinder (average diameters of 80 cm) is achieved in various ways, but mainly by means of thick applications of plaster or the addition of rounded elements in stone attached with gypsum and/or lime plaster.

In every case there is an arch above the columns consisting of brick masonry laid in various ways: horizontally, diagonally or a combination of ways. The shape and size of the arches varies and differs depending on the widths of the spans and height of the columns. The only regularity is the spacing between the columns and between the rows of columns (3.50-3.70 meters). Between the curve of the arches in brick and the columns described, a capital is often inserted. This has the fundamental function of discharging the load of the arch onto a smaller area which is that of the column.

The problems of a static and structural nature relative to the column-capital-base system of the arch can be stated as follows:

- columns with tilted axis
- staggering of column axis vs axis of the base of the arch
- fissured capitals and arch bases
- slim columns
- mixed capitals: wood-stone or irregular wood-brick

The study of these defects or irregularities was fundamental considering that the system of column - capital - arch is what supports the entire roof.

This, for its structure, is a system weighing 400-500 Kg/sq.mt. (value estimated by an assay made back in 2006. It should be noted that this load tends to increase in time if, in repairing the rainproofing, a layer of mortar is added each time.

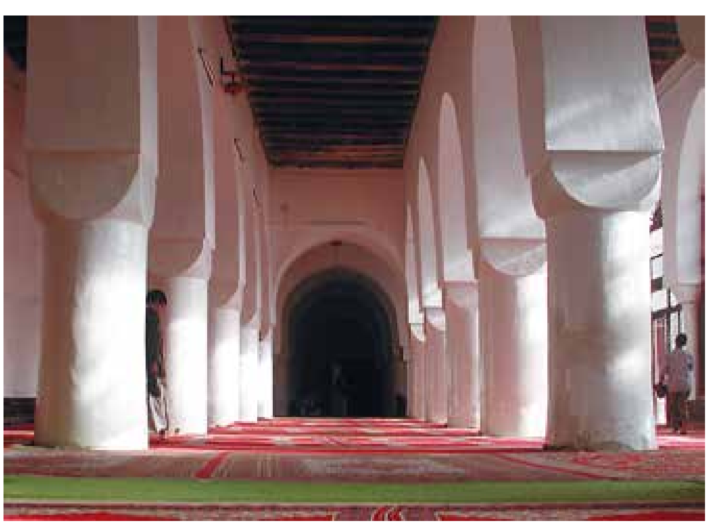


Fig. 74. In the image a shot of the south aisle of the Great Mosque with the characteristic columns made up of massive cylinders.

Figs 75, 76. In the images a phase of recovery of the ancient columns, freed from the thick layers of plaster and other materials.

The analysis of the capacity of a system of column - capital refers to the dimensions and height of the column - capital, its solidity and the solidity and strength of the construction materials, the centrality of the load axis with the axis of the structure, the weight of the load deriving from the roof, the state and consistency of the foundations.

To arrive at a characteristic capacity value for each column, then compare it with what is effectively present and thus determine the coefficient of safety, we need to give all the elements described above a numerical value.

For example, the height, diameter, strength of the stone and mortar, the value of eccentricity of the load, the measurements of the foundations, the angle of inclination if the column is tilted.

This is possible for some columns that we can call regular. If, however, irregularities of the verticality, composition and structure of the capitals force us to reduce characteristic value with ever-increasing coefficients, the consequence is that the working load is greater than that which the column can withstand.

The bare columns, those made of recovered and reused ashlars previously employed in the construction of other buildings are, in many cases, misaligned to a large degree. From the assays and excavations made, these columns are offset with regard to the line of the floor by about 30-50 cm.

The archaeological excavations exhibit a stratigraphy of succeeding elevations with stratified foundations and elevations of more than a meter of the entire column. In any case the implant, even if deeper than 50 cm, does not result in an interlocking constraint at the base of the column.

A coherent static outline has to consider a hinge-hinge bond (the horizontal stresses of wind or earthquake are not considered) and thus the horizontal element that is created by the tilt of the column has to be absorbed only by friction.

In any case, in the presence of a slim tilted column, it is necessary to eliminate the defect with the return to vertical by means of steel wedges or the addition of high-strength mortar, or by flanking the column, where possible, with a sort of additional column.

Flanking with a stone column could be another way to balance the load line, in addition to serving for realignment of the misaligned column/arch system.

In the case of irregular capitals in a combination of wood and stone or wood and brick, we provided to circle them with steel plates and threaded pass-through bars, or to reconstruct them with the same materials in an orderly way, as can be seen from a number of examples show here below.

Conservative treatment of column no. 16 K, southeast wing
Type of treatment: removal of old plaster and cleaning of surfaces. Structural repair with closure of large gaps using bricks and Lafarge hydraulic lime.
Application of a metal cage structure for containment.

Fig. 77. Column no. 16 K north side.

Fig. 78. Column no. 16 K west side.

Fig. 79. Column no. 16 K, east side, application of plaster at the base before the final layer.

Fig. 80. Column no. 16 K, west side, application of base coat in preparation for final plastering.

Conservative treatment of column no. 18 I, southeast wing

Type of treatment: cleaning and consolidation for repair of the masonry structure in brick, closure and repointing of gaps with brings and Lafarge hydraulic lime. The surface was unified and repointed with hydraulic mortar. Application of a metal cage structure for containment.

Conservative treatment of column no. 17 K, southeast wing

Type of treatment: cleaning and consolidation for repair of the masonry structure in brick, closure and patching of gaps with bricks and Lafarge hydraulic lime. The surface was unified and repointed with hydraulic mortar. Application of a metal cage structure for containment.

Fig. 81. Column no. 18 I, south side, cleaning and repointing of the surface.

Fig. 82. Column no. 18 I, east side, cleaning and repointing of the surface.

Fig. 83. Column no. 18 I, northwest side, application of metal cage.

Fig. 84. Column no. 18 I, south side, cleaning and repointing of the surface.

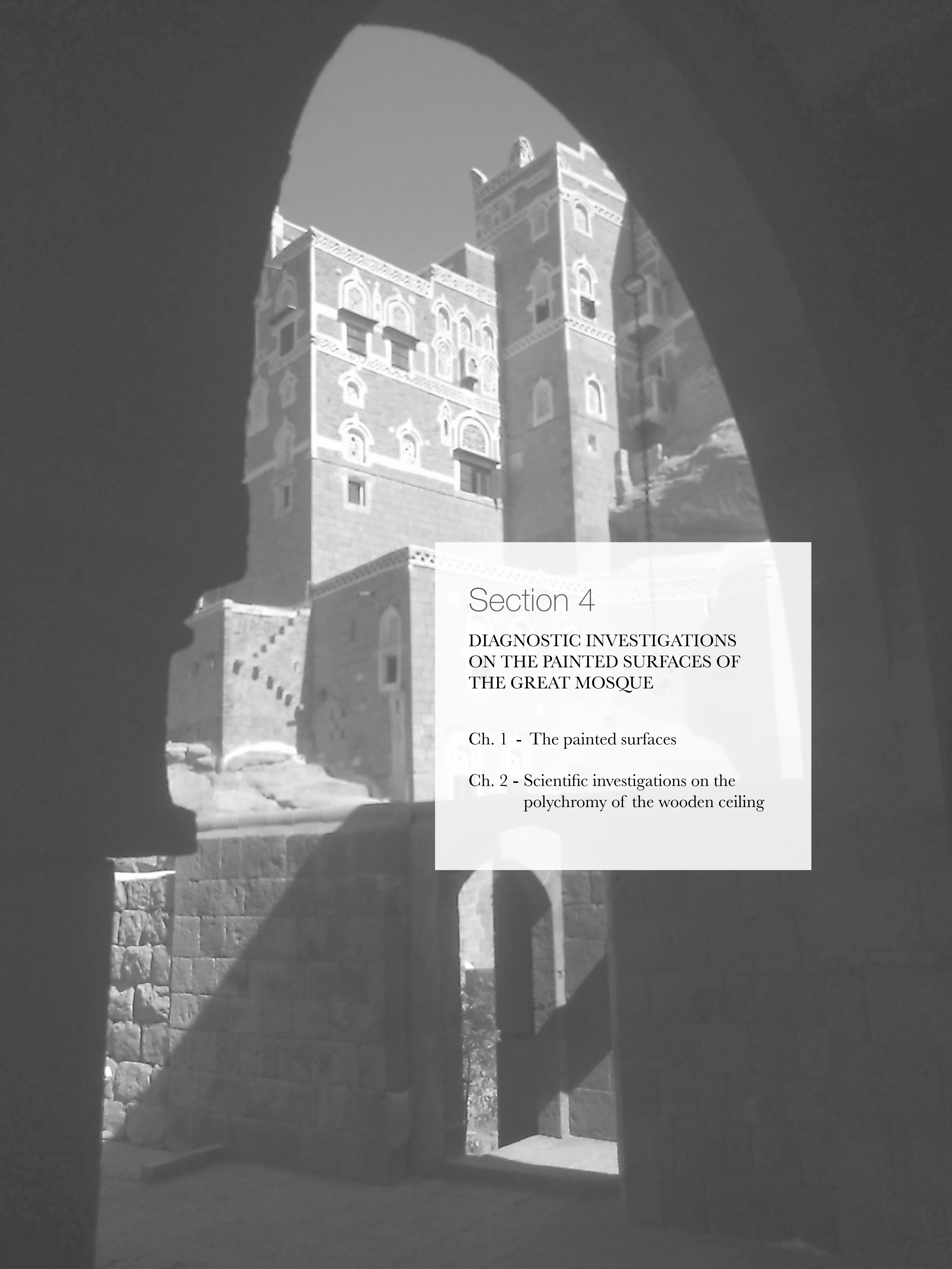
Fig. 85. Column no. 17 K, east side.

Fig. 86. Column no. 17 K, south side.

Figg. 87, 88. Column no. 17 K, north side, Example of gap and relative repointing with bricks and hydraulic lime.

Fig. 89. Column no. 17 K, north side, patching of gaps with hydraulic lime and application of metal cage.

Some drawings of uncertain origin discovered on the rear parts of the coffered ceiling in the northern sector.



Section 4

DIAGNOSTIC INVESTIGATIONS ON THE PAINTED SURFACES OF THE GREAT MOSQUE

Section 4 - Chapter 1

THE PAINTED SURFACES OF AL-JĀMI‘ AL-KABĪR MOSQUE OF ṢAN‘Ā’

SCIENTIFIC ANALYSIS

ARIANNA GAMBIRASI

Since the definition of the restoration projects, the interventions conducted by the Istituto Veneto per i Beni Culturali in Yemen have been supported by scientific investigations aimed at defining the executive techniques, identifying the constituent materials and defining the state of conservation of the polychrome wooden ceiling of the mosque al-Jāmi‘ al-Kabīr of Ṣan‘ā’.

The investigations were initially conducted at the laboratories of the Istituto Veneto per i Beni Culturali (period 2006-2009) and subsequently continued with the coordination of Prof. Paolo Bensi at the laboratories of the Chemistry Department of the University of Modena and Reggio Emilia (P. Baraldi) and of ArteMateria - Mele (Genoa) (A. Mairani). The analytical techniques used by the laboratory of the Istituto Veneto per i Beni Culturali for the study of the samples are listed below:

• **Stereomicroscope observation** of the samples as they are in order to allow a preliminary macroscopic description of their morphological characteristics.

• **Preparation and study of the pictorial fragments set up in cross section**: the sample is incorporated in polyester resin, orienting it in such a way as to obtain a section perpendicular to the external surface; subsequently it is observed under a microscope in reflected visible light and ultraviolet radiation, in order to identify the succession and composition of the layers and the possible presence of organic fluorescent material. The description of the layers is performed starting from the innermost one (NorMal 14/83).

• **Microchemical tests** on cross sections and powders for the identification of pigments and binders (proteins, oils, etc.) (Dimos, part I, module 3, 1978).

• **FT-IR spectrophotometry analysis** with infrared spectrophotometer in Fourier transform; this method allows to recognize, on the basis of the reading of the absorption spectra of infrared radiation, natural and synthetic organic compounds and inorganic compounds referable to constituent and decaying materials.

• **Ion chromatography**: the sample is immersed in a known volume of distilled water in order to extract any soluble salts contained within it; subsequently the concentration of the ionic species is measured by separating the anions in an ion exchange chromatographic column. The sample solutions are prepared according to NorMaL 13/83.

• **Petrographic study on thin section**: petrographic analysis by observation of thin sections with a polarizing optical microscope in transmitted light, aimed at identifying the mineralogical components of the material and its textural characteristics (NorMaL 10/82, 12/83, 14/83, 23/86, 27/88).

At the laboratories of the Chemistry Department of the University of Modena and Reggio Emilia, the samples were analyzed by:

• **Raman microscopy**: non-destructive and non-invasive investigation technique that allows to identify the molecular and crystallographic nature of the species present in both a macro and microscopic sample. It can be applied both in situ and in the laboratory, but also without sampling. If you have samples, you can carry out the investigations by keeping the samples intact for other tests. The sample is irradiated by a laser beam which causes the diffusion of light, which contains the molecular information mentioned. The combination of a spectrometer with a microscope allows you to analyze powder samples with granules of even a few micrometers size.

• **FT-IR spectrophotometry**

• **X-ray diffractometry** for the crystallographic characterization of samples.

While at the ArteMateria laboratories the samples were analyzed by:

• **SEM scanning electron microscope coupled to EDS spectroscopy** for the qualitative characterization of solid substances through elemental analysis, with the possibility of detecting the presence of trace elements. The samples were analyzed following a gold metallization procedure.

As it is not possible to report in detail all the results collected, only the most significant information regarding the executive techniques and the constituent materials that emerged during the various survey campaigns will be presented below. The historical and artistic information that gradually correlates the analytical results were obtained from what was reported by Prof. Bensi in the two scientific reports that show the overall pictures of the results obtained in the mosque al-Jāmiʿ al-Kabīr of Ṣanʿāʾ.

For a complete reading of all the data collected during the various survey campaigns, please refer to the related scientific reports.

1. Materials and techniques identified in the painting decorations of the wooden ceilings

1.1 Pigments

Red

In the samples with red painting layers, the scientific investigations identified the cinnabar pigment (HgS), often in combination with minium (Pb_3O_4). In some samples, red earths (clays colored by anhydrous iron oxides) were also found, the latter also identified in some repainting layers.

As reported by Prof. Bensi in the report that summarizes the results obtained during the analysis of the samples coming from the polychromy of the ceiling of the Great Mosque of Ṣan‘ā’, the cinnabar pigment could be both natural and artificial but, as there are no mercury deposits in Yemen, it is reasonable to hypothesize that it has been imported. The natural pigment is present in Spain, Syria and China while the manufacture of artificial cinnabar appears to have been described for the first time by Arab alchemists in the 9th century, and a 10th century Islamic source mentions Basra, in present day Iraq, as a place of production of the material, as well as of minium and other colors. It should be noted that in all the samples analyzed the pigment does not show signs of blackening, as it did in European paintings.

Minium could easily be obtained by roasting lead white ($2PbCO_3 \cdot Pb(OH)_2$), a white pigment found in the polychromy of the ceiling, and therefore it is presumable that this orange pigment is locally produced, just as red earths are of Yemeni origin.

No red lacquers have been identified based on organic vegetable or animal materials, which in some cases appear in Islamic polychrome on wood.

Below are some images relating to a fragment of red colored painting layer in which the presence of cinnabar and minium pigments has been identified, Figs 1-3.

Fig. 1. Stereomicroscope image of the red paint sample Y4, taken from the second aisle of the north wing of the al-Jāmi‘ al-Kabīr mosque in Ṣan‘ā’.

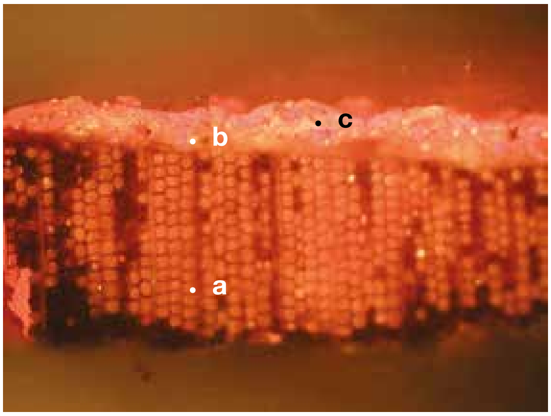


Fig. 2. Image at the optical microscope of the cross section of paint sample Y4 viewed in reflected visible light showing the wooden substrate (a), a ground layer of a proteinic nature (b) and the red layer containing the pigments cinnabar and minium (c).

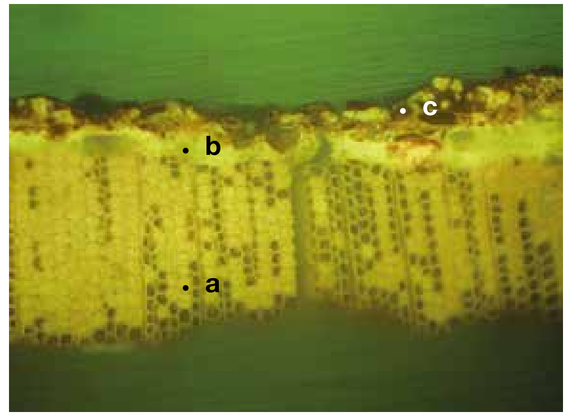


Fig. 3. Image at the optical microscope of the cross section of paint sample Y4 viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

Blue

The analyzes carried out on the fragments of blue painting layers have identified ultramarine blue as the main blue pigment, Figs 4-6, whose blue color is due to the presence of the mineral lazurite ($3Na_2O_3 \cdot Al_2O_3 \cdot 6SiO_2 \cdot 2Na_2S$). In some blue layers the indigo pigment of vegetable origin ($C_{16}H_{10}N_2O_2$) has been identified, Figs 7-10.

As for the ultramarine blue pigment, it is reasonable to hypothesize that it is the natural blue pigment obtained from the grinding of the mineral lapis lazuli since the pigment grains, observed even at high magnifications by scanning electron microscope, appear as fragments with irregular outlines and varying in size unlike the morphology found in the case of the artificial ultramarine blue pigment, which came into use after 1826, and is made up of rounded and small particles of similar size.

As reported by Prof. Bensi in the overall report, Arab sources of the 13th century give indications on how to purify lapis lazuli and obtain the best quality of natural ultramarine blue, probably the pigment used is imported from Afghanistan, the main source of the mineral until the 19th century.

In some samples a blackish layer was detected under the ultramarine blue-based coating, probably applied as pictorial expedient to intensify the shade of blue, as is often found in European painting.

In some blue layers, indigo was found with natural ultramarine blue pigment. It was not possible to establish whether indigo was used as a background layer of the natural ultramarine blue layer or, more likely, mixed with it, with the aim of saving on the precious mineral or in order to obtain particular shades of color.

The use of the two pigments mixed together has been observed in ancient artifacts, such as in the stuccoes of Samarra (Iraq), datable to the 9th century, and in Egyptian

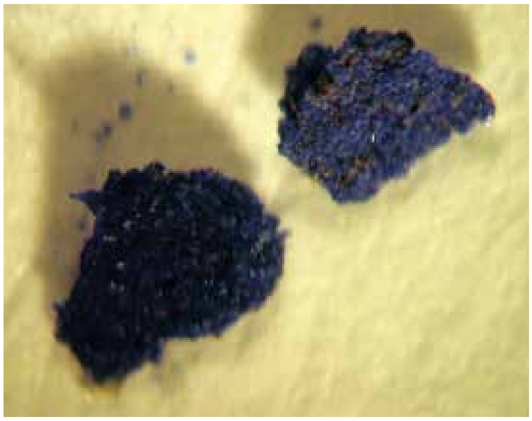


Fig. 4. Stereomicroscope image of the blue paint sample E1 C65 b - top, taken from the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

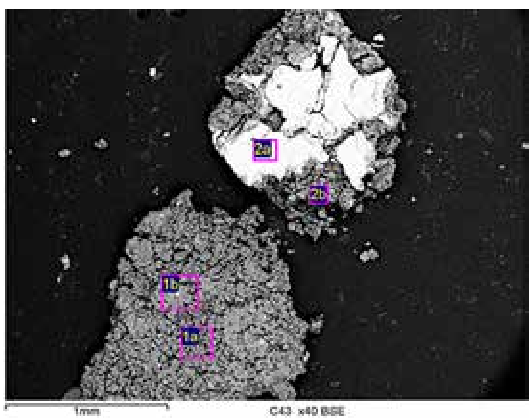


Fig. 5. SEM image of paint sample E1 C65 b - top.

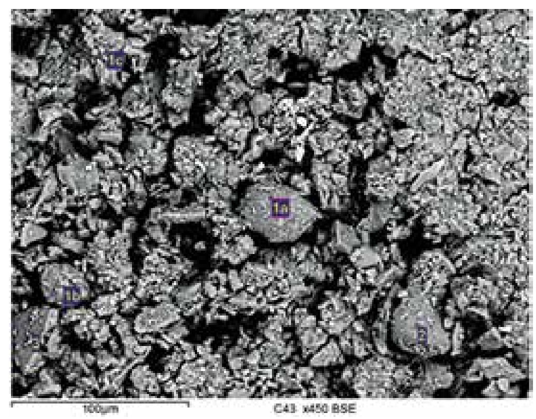


Fig. 6. SEM image of paint sample E1 C65 b - top showing the morphology of the blue pigment grains characteristic of the natural ultramarine blue pigment.

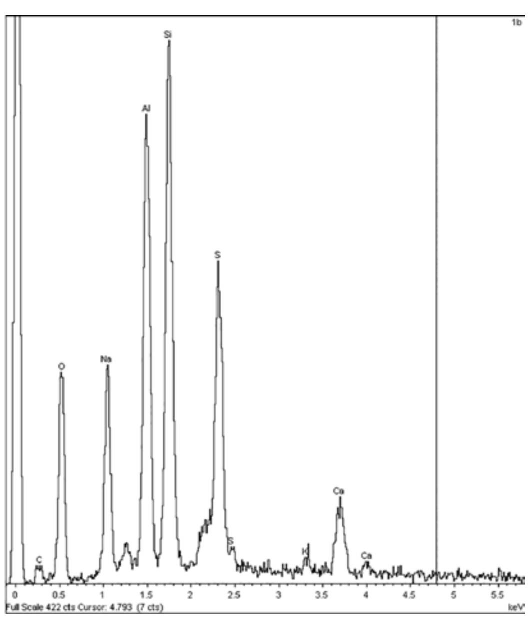


Fig. 7. EDS spectrum acquired from sample E1 C65 b - top made of grains of the natural ultramarine blue pigment in which the characteristic elements of the mineral lazurite are identified.

Fig. 8. Stereomicroscope image of the blue paint sample YSB, taken from the first aisle of the east wing of the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

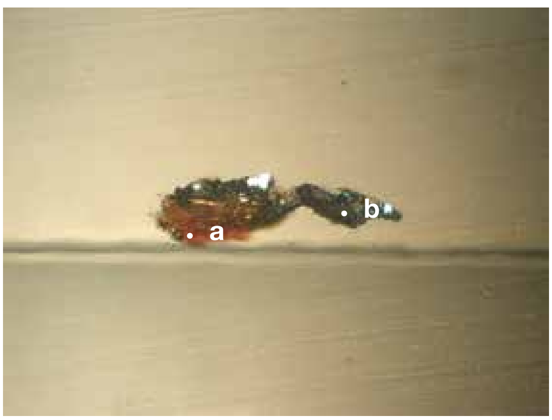


Fig. 9. Image at the optical microscope of the cross section of paint sample YSB viewed in reflected visible light showing the wooden substrate (a) and the blue panting layer (b) containing indigo, traces of red earth and some grains of a white pigment.

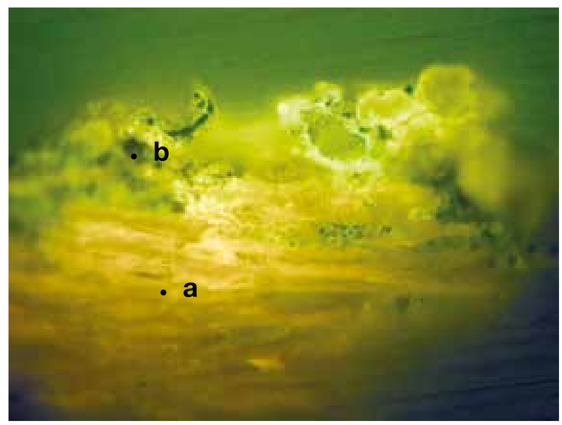


Fig. 10. Image at the optical microscope of the cross section of paint sample YSB viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

geographical maps of the beginning of the 13th century while indigo as a substrate of a blue pigment has been identified in the wooden dome of the al-Aqṣā Mosque in Jerusalem (14th century).

The Indigo plants from which the vegetable dye is extracted have been cultivated in Yemen for many centuries, particularly in the Zabīd area.

Among the blues, the use of smalt is not excluded, Figs 11-13, this pigment was detected in a sample on the basis of the morphology of the pigment grains observed under an optical microscope, however for a certain attribution it would be necessary to investigate further by means of instrumental analytical techniques (e.g. ESEM-EDS).

Smalt (glass colored by cobalt compounds) appears in sacred buildings in Egypt in the mid-14th century, precisely in the decoration of wooden ceilings, about the same time when smalt began to be used in Europe, although it is probable that in Arab countries cobalt appears from the 10th century in the coloring of glass. Among the blues, azurite is absent.

Finally, in a sample beneath an ultramarine blue-based layer, was observed a blue

Fig. 11. Stereomicroscope image of the blue paint sample Y6, taken from the second aisle of the north wing (mezzanine) of the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

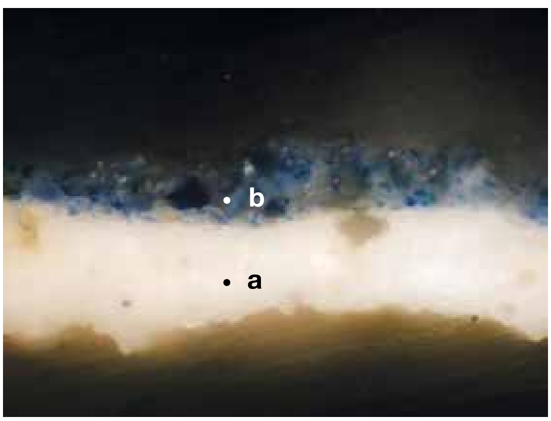


Fig. 12. Image at the optical microscope of the cross section of paint sample Y6 viewed in reflected visible light showing a white layer (a) based on lead white in protein binder and a blue layer (b), presumably based of smalt and lead white.

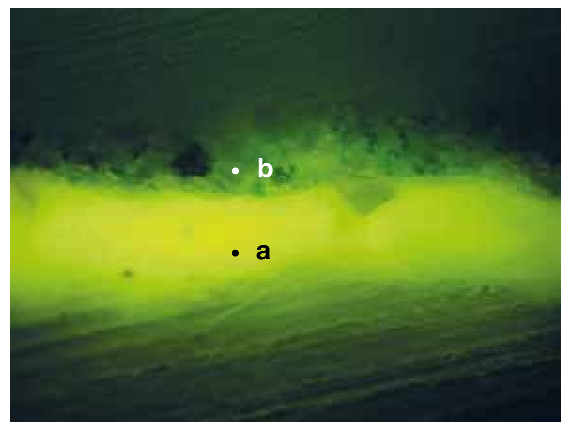


Fig. 13. Image at the optical microscope of cross section of the paint sample Y6 mounted viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

Fig. 14. Image of the sampling point of the blue paint sample Y-S1-13.

Fig. 15. Stereomicroscope image of the paint sample Y S1-13.

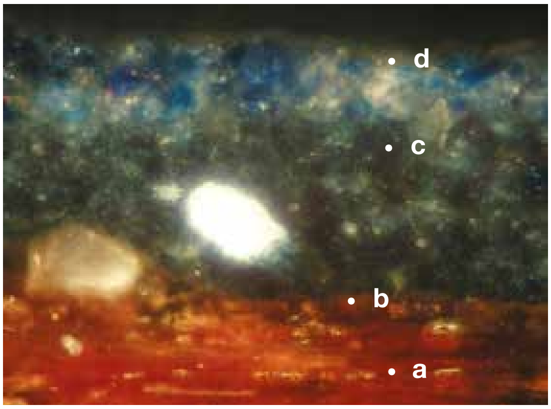


Fig. 16. Image at the optical microscope of the cross section of paint sample Y S1-13 viewed in reflected visible light showing the wooden support (a), the ground layer of a proteinic nature (b), a blue layer positive to microchemical assay for the identification of iron-based pigments which suggests the use of the pigment Prussian blue in addition to lead white in oleic binder (c), a painting layer containing ultramarine blue and lead white in protein binder (d).

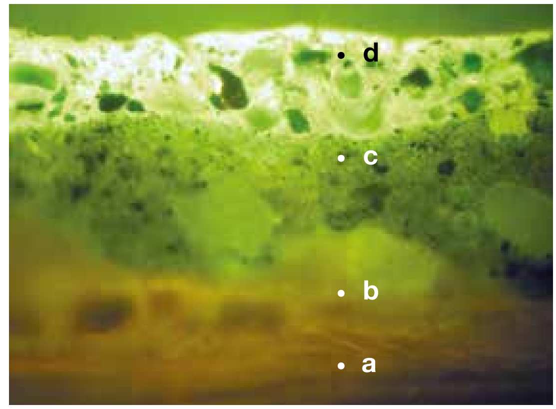


Fig. 17. Image at the optical microscope of the cross section of paint sample Y-S1-13 viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

layer with positive result to a specific microchemical assay for the identification of iron-based pigments, suggesting the use of the pigment Prussian blue $Fe_4[Fe(CN)_6]_3$, a synthetic pigment produced on a large scale starting from 1730, Figs 14-17.

Yellow

The yellow pigments identified during the various diagnostic campaigns are the orpiment, Figs 18-20, and the yellow ocher. Furthermore, the use of a lead-based yellow pigment is also not excluded, for the precise characterization of which an in-depth investigation would be necessary.

The orpiment (As_2S_3), very poisonous, was a material seen with a certain diffidence in Europe but still used quite frequently between the 10th and 14th centuries: it was also used for its ability to keep insects away from perishable supports such as paper and wood. In Islamic countries, it seems to have had a considerable diffusion, in the miniature where it appears until the 18th century, and in painting. As for the latter, it is present in the polychromy of the Samarra stuccoes and the dome of the al-Aqṣā Mosque.

The natural orpiment probably came from Syria or the Persian Gulf, it was also found in Ethiopian icons and it is therefore possible that it was also imported from Africa. Since the Middle Ages it has also been synthesized, but starting from arsenic minerals that do not seem to be found in Yemen.

As regards the possible use of a lead-based yellow pigment, it should be noted that in the surveys carried out during the restoration of the Yemeni Mosque of the Madrasah al-ʿĀmiriyyah by an Italian working group, the pigment massicot, or yellow lead oxide, was identified. This pigment could be prepared roasting the lead white.

Fig. 18. Stereomicroscope image of the yellow paint sample YCG, taken from the fourth aisle of the south wing (sleeper) of the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

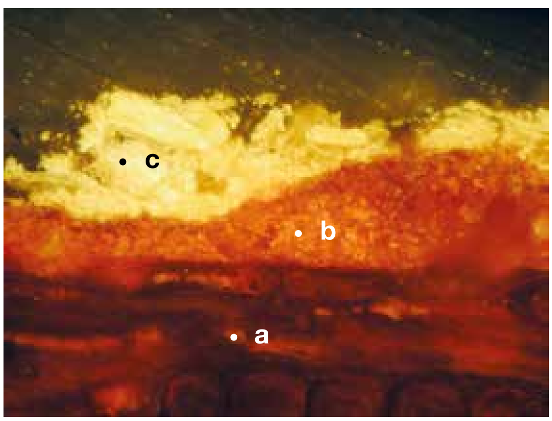


Fig. 19. Image at the optical microscope of the cross section of the paint sample YCG viewed in reflected visible light showing the wooden support (a), a red layer based on minium (b) and a yellow layer based on orpiment (c).

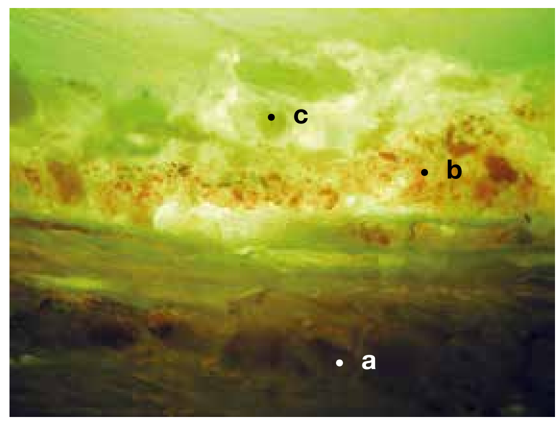


Fig. 20. Image at the optical microscope of the cross section of the paint sample YCG viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

Orange

For the realization of the orange painting layers, in addition to minium, whose use was also found in the red painting layers, layers were observed in which the orange color was obtained by mixing the pigments orpiment, pararealgar and cinnabar, Fig. 21.

As Prof. Bensi reports, in addition to minium, the orange tones could be obtained with realgar, arsenic sulphide As_4S_4, very similar to the orpiment, with which it shares the poisonousness, so much so that it was used in the European Middle Ages as an antiseptic for egg tempera paintings. The investigations conducted so far have not identified realgar but the polymorph pararealgar, a material that occur as a light induced alteration product of realgar. Pararealgar has the same appearance as realgar but has a dark yellow color. Some studies have shown that the pigment alteration can take place even in 24 hours, so it cannot be used for any dating of the pictorial layer; on the other hand, pararealgar can be found in nature, associated with realgar.

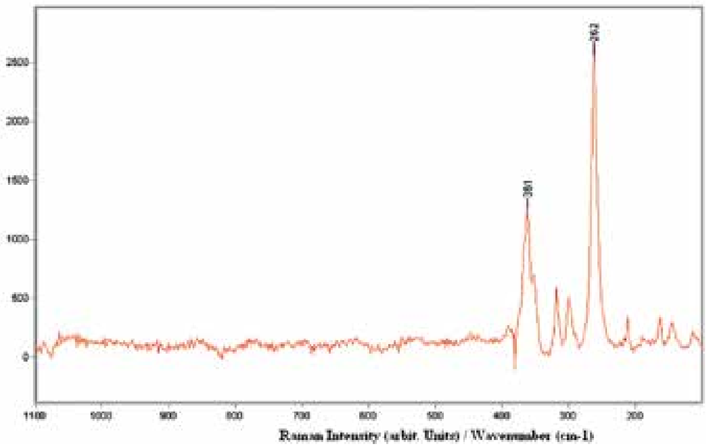


Fig. 21. Raman spectrum acquired from the orange paint layer of sample 41 N2, T30 / fO in which the characteristic peaks of orpiment and pararealgar pigments are observed. In the same paint layer, the presence of the pigment cinnabar was also identified.

The two pigments could have come from Turkey, Syria or the Persian Gulf. Realgar is mentioned in Persian miniature treatises of the 16th-17th centuries and has been found in the Madrasah al-ʻĀmiriyyah and Quṣayr ʻAmrā murals. Pararealgar has been identified in the Samarra stuccoes and in Persian miniatures from the 16th century.

The cinnabar-orpiment mixture also appears in the dome of the al-Aqṣā Mosque and in the wood decoration of the Nur al-Din Room of the Metropolitan Museum in New York, which comes from Syria (1707).

Green

The green painting layers observed in few samples during the various survey campaigns were realized using the pigment green earth (clays colored by hydrated iron (II, III) oxides), Figs 22-24, mixtures of orpiment and indigo, Figs 25-26, or mixture of yellow ocher and indigo.

It should also be emphasized that not many fragments of green pictorial film were analyzed during the various analysis campaigns and only for some the investigations conducted led to the univocal identification of the pigments used, while for other samples the complete and univocal identification would requires an in-depth investigation.

It should be noted that in one sample the presence of a green pigment of organic nature was also detected, Figs 27-28.

As Prof. Bensi observes, the mixture of orpiment and indigo to obtain green painting layers is well known in medieval European painting techniques with the name of "vergaut" or "vergant". The mixture is reported in Italian sources of the 14th century-early 15th century, it was used intensively in miniature from the 8th to the 14th century and in Europe its use decays in the 15th century.

Fig. 22. Stereomicroscope image of the white/green paint sample Y1N, taken from the second aisle of the north wing (mezzanine: beam with panes) of the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

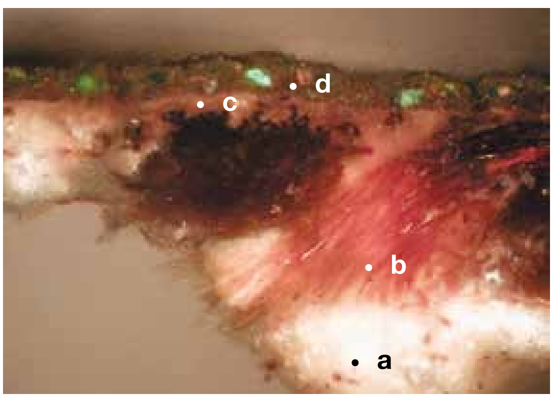


Fig. 23. Image at the optical microscope of the cross section of the paint sample Y1N viewed in reflected visible light showing a white layer (a), the fibers of the cloth used for the coating (b), a brown layer of organic nature (c) and a brown green layer in which grains of green earth and ocher in oleic binder are observed (d).

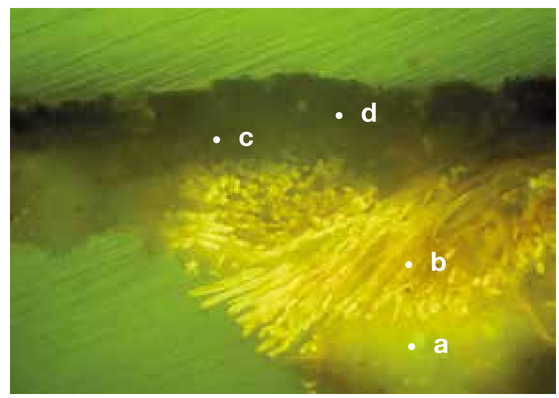


Fig. 24. Image at the Optical Microscope of the cross section of the paint sample Y1N viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

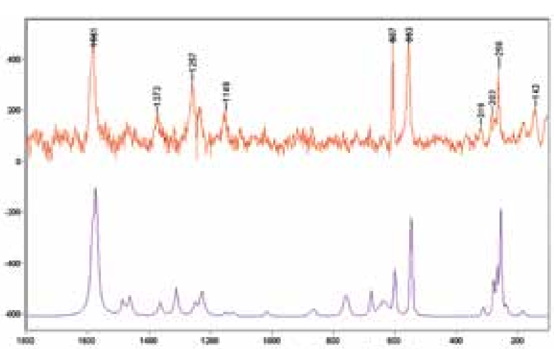


Fig. 25. Raman spectrum acquired from the green painting layer of sample N2, T30 / fO (a) in which the characteristic peaks of indigo are observed as confirmed by comparison with the reference spectrum of indigo (b).

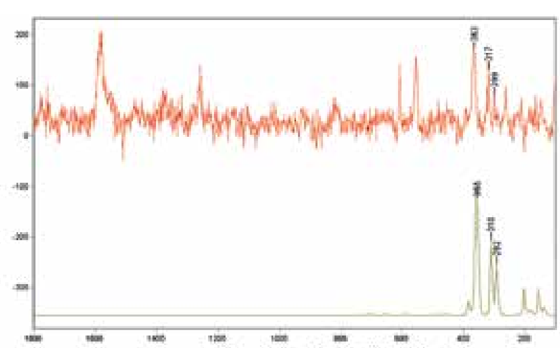


Fig. 26. Raman spectrum acquired from the green painting layer of sample N2, T30 / fO (a) in which characteristic peaks of the indigo and orpiment pigments are observed. In this case the Raman spectrum is compared with the reference spectrum of the orpiment (b).

Fig. 27. Stereomicroscope image of the greenish paint sample 11 / E3C96B.

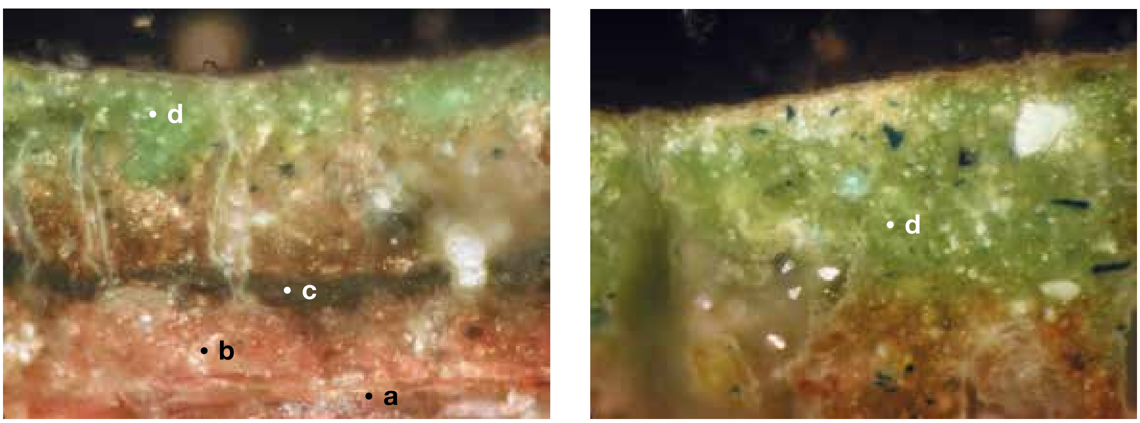


Fig. 28. Images at the optical microscope at different magnifications of the cross section of the paint sample 11 / E3C96B viewed in reflected visible light showing the wooden support (a), a layer of organic nature probably applied as a ground layer/'imprimitura' (b), a layer based on a black pigment of an organic nature (probably carbon black) (c) and a green layer in which blue grains are observed, identifiable with natural ultramarine blue (d). The innermost part of the green layer is chromatically changed from green to brown presumably by reaction with some components of the underlying layers, this alteration suggests the use of an organic green pigment in the creation of this layer.

In contrast, we do not have much information from Islamic sources, except from texts on Persian miniatures from the end of the 16th century and the beginning of the 17th century. On the other hand, studies on the artworks show that the mixture has been used for a long time in Islamic art. The oldest known case is the Samarra stuccoes, which date back to the 9th century; we also have the geographical text *Kitāb Gharā'ib al-funūn wa-mulaḥ al-ʿuyūn* ('The Book of Curiosities'), which dates back to the 13th century. It continues to be used in 16th century Persian miniatures and in decorations on wood, as in the three rooms of Syrian origin preserved in Germany, which can be dated between 1601 and 1810, and in the Nur al-Din Room of the Metropolitan Museum of New York (1707), also Syrian. It has also been found in Ethiopian icons of the 17th and 18th centuries.

Black

The black painting layers were realized using carbon black, a fine particle carbon pigment obtained as soot from the incomplete combustion of many different types of organic materials, such as fruit pits, vine stalks, husks, cork, etc., or lampblack, a type of carbon black obtained from the soot of burned fat, oil, tar, or resin. No black pigments of animal origin such as bone black have been identified.

White

The main white pigment identified in most of the samples analyzed is lead white, Figs 29-30, the use of gypsum and calcite has rarely been detected, particularly in the repainting layers.

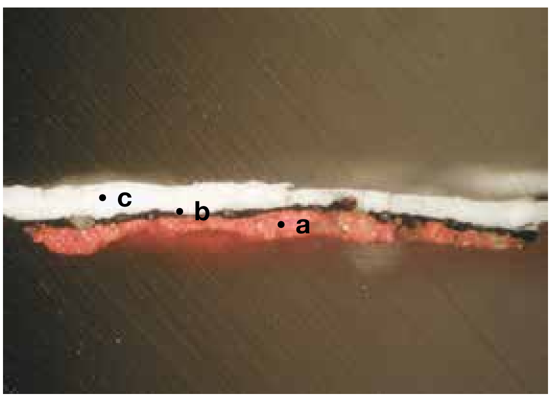


Fig. 29. Image at the optical microscope of the cross section of the paint sample Y9 with white pictorial film, taken from the third aisle of the west wing, viewed in reflected visible light showing a red layer based on minium and lead white in oleic binder (a), a black layer containing a pigment of vegetable origin (b) and a white layer based on lead white in protein binder.

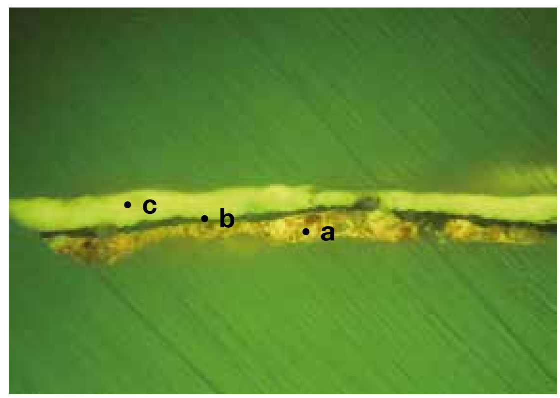


Fig. 30. Image at the optical microscope of the cross section of the paint sample Y-9 mounted in a cross section viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

1.2. Gildings

The gilding analyzed are performed some '*a missione*', Fig. 31, others with a technique similar to the '*doratura a bolo*'.

In the samples in which the gilding is performed '*a missione*', a red color layer made of cinnabar with oil binding media is observed, on top of this layer there is the '*missione*' layer made with a protein-based material on which the gold leaf has been applied.

In other gildings, on the other hand, the gold leaf is directly applied over a red layer containing cinnabar, minium and lead white, Figs 32-34. In the samples where the gold leaf has been applied in this way, an increase in fluorescence is observed in the upper part of the red layer which could be due to the presence of an organic substance, used for the application of the gold leaf and penetrated inside the red layer.

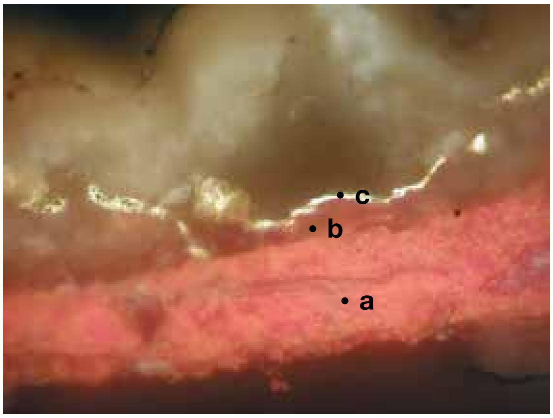


Fig. 31. Image at the optical microscope of the cross section of gilding sample Y-S1-12, taken from a tablet of a chest of drawers in sector I - al-Jāmi‘ al-Kabīr mosque of Ṣan‘ā’, viewed in reflected visible light.

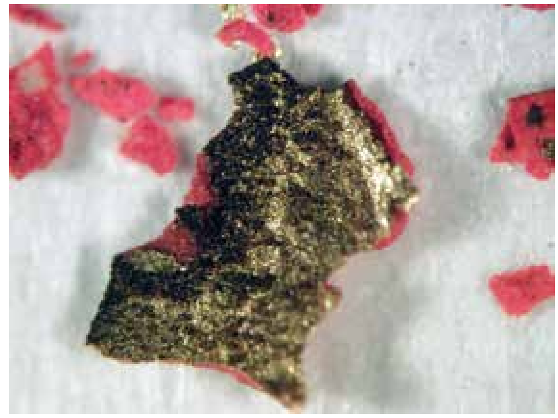


Fig. 32. Stereomicroscope image of the gilding sample YS1-16, taken from the third beam of sector I of the al-Jāmi‘ al-Kabīr mosque in Ṣan‘ā’.

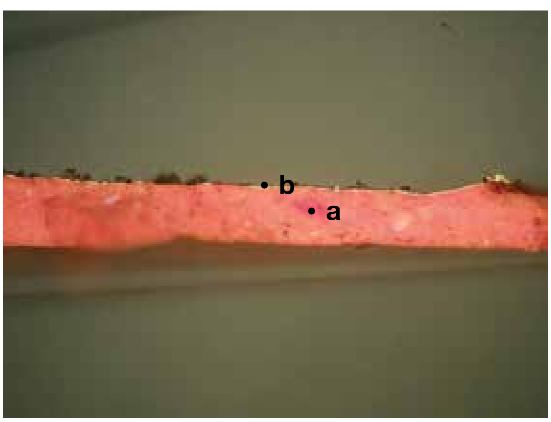


Fig. 33. Image at the optical microscope of the cross section of the gilding sample YS1-16 viewed in reflected visible light showing a red layer based on minium, cinnabar and lead white in oleic binder (a), on which is applied the gold leaf (b).

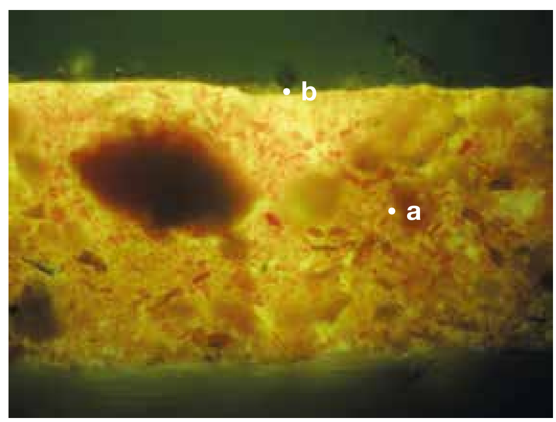


Fig. 34. Image at the optical microscope of the cross section of gilding sample YS1-16 viewed in ultraviolet radiation in order to highlight the presence of fluorescent materials.

1.3. Ground layers

In some samples including the wooden support, on top of the wooden surface were detected a thin layer containing protein-based materials, identified by specific micro-chemical tests. It is assumed that these layers were applied as ground layer ‘*imprimitura*’ on the wooden surface before applying the paint layer, Figs 1-3 and Figs 35-37.

In some cases, ground layers containing gypsum have been identified, in others no ground layers are observed between the wooden support and the painting layers. It cannot be ruled out that these differences depend on different execution chronologies.

Fig. 35. Stereomicroscope image of the paint sample YTSBV, taken from the second aisle of the north wing of the al-Jāmiʿ al-Kabīr mosque in Ṣanʿāʾ.

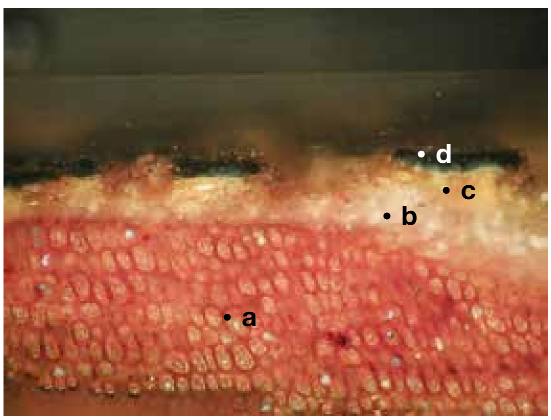


Fig. 36. Image at the optical microscope of the cross section of paint sample YTSBV viewed in reflected visible light showing the wooden support (a), two whitish layers presumably corresponding to ground layers (b) and (c). Microchemical tests have identified the protein nature of layer (c).

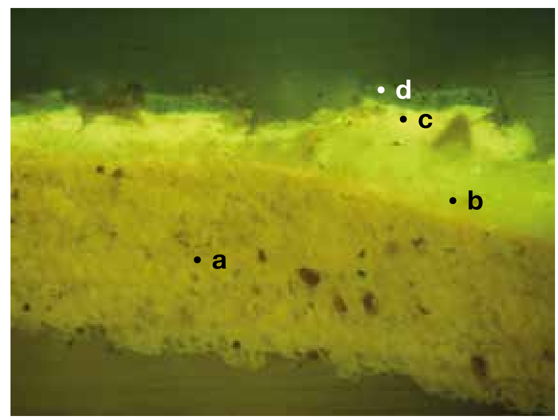


Fig. 37. Image at the optical microscope of the cross section of the paint sample YTSBV viewed in ultraviolet radiation which highlights the preparatory layers (b) and (c).

It should be noted here that in the wooden decoration of the ceiling of the Mexuar Palace in Granada a layer of minium was placed as a ground layer, probably also to discourage the action of xylophagous insects, which however is absent in Ṣanʿāʾ.

1.4. Binding media

In the various analytical campaigns, by means of specific microchemical tests, materials belonging to the classes of protein and oil binders were identified. The proteins should correspond to glue-based tempera, widely used both in Europe and in the Islamic world for polychromies on wood.

Of course, it is not possible to rule out the hypothesis that the lipid and protein substances also derive from subsequent restoration work on the decoration.

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photo: Fawzi Dubhani

Section 4 - Chapter 2

SCIENTIFIC INVESTIGATIONS ON THE POLYCHROMY OF THE WOODEN CEILING

PAOLO BENSI

From the moment in which, at the end of 2009, the architect Renzo Ravagnan, director of the Istituto Veneto per i Beni Culturali (IVBC), involved me in the Istituto Veneto's beautiful undertaking in Ṣan'ā', with the task of coordinating a new analytical campaign on the polychromy of the wooden ceiling of the mosque itself, I had the opportunity to make an extraordinary human experience and a very interesting scientific experience.

From a human point of view I have known, and loved, from a privileged point of view, a wonderful country; from a scientific point of view I have applied my historical and technical knowledge on coloring materials in a new field for me, namely the polychromy of Islamic arts. In this regard, I initially had some perplexities, given that the material characteristics and dating of the use of colors in Europe have been much studied, while for the medieval and modern Near East the data available at the time seemed not to be numerous enough, which could create the problems regarding one of the purposes of the investigation campaign, that is to offer useful information to understand the dating of the pictorial decoration of the wooden ceiling, object of the conservation interventions led by the Istituto Veneto.

However, in 2010, at the time of the conclusion of the analyses, then presented during the East Near conference (Venice, 22-23 October 2010), I was able to have a sufficient set of results obtained by other researchers to be able to establish valid comparisons, even if they were scientific studies on heterogeneous materials, ranging from manuscripts to Persian miniatures, from stuccos and architectural decorations to Spanish, Egyptian, Jordanian and Iranian wooden structures. Resuming now, ten years later, the results obtained, I have been able to acquire new technical elements of comparison published in the meantime: it must be said, however, that still further studies would be necessary.

The investigations coordinated by me were carried out on a batch of samples, coming from the north (mainly) and east sectors, chosen in order to document the main shades present and the overlapping of successive layers, given that in different parts there was the presence of two overlapping layers of color.

The samples were analysed by two excellent working groups, coordinated by the writer, the group led by Dr. Angelita Mairani (for ArteMateria, Genoa) and the group led by Prof. Pietro Baraldi, of the Chemistry Department of the University of Modena and Reggio Emilia: they used different methodologies, on the same samples or on different samples, respectively with a scanning electron microscope (SEM) coupled to an EDS microprobe on samples as they were or on cross-sections of the same (Mairani) and Raman microspectroscopy, FT-IR infrared spectroscopy and X-ray diffraction (XRD) (Baraldi). The different diagnostic techniques have complemented each other with considerable effectiveness.

Between 2006 and 2009, investigations were carried out, coordinated by Arianna Gambirasi, in the laboratory of the Istituto Veneto per i Beni Culturali, on samples from various sectors, which were taken into account for the appropriate comparisons. The methodologies used were microchemical analysis, FT-IR infrared spectroscopy and Raman spectroscopy.[1]

We now give some brief information on the analytical methods used, underlining what kind of results they are able to provide.

The cross-sections on which the analyses were carried out in many cases were obtained by incorporating the samples, or portions of them, in fluid synthetic resins, then solidified and cut perpendicularly to the fragment in order to make the layers that compose it visible: in this way the sampling is perfectly suited to the observation with the optical microscope and the electron microscope, as well as the analyses carried out with electromagnetic radiations of different frequencies in order to identify the constituent materials present.

Electronic scanning microscope with sem-eds micro probe

The scanning electron microscope (SEM) coupled to an energy dispersion detector (EDS) is able to carry out qualitative and semi-quantitative elemental microanalyses, i.e. to identify the chemical elements present in the materials under examination: in the case of cross-sections obtained from samples it can recognize the elements layer by layer and also on single particles present in the layers.

Ft-ir infrared spectroscopy

Fourier Transform Infrared Spectroscopy (FT-IR) is an absorption spectroscopic analysis technique that can provide qualitative information on the molecules present in the sample: in the case of cross-sections obtained from withdrawals can recognize them layer by layer. Particularly suitable for the recognition of organic materials (binders, adhesives, lacquers and dyes). The instrument used was a Jasco 2400 spectrometer with a spectral resolution of 2 cm^{-1}, TGS detector, number of scans adjusted by the instrument according to the transmission.

1 I referred to the analytical reports edited by Dr. Gambirasi and kindly provided by IVBC.

Raman microspectroscopy
Non-destructive and non-invasive spectroscopic investigation methodology, which allows to identify the molecular and crystallographic nature of the species present in both macro and microscopic samples was applied. The sample comes irradiated by a laser beam that causes the diffusion of light, which contains the molecular information cited. Also in this case it is possible to apply the method to the various layers of a stratigraphic section. This is suitable for the recognition of organic and inorganic materials.

A Jobin Yvon-Horiba Raman Labram microscope was used, with a red laser at 632 nm, CCD with 1024x 256 pixels, edge filters to eliminate the exciter, 50x and 100x Olympus long distance lenses.

X-ray diffraction (xrd)
This is an analytical methodology that exploits the diffusion of X-rays that interact with different materials. Provides qualitative information on the molecules present in the samples, provided that they have a crystalline structure.

The diffractograms of the sample surfaces were collected using a Panalytical XPert Pro diffractometer with Cu counter-cathode (40kV - 40 mA) and solid state X-CELERATOR detector, in a range 5-60 2theta.

Comments on the results of the analysis
I will present below the historical-critical considerations relating to the results obtained in the campaigns of survey, conducted almost entirely in the northern sector. They also take into account the analyses carried out previously, edited by the Istituto Veneto per i Beni Culturali, on other sectors of the wooden ceiling, and are based on comparison, when possible, with ancient sources and international studies on the works of art of Islamic culture, with particular attention to the polychromies of the architectural decorations. Over the past decade they have made available it further significant data on Yemeni objects and monuments also on neighboring areas. Also research on the painting techniques used in Ethiopia, given the proximity and relations between the two countries has been taken into account. Details on the structure and composition of the individual samples analysed are given in the Appendix.

COLORING MATERIALS

Blue

Ultramarine
It is the main blue detected, even in previous survey campaigns. It is a natural or artificial pigment: the natural type is mainly composed of lazurite, an aluminum and sodium silicate containing sulfur, of the sodalite group, from the formula $Na_8[S_2,(AlSiO_4)_6]$; it

was obtained by grinding the semi-precious stone lapis lazuli, formed by a mixture of minerals, in which lazurite prevails, for 25-40%: it contains variable quantities of other aluminosilicates and impurities of calcite ($CaCO_3$), mica and pyrite (FeS_2). For centuries the main source of the mineral were the mines of present-day Afghanistan; later deposits of lapis lazuli were also found in Russia, Chile and the United States. The morphology of the particles of ultramarine obtained from the purification of lapis lazuli in the samples of the Great Mosque is always the same, with fragments with irregular and variable dimensions, clearly visible at high magnification of the electron microscope.

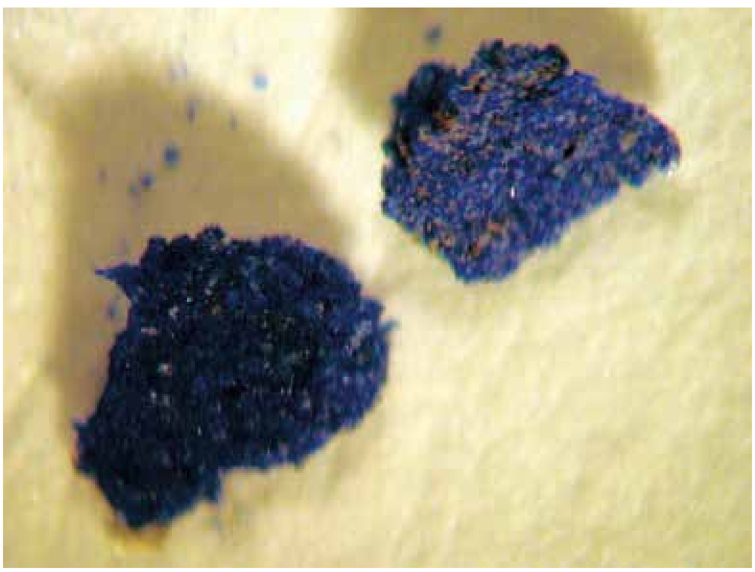

Fig. 1. Sample C43 - M.O. photograph - 30x magnification - reflected light.

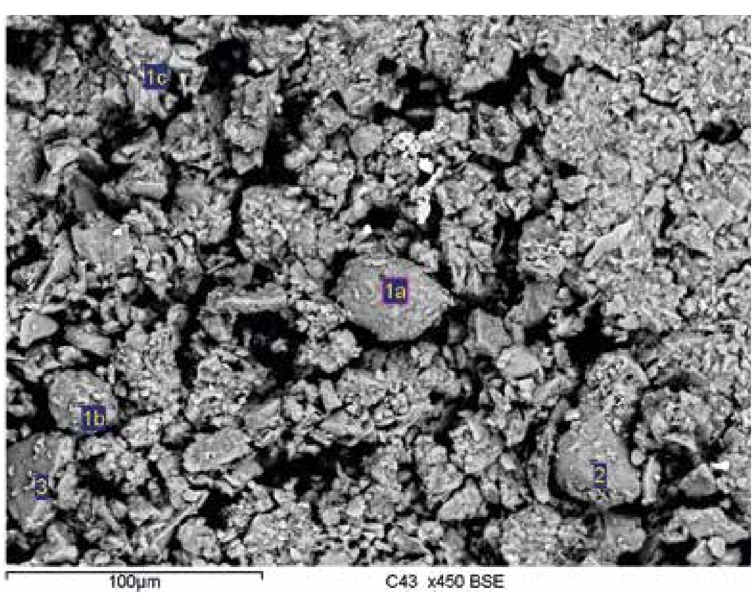

Fig. 2. Sample C43 - SEM micrograph - 450x magnification - BSE detector.

We can therefore be sure that what is in question is the natural pigment obtained from the grinding and purification of lapis lazuli, given that the corresponding artificial pigment, which came into use after 1826, has the same formula as that natural, but it is made up of rounded and small particles. It should almost certainly have been imported from Afghanistan, via the trade route between India and Africa. Arab sources of the thirteenth century give indications on how to purify lapis lazuli and obtain quality overseas better (Seccaroni 2006b). The same material has been identified in previous analyzes conducted in other sectors of the Mosque. The presence of a blackish layer is identified under the blue in C 43, probably a pictorial expedient to intensify the shade of blue, which is often found in European painting and also in the Great Mosque of Işfahān (Cornale *et al.* 2016: 79 and 103). The ultramarine is reported in the decorations of Islamic buildings in various areas of the Near and Middle East (Cornale *et al.* 2016: 102-103).

Indigo

In sample C42, indigotine appears next to the ultramarine, most likely also present in C 44: it was also found in other areas of the ceiling. Indigotine is the main component of raw natural indigo – in average 40-50% proportions - the rest consists of indirubin, flavonoids, mineral substances: it is classified among the organic pigments. It is obtained from the leaves of different types of plants found in various countries of the world of the genus Indigofera, and from *Isatis tinctoria*, widespread in Europe: the leaves of the latter are much less rich in indigo carmine than the Indigofere, their extract is called "guado".

It was not possible to establish whether indigo was placed as a background for ultramarine or, more likely, mixed with it, perhaps to save on the precious mineral or obtain particular shades of color. Both hypotheses are plausible and similar cases have been found in Europe, especially in the 14th and 15th centuries (Martin, Bergeon 1996).

It should be noted that the mixture of the two pigments has been recorded in ancient Islamic artefacts, that is, in the stuccoes of Samarra (Iraq), certainly datable to the 9th century (Burgio *et al.* 2007), in Egyptian geographical maps of the early 13th century (Chaplin *et al.* 2006) and in Persian miniatures from 1515 (Muralha 2012). Indigo carmine as a substrate of another blue (azurite) is present in the wooden dome of the al-Aqṣā Mosque in Jerusalem (14th century) (Lazzarini, Schwartzbaum 1985).

Plants of the genus Indigofera have been cultivated in Yemen for many centuries, in particular in the area of Zabīd (Cardon 2007). Indigo appears alone in the 16th century decoration of the Madrasah al-'Āmiriyyah of Radā', Yemen, and in a Yemeni manuscript, dated to 1711, kept in the Museum of the Central Institute for Restoration and Conservation of the Artistic and Book Heritage (ICRCPAL) of Rome (Zizola 2005; Capitani 2014-2015): in the latter was also mixed with orpiment to form a green (see below).[2]

2 The Madrasah al-'Āmiriyyah of Radā' was the subject of restoration interventions by the Center for Archaeological Conservation of Rome between 1998 and 2005 (Zizola 2005).

Other blues are absent, such as Azurite, which is instead present in the wall paintings of the al-Ashrafiyyah Mosque of Ta'izz in Yemen (Barban *et al.* 2011), almost certainly from the 15th century, or the Enamel (stained glass made from cobalt), which appears in sacred buildings in Egypt of the mid-fourteenth century, precisely in the decoration of wooden ceilings (Abdel-Ghani *et al.* 2007) and in Iran, probably at the same time: in the same century, therefore, in which began to use enamel in Europe, although it is likely that in the coloring of glass in the Arab countries cobalt appears from the 10th century (Borgia, Seccaroni 2005; Holakooei, Karimy 2015).[3]

Red

Cinnabar

Identified in samples C37, 39, 40, 41, 42, 46, 47, 48, it is a pigment based on Mercury Sulfide (HgS), which can be natural or artificial; since there are no mercury deposits in Yemen (www.ygsmrb.org.ye/geo_of_yemen.htm), it is almost certain that it was imported. The material was detected in various sectors of the Mosque also in previous analytical campaigns. The natural pigment is present in Syria and China.

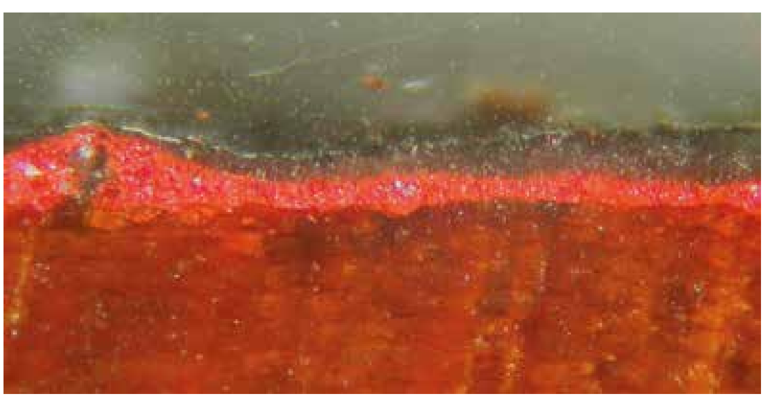

Fig. 3. Sample C47 - photograph at M.O. of the glossy section - 250x magnification - reflected light.

The manufacture of artificial cinnabar appears to have been described for the first time by Arab alchemists in the 9th century (Perego 2005), while a 10th century Islamic source cites Basra, in present-day Iraq, as the place of production of the material, as well as of lead and other colors (Burgio *et al.* 2007). It was not possible to understand with certainty whether it is a natural or artificial pigment; it should be noted that it does not show signs of blackening, as it did in European paintings. Cinnabar is reported in two Yemeni manuscripts, dated 1695 and 1711, kept in the ICRCPAL Museum in Rome (Capitani 2014-2015).

3 The school site in the al-Ashrafiyyah Mosque in Ta'izz was also led by the IVBC, in agreement with the Social Fund of Development of Ṣan'ā': the writer coordinated the scientific analyzes carried out in 2010 and 2011 on the polychromy of the decorations of the Mosque.

Minium

This is an artificial pigment, identified in previous investigations, based on lead oxide Pb_3O_4: it could easily be obtained by roasting the lead white (basic lead carbonate), which was found in the polychromy of the ceiling, and therefore we can assume that it was produced locally. Known since antiquity, in Europe it was widely used from the early Middle Ages to the 15th century, only to be gradually abandoned. The pigment appears in a 1711 Yemeni manuscript of the ICRCPAL Museum (Capitani 2014-2015).

Red Earths

Natural pigments, consisting of clays (silico-aluminates) colored by anhydrous iron oxides (hematite, Fe_2O_3). In our case the content of iron oxides is rather low, so that they can be classified as “ferrous earth”; with good certainty we can think that they are of Yemeni origin. Known since antiquity, they have been used up to the present day.

In the samples of the northern sector, samples C46 and 48 were found under ultramarine blue in sample C43 and in the repainting layers, gray or yellowish, on the oldest gypsum-based colors, while repainting shows traces of hematite. No red lacquers have been identified based on organic vegetable or animal materials, which in some cases appear in Islamic polychromes on wood. Red lacquers deriving from insects are also present in a 1711 Yemeni manuscript from the ICRCPAL Museum (Capitani 2014-2015).

Yellow

Orpiment

This is a natural or artificial inorganic pigment, based on arsenic sulphide As_2S_3. It is very poisonous: it was a material considered with a certain diffidence in Europe, though in any case of fairly frequent use between the X and XV centuries- Subsequently its use decreased; it was appreciated for its ability to keep insects away from perishable media such as paper and wood.

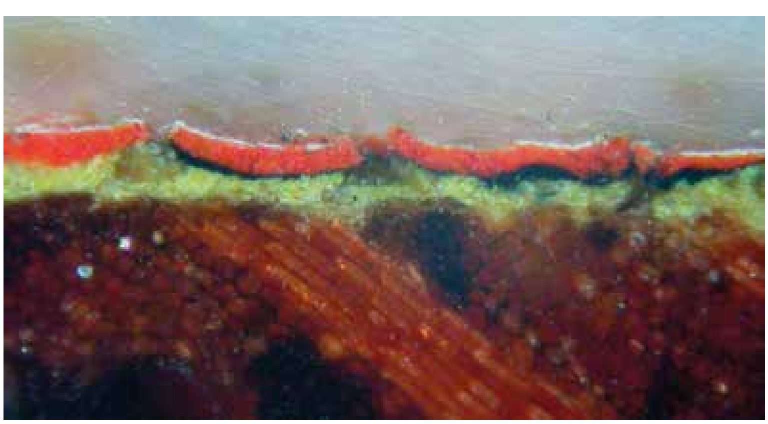

Fig. 4. Sample C47 - photograph at M.O. of the glossy section - 200x magnification - reflected light.

In Islamic countries it seems to have had a considerable diffusion, in miniature (Purinton, Watters 1991; Burgio *et al.* 2008), where it appears until the 18th century, and in painting.

As for the latter, it is present in the polychromy of the Samarra stuccoes (Burgio *et al*. 2007) and in the dome of the al-Aqṣā Mosque (Lazzarini, Schwartzbaum 1985); was found, alone or mixed with indigo, in a 1711 Yemeni manuscript of the ICRCPAL Museum (Capitani 2014-2015). The pigment was identified in the northern sector also on previous investigations.

Natural orpiment could have come from Syria or the Persian Gulf (it is present in Iran): it has also been found in Ethiopian icons (James 2005) and in Coptic paintings (Abdel-Ghani *et al.* 2010) and it is therefore possible that it was imported also from Egypt, where it has been in use for many centuries (Colinart *et al.* 1996: 37). Since the Middle Ages it has also been synthesized, but starting from arsenic minerals that do not seem to be found in Yemen.

The pigment was also used Ṣan‘ā’ to form orange and green shades, as we shall see.

Yellow ochre

This is a family of natural inorganic pigments, based on clays colored by variously hydrated iron oxides (Goethite, Lepidocrocite). Used by artists from prehistoric times to today. In our case it is certainly of Yemeni origin.

In the previous investigations in other sectors of the Great Mosque, a yellow pigment was identified in the south sector in three samples, which could correspond to the yellow of lead and tin (lead stannate), on which it would be worth carrying out more in-depth analyses, given that this pigment was widespread in Europe and its history has been traced in recent years rather precisely, while a lot less known are both the dating of use and its diffusion in Islamic countries.

A similar material, lead oxide yellow (massicot), was found in the paintings of the Madrasah al-’Āmiriyyah: unfortunately, the analytical techniques on the basis of which the recognition would have been made were not indicated in the texts relating to this intervention (Zizola 2005).

Orange

Realgar

In addition to the minium, already mentioned, the orange tones could be obtained with realgar, an arsenic sulphide As_4S_4, very similar to the orpiment, with which it shares the poisonousness, so much so that it was used in the European Middle Ages as an antiseptic for egg-based tempera. During the investigations, however, realgar was not found but para-realgar, a material that is formed by transformation of realgar exposed to light: it has the same appearance as the first but has a dark yellow color. Recent studies have shown that the transformation of one substance into another can also take place in 24 hours (Douglass, Shung 1992; Trentelman, Stodulsky 1996) so it cannot be used for any dating of the pictorial layer;

on the other hand, para-realgar can be found readymade in nature, associated with realgar.

The two pigments could have come from Turkey, Syria or the Persian Gulf. The realgar is mentioned in Persian miniature treatises of the 16th-17th centuries and was found in the Madrasah al-ʻĀmiriyyah (Zizola 2005) and in the murals of Quṣayr ʻAmrā (Jordan) (Bianchin *et al.* 2007): it must be said, however that only Raman spectroscopy can distinguish between realgar and para-realgar, as happened in our case, and therefore the investigations carried out on these two monuments may not have grasped this distinction. On the other hand, not even the artists were able to distinguish them.

Para-realgar has been identified in the stuccoes of Samarra (Burgio *et al.* 2007) and in Persian miniatures of the 16th century (Burgio *et al.* 2008).

Orange tones were also obtained in sample 41 by mixing cinnabar, orpiment and para-realgar. The cinnabar-orpiment mixture also appears in the dome of the al-Aqṣā Mosque (Lazzarini, Schwartzbaum 1985) and in the wood decoration of the Nur al-Din Room of the Metropolitan Museum in New York, which comes from Syria (1707) (Baumeister *et al.* 2010).

Green

In the present investigation campaign, green shades were found in only two samples and in both cases, they were the original layers or in any case deeper: the green was formed by a mixture of orpiment and indigo and in one case by yellow ocher and indigo.

Fig. 5. Sample C38 - photograph at M.O. of the glossy section - 250x magnification - reflected light.

In previous analytical campaigns the presence of green earth was also found (clays colored by divalent and trivalent iron oxides variously hydrated), found in several cases in monuments of Islamic culture.

The orpiment + indigotin blend deserves particular attention. It is known that the orpiment, in addition to the problems already noted, presents the difficulty of mixing with lead and copper-based colors, due to the danger of transforming them into sulphides, altering their color. It was therefore inadvisable to mix it with azurite, malachite and

Fig. 6. Sample c39 - N2T30fo first level decoration.

verdigris; it could instead form stable greens with ultramarine and indigo carmine. This latter mixture is well known in medieval European painting techniques with the name of "vergant" (Clarke 2004), it is cited in Italian sources of the 14th century-early 15th century (*De Arte Illuminandi or Libellus ad faciendum colores*; The Book of art of Cennino Cennini) (Bensi 2009), and was used intensively in miniature from the 8th to the 14th century; with the 15th century in Europe its use decays.

On the other hand, we do not have much information from Middle Eastern sources, except from texts on Persian miniatures from the end of the 16th century and the beginning of the 17th century. On the other hand, studies on the works show that the mixture has been used for a long time in Islamic art. The oldest known case is the Samarra stuccoes, which, as we have seen, date back to the 9th century; we also have the geographical text of 'Abd al-Ghanī al-Miṣrī (d. 854/1450), *Kitāb Gharā'ib al-funūn wa-mulaḥ al-'uyūn* ("The Book of Curiosities"") (Chaplin *et al.* 2006). It continues to be used in 16th-century Persian miniatures (Purinton, Watters 1991; Muralha *et al.* 2012) and in decorations on wood, as in the three environments of Syrian origin preserved in Germany, which are dated between 1601 and 1810, and in the Nur al-Din Room of the Metropolitan Museum of New York (1707), also Syrian (Baumeister *et al.* 2010; Scharrhas 2010). It has also been found in 17th and 18th century Ethiopian icons (James 2005).

On the other hand, we did not find traces of copper-based pigments, such as malachite and verdigris, cited by the sources and present in various Islamic architectural decorations.

Black

Black pigments have been recognized as carbonaceous materials: since no phosphates and carbonates are present, it can be assumed that they are vegetable or carbon black materials and not blacks of animal origin, black of bone, present in the Madrasah al-ʻĀmiriyyah (Zizola 2005).

White

Lead white (basic lead carbonate) is present in the mixture of colors applied as the deepest layer, which shows no traces of blackening, as has happened in several cases in Europe; in two cases there is also gypsum (calcium sulphate bi-hydrate). In the repainting layers both gypsum and calcite (calcium carbonate) were found.

Gildings

In the previous analysis campaigns, applications of gold leaf were identified in other sectors, fixed with *"missione"*, a family of adhesive mixtures based on oily materials, similar to those used in Europe. The use of gilding does not seem to be very frequent in the Middle East: in the Madrasah al-ʻĀmiriyyah they do not appear, nor in the Taʻizz Mosque: they are instead present in the painted fragments of the Great Mosque of Işfahān, probably from the 12th century, and in the Soltanieh dome in Iran, 1302-1312 (Saffaran 2006; Cornale 2016: 93-98, 105-107),

The gold leaf should derive either from the beating of gold coins or from the processing of native gold or gold objects (Cornale 2016: 195-107): further analysis and further comparative studies would be needed to try to shed light on this appearance.

PREPARATIONS

In the current survey campaign, no preparation layers were detected in the samples taken up to include the wooden support. As mentioned in sample 43 under the blue there is a blackish layer that may have served to intensify the tone of blue: however, as there are no layers in contact with the wood, we do not know if there are real underlying layers of preparation.

The previous diagnostic campaigns have instead identified in some cases base layers containing gypsum: it would have been appropriate to make a comparison between the results of the different areas to try to understand if these differences depend on different chronologies.

When there are repaintings, as in the case of Samples 46 and 48, the original layer was covered with greyish or beige layers based on gypsum (sometimes with calcite), terra, carbon black, ocher, on which the new application of color: the chalky layer in two cases (C37 and 47) surmounts the older one, with no trace of overlying repainting.

In the decoration on the ceiling of the Mexuar Palace in Granada a layer of minium was placed as a preparation, probably also to discourage the action of xylophagous insects, which however is absent in Ṣanʻā’ (Cardell *et al.* 2009).

BINDING MEDIA

No significant data was found for the binding media of the pictorial layers: in the previous analytical campaigns, however, materials of the classes of rubber, protein and oil binders were identified. The proteins should correspond to glue-based tempera, widely used both in Europe and in the Islamic world for polychromies on wood. Of course, we cannot discard the idea that lipid and protein substances also derive from subsequent restoration work on the decoration.

CONCLUSIONS

The coloring materials identified mostly belong to classes of compounds used continuously for centuries, such as earths, cinnabar, indigo, ultramarine, and therefore cannot be used for possible dating. Cinnabar, orpiment, realgar almost certainly had to be imported from other areas, the ultramarine certainly was: despite being very expensive, it was used to a large extent, underlining the importance of monumental decoration.

No modern coloring materials have been detected, that is, invented and put on the market since the beginning of the nineteenth century, even in the outermost layers.

Chronological considerations are hampered by the not yet sufficiently in-depth knowledge of Islamic painting techniques, especially those applied to architectural decoration, although in recent years the results of a good number of investigations of Islamic works of art have been disclosed.

However, we underline some significant aspects of the analysis results:

- there are two layers, separated by grayish or beige chalky layers.
- The mixture of ultramarine and indigo, which appears in the oldest layers in Ṣan‘ā’, is present in Islamic artifacts between the 9th and 16th centuries. Even in Europe such blends are typical of the Middle Ages.
- The orpiment-indigo mixture, which appears in Ṣan‘ā’ in the most ancient layers, is also present in Samarra and in geographical maps of the 13th century: in Europe it is widespread from the 8th to the 16th century and then almost completely disappears. However, in the Islamic area it continues to be used until the 18th century
- *Smalt* is absent among the blues, which seems to begin to be used in painting from the 14th century both in Europe and in Islam
- Azurite was not found among the blues, but is present in the Ta‘izz Mosque, whose decoration should be from the 15th century. By consulting the results of the investigations on the polychromies of other Islamic monuments and codes, it can be seen that azurite appears later than indigo and ultramarine. In fact, it is not present on the stuccoes of Samarra, in Quṣayr ‘Amrā (Jordan) (Bianchin *et al.* 2007) in the 7th-8th century, in the *Book of Curiositie*s of the beginning of the 13th century (Chaplin *et al.*

2006): it begins to appear in the 14th century in Spain (Bueno, Florez 2004), in the dome of Soltanieh in Iran, 1302-1312 (Saffaran 2006), in the mosque of al-Aqṣā in Jerusalem, 1345-1350 (Lazzarini, Schwartzbaum 1985), in the Persian miniatures of the 16th century.

In the Madrasah al-ʻĀmiriyyah both ultramarine and azurite do not appear, substituted by indigo.

It would be appropriate further to investigate the possible presence of lead-based yellows, hypothesized in previous diagnostic campaigns on the Great Mosque. In Europe it is known that the yellows of lead and tin and lead and antimony in paint are derived from the technology of glass and ceramic coatings. We know that even in the countries of the Near and Middle East, glassy materials were colored yellow with compounds of lead, tin and antimony (Bater *et al.* 2017; Matin *et al.* 2018): however, the analyzes on the glass and ceramics of Yemeni origin available are very rare. Based on current knowledge, it is established that the "loan" from the glass-ceramic field to painting took place in Europe in the 13th century for lead and tin yellows and in the 15th century for lead and antimony ones, but we do not know when this transition took place in Yemen and in the Middle East in general (Seccaroni 2006a).

The dating proposed for the decoration of the Great Mosque are based on indirect methods based on the most precise knowledge of the history of the discovery and use of pictorial materials.

Despite the progress in studies over the last ten years, we are still unable to trace a history for Yemeni works that accounts for the beginning – discovery, arrival from abroad – and the possible end of the use of pigments and dyes.

In terms of absolute dating, investigations on the composition of lead isotopes in lead white could be hypothesized, but even here, however, we would collide with the problem that such analyzes have a precise meaning in Europe, given that we know the mines from which the producers drew in the course of the centuries, while we do not know precisely what were the sources of lead for Yemeni production.

Also the dating of the wooden beams on which the decoration is applied could be of some relative help, since we could date the supports, but not the time of application of the colors, if not for *post quem* dating.

However, we can provisionally hypothesise that the pictorial decoration object of the samples, at least in the innermost and therefore more ancient layers, may be prior to the 14th century.

We are confident that disclosing the results of the accurate investigations to which the pictorial materials have been subjected can be a first starting platform for subsequent desirable analyses.

APPENDIX

Stratigraphic cross-sections in detail

It should be noted that in each cross-section, unless otherwise indicated, the first layer consists of the wooden support.

Sample C 37) Sector N2, C35b / E3.
Repainting yellow with red underlying layer.
In the stratigraphic cross-section from the bottom (innermost layer) to the top (outermost layer) we have:
- Red layer of cinnabar (HgS);
- White-yellowish white layer in which calcite ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), HEMATITE (Fe_2O_3) and silicates have been identified. Consistent quantities of carbon-based substances have also been identified, almost certainly attributable to organic materials, probably binders of the pictorial layer.

There are no layers of preparation.

C38) Sector N2, C35b / E3.
Repainting yellow on the underlying green layer.
In the micro section from bottom to top we have:
- A green layer, obtained from a mixture of orpiment and indigo, the latter confirmed by analysis with Raman spectroscopy;
- A white-yellowish layer, similar to that present in sample C37.

There are no layers of preparation.

C39) Sector N2, T30 / fO: beam head, located inside the masonry.
Green of the original decoration.
The sample was examined in fragment form with Raman spectroscopy alone.
The following materials were detected:
- Greens obtained with a mixture of orpimento and indigo;
- Greens obtained from a mixture of goethite (iron hydroxides, attributable to the presence of ochre Yellow) and indigo;

There are also cinnabar and pararealgar particles.

C40) Sector N2, T30 / fO.
Yellow of the original decoration.
The sample was examined in fragment form with Raman spectroscopy alone.
The following materials were detected: orpiment, also confirmed by X-ray diffractometric analysis (XRD), and cinnabar.

C41) Sector N2, T30 / fO.
Orange-red of the original decoration.
The sample was examined in fragment form with Raman spectroscopy alone.
Cinnabar, orpiment and pararealgar have been identified.

C42) Sector E1, C 64c (top).
Blue layer.
The sample was analyzed in fragment form, with SEM-EDS methodologies and Raman spectroscopy:
The blue layer is made up of a rather complex mixture of indigo, lazurite or lapislazuli, ground, lead white, silicates. Cinnabar particles are also present, possibly from adjacent color zones.
There are no preparation layers.

C43) Sector E1, C65b (top).
Blue layer.
The sample was analyzed in fragment form only with SEM-EDS methodologies.
The blue layer appears to be made up of ultramarine (lapislazuli ground) which, based on the morphology and size of the particles observed at high magnification (450 X) with the electron microscope, appears to be of natural origin. Lead white is also present.
Under the blue there is a layer of blackish color, which almost certainly serves as a preparation, based on gypsum, silico-alumitaes with little presence of iron (therefore poorly colored earths) and carbon material.

C44) DF 66 (frame, under the T66 f).
Blue layer with "pinetti" decoration.
The wooden support appears light in color, different from that present in samples 42 and 43. The blue is formed by ultramarine (which appears to be natural), by an organic type of blue, probably indigo, gypsum and silico-aluminates.
No preparation layers were detected.

C46) N3T18 CO.
Blue layer.
The sampling was analyzed only in the form of a stratigraphic micro-section with SEM-EDS methodologies.
The stratigraphic structure, from bottom to top, is as follows:

- Red based on cinnabar;
- Greyish: plaster with ochre;
- Azure, based on natural ultramarine, as deduced from the morphology of the particles, with gypsum and earth.

C47) N2 C35 e.
Black, blue and red from the northwest triangle.
The sample was analysed only in the form of stratigraphic micro-section with SEM-EDS methodologies: it appears blackish on the surface, no blue parts are noted.

Stratigraphic structure:
- Cinnabar red;
- Black based on gypsum and black carbon.

C48) N2 C35d.
Black, yellow and red from the northwest triangle.
The stratigraphic structure is the following:
- Light yellow, based on orpimento with quartz particles;
- Thin and discontinuous blackish layer, based on gypsum, black carbon and earth with low iron content;
- Cinnabar red.

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وفي الأخير لا ننسى أن نكرر الدعاء بالرحمة للأستاذ عبد الكريم إسماعيل الأرحبي الذي كان وراء بدء وإنجاح هذه الحملة المشهودة من العمل.

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Managing Director
Social Fund for Development

لأول مرة إلى جانب الجهد التدريبي الذي صاحب هذه الأعمال وأوجد كادر وطني متمرس كمخرج ثانوي من أعمال المشروع.

- ثم جاءت الخطوة العملية الكبيرة والرئيسية بإختيار معهد فينيتو للتراث الثقافي في البندقية ISTITUTO VENETO PER I BENI CULTURALI الذي يُعد المعهد الأكاديمي المتخصص في أعمال التدريب وأعمال الترميم في مجالات متنوعة كترميم الأخشاب المزخرفة والزخارف الجدارية الجصية مروراً بترميم الجدران الحجرية ولقد كان إختيار هذا المعهد بناءً على تحليل العروض التي تحصلت عليها إدارة الصندوق كان عرض معهد فينيتو لتنفيذ الأعمال الترميمية مقاربةً غير ربحية وتعاوناً صادقاً حرص فيه على تخفيف التكاليف ووضعها في حدودها الفعلية ، كما حرص عرضه على نقل الخبرة الفنية عبر التدريب النظري والعملي متنوع التخصص على رأس العمل لنحو 80 متدرب ومتدربة من الكوادر اليمنية إضافةً إلى إبتعاث المتميزين منهم إلى إيطاليا خلال سنوات العمل في مجالات ترميم الأخشاب والمصندقات الخشبية الأثرية وترميم الزخارف الجصية وترميم الأحجار وغيره هؤلاء أصبحوا فيما بعد قوة العمل الرئيسية تمثلت فيهم الخبرة والكفاءة الفنية المطلوبة كأخصائيين مرممين مُعتَبَرين. وأستمر المعهد وكوادره المثابرة تحت قيادة مديره المهندس الخبير والإنسان السيد رينزو رافجنان في أداء مهامهم الإشرافية والتوجيهية العملية العظيمة والجليلة بكل إخلاص ومثابرة وحب حتى قبيل إندلاع الحرب أوائل العام 2015.

شكر:

في الأخير وبوصولنا إلى هذه المرحلة وبعد رحلتنا الطويلة في أعمال الترميم لا يمكن إلا أن نسجل شكرنا العميق لمعهد فينيتو للحفاظ على التراث الثقافي برئاسة المهندس المخضرم السيد رينزو رافجنان Renzo Ravagnan وفريقه الفني المتميز على كل الجهود التي بذلوها وعلى المهنية العالية التي نفذوا بها أنشطة الترميم المتنوعة على مدى سنوات طويلة أنقذت في المقام الأول عناصر ثقافية نفيسة مرممة بمهنية عالية وفق أفضل الممارسات الدولية المتبعة في مثل هذه النوعية من الأعمال وأنتجت ثانياً كوادر وطنية مؤهلة يمكنها مواصلة الأعمال وتنفيذ عمليات إدارة وترميم وصيانة مستقبلية إن كان للجامع الكبير بصنعاء أو لأي معلم ثقافي آخر بنفس المستوى من الأهمية والقيمة المعمارية والفنية والتاريخية.

كما لا يفوتنا تقديم الشكر للسادة المشرف العام على أعمال الترميم السيد البروفيسور رونالد ليوكوك Ronald Lewcock ورئيس فريق العمل السيد المهندس عصام عواد يرحمه الله وأيضاً الشكر موصول للسيد كريس إيدينز Christopher Edens رئيس الفريق الآثاري ومساعدته السيدة باكية إيدينز Bakiye Yukmen Edens وأيضاً نسجل شكرنا العميق للسيد إيفز إيجيلز Yves Egels وللسيد دانيال شيلستريت Daniel Schelstraete وللسيدة رافائيل هينو Raphaële Héno الخبراء

- دراسة تشخيصية لمناطق التضرر والتداعي ومسبباتها في الجامع مرافقه.
- دراسة تاريخية للوقوف على أهم المحطات التاريخية التي مر بها الجامع منذ إنشائه حتى فترة ما قبل التدخل.
- دراسة معمارية توثيقية شاملة لمبنى الجامع ومرافقه نفذتها كوادر متخصصة من قسم العمارة في جامعة صنعاء بمشاركة وإشراف أساتذة القسم وفرت مخططات هندسية دقيقة عُمِلَت لأول مرة بذلك التفصيل وبتلك الكيفية وأستفيد منها للبدء في أعمال التخطيط العلمي المنهجي لمراحل ومناطق التدخل.
- وأعقب ذلك قيام وحدة التراث الثقافي بالصندوق الاجتماعي للتنمية SFD باستقطاب بعض من أفضل الكوادر والخبرات الإستشارية الفنية الدولية والعربية والمحلية لقيادة وتنفيذ برنامج التدريب والتوثيق والترميم وتضمن ذلك:

- بمساعدة الخبيرة وأخصائية الترميم السيدة ماريلين باريت تم إختيار المعهد الوطني لعلوم الجغرافيا بباريس ENSG (Ecole Nationale des Sciences Géographiques) لتنفيذ توثيق معمارية مساحي ثلاثي الأبعاد(الفوتوجرامتري) للجامع ومحيطه بما في ذلك توثيق الأسقف الخشبية المزخرفة وكذا الزخارف والنقوش الجصية والجدارية أينما وجدت بطرق علمية ممنهجة وفق أحدث التقنيات المتوفرة في هذا المجال.
- ولغرض الإشراف العام والتخطيط والبرمجة الشاملة لبرنامج الترميم أختير الإستشاري الدولي البروفيسور رونالد ليوكوك أستاذ العمارة في جامعة كامبريدج في بريطانيا وأستاذ العمارة في المعهد التيكنولوجي في جورجيا بأمريكا وأستاذ العمارة المشرف على رسائل الماجستير والدكتوراة في برنامج الآغاخان بمعهد ماساسوسيتش للتيكنولوجيا (MIT) ببوسطن – أمريكا إضافة إلى كونه محاضراً مرموقاً في عدد من الجامعات في أستراليا وجنوب أفريقيا علاوةً على كونه مختص ترميم ومخطط حفاظ دولي وصاحب عدد من المؤلفات عن اليمن وبالأخص مدينتي شبام حضرموت وصنعاء القديمة ولعل أهم مرجع تعتز به المكتبة اليمنية هو صنعاء مدينة عربية إسلامية الذي ألفه بالتشارك مع زميله سارجنت
- إختيار المرحوم المهندس عصام عواد كرئيس لفريق العمل وهو معماري ومختص حفاظ دولي مرموق وكان المشرف على أعمال ترميم قبة الصخرة في القدس الشريف وجاء إختياره بموجب منافسة تقدم لها عدد من الإستشاريين الدوليين مثل المعماري الباكستاني مسعود خان وآخرين.
- إختيار الآثاري والخبير السيد كريس إيدينز المدير السابق للمعهد اليمني الأمريكي رئيساً للفريق الآثاري للمشروع الذي قاد أكبر وأعقد عملية توثيق أثرية نفذت في الجامع الكبير تم من خلالها الوقوف على أهم مراحل مبنى الجامع ومراحل تأسيسه وأفرزت أدلة ومعلومات قيمة تم الوقوف عليها

مشروع ترميم الجامع الكبير بصنعاء

الأهمية/ المكانة:

للجامع الكبير بصنعاء الكثير من القيم الإستثنائية العالية إن كان من المنظور الديني أو العلمي أو التاريخي أو الأثري من كونه بُنِي في العام السادس الهجري بوصف دقيق لموضعه وتحديد إتجاه قبلته بأمر وإرشاد مباشر من النبي محمد عليه الصلاة والسلام ما يعني أنه يُعَدُ من أقدم وأوائل المساجد في الإسلام ولعله الوحيد الذي ما زال يحتفظ بالكثير من خصائصه وعناصره الأصلية عبر القرون وهو كذلك يحتل أهمية كبيرة على المستويين العربي والإسلامي وعلى المستوى الإنساني عموماً, وإن كان من ناحية ما يتمتع به الجامع الكبير أيضاً من قيم أثرية وفنية ومعمارية إستثنائية على إعتبار أنه يُعدُ أحد أهم المواقع الأثرية في مدينة صنعاء القديمة وأحد المكونات التاريخية للمدينة إن كان من حيث وضعه الحفاظي الحالي أو من حيث موقعه التاريخي الذي بُني عليه.

إن هذه القيمة الأثرية والفنية العالية كانت مع نهاية القرن الماضي على وشك الإطاحة بها فيما لو نفذت عملية التوسيع والتجديد الشاملة التي كانت بصدد التنفيذ وهي كانت عملية لا تراعي أسس الحفاظ المتعارف عليها دولياً لا من قريب ولا من بعيد. وهذا بحد ذاته كان أخطر وأضر على الجامع من التدهور الطبيعي بسبب عامل الزمن والمؤثرات الطبيعية.

وهنا قامت إدارة الصندوق الاجتماعي للتنمية ممثلةً بمديره السابق المرحوم الأستاذ عبد الكريم إسماعيل الأرحبي بخطوة مبادرة حاسمة أنقذت الجامع من ذلك الخطر الماحق وتمثل ذلك في إقناع قيادة البلد بإيقاف ذلك التدخل وإطلاق عملية ترميم واعية وحساسة تحترم مكانة الجامع وما يختزنه مبناه من القيم الجمالية والأثرية وتتبع أعلى معايير الحفاظ التي تليق بمكانة هذا المعلم الإستثنائي وتلا ذلك إقناع الصندوق العربي للإنماء الإقتصادي والإجتماعي بتمويل عملية الترميم، وقَبِلَ الصندوق العربي ممثلاً بمديره العام السابق ورئيس مجلس إدارته السيد عبد اللطيف يوسف الحمد تمويل برنامج الترميم بعدد من المنح طالباً حصر شرف تمويل هذا البرنامج في للصندوق العربي وهو ما تم بالفعل.

ثم بدأت الخطوات العملية باستصدار القرار الجمهوري رقم (354) لسنة 2001م بتكوين مجلس أمناء الجامع الكبير للإشراف العام وضمان إستقلالية برنامج الترميم إدارياً ومؤسسياً، وكانت هذه ضرورة لتفادي تداخل الصلاحيات بين عدة جهات متشابكة الاختصاصات وتعوزها القدرة الفنية والإدارية اللازمة.بالتوازي مع ذلك بادرت وحدة التراث الثقافي من خلال إستشاريين محليين متخصصين تنفيذ عدة دراسات كان أبرزها:

الجامع الكبير بصنعاء

مشروع الترميم (٢٠٠٥ – ٢٠١٥)

مشروع ترميم الجامع الكبير بصنعاء

اهداء إلى الشعب اليمني

الجامع الكبير بصنعاء

مشروع الترميم (٢٠٠٥ – ٢٠١٥)