A METHODOLOGY FOR STUDYING MUQARNAS: THE EXTANT EXAMPLES IN PALERMO

The muqarnas (a system of projecting niches used for zones of transition and for architectural decoration) is one of the key motifs of Islamic art. The use of these decorative elements has not influenced other cultures a great deal, with a few exceptions. The muqarnases still present in Palermo are a rare case of non-Islamic manifestations of the form; to be exact, they were built by Islamic craftsmen, but commissioned by the Normans.

What follows is a detailed analysis of the muqarnases found at the Zisa of Palermo, a palace commissioned in 1164 by Guglielmo I d’Altavilla (r. 1154–66), who intended to use it as a sollatium, a place of delight and summer repose (fig. 1). Beginning with an examination of the muqarnas in the central niche of the iwan—a tri-lobed hall with a fountain located on the ground floor of the Zisa—this paper provides a methodology for analyzing the composition of this decorative motif, which is made up of simple elements, although at first sight they appear to be very complex (fig. 2). The muqarnases of the Zisa are here analyzed with respect to their basic components and registers, and compared with similar elements belonging to the Eastern and Western Islamic traditions (see Appendix, which also contains a glossary of relevant terms). The aim of this work is to find the key to identifying the place of origin of the artisans who crafted the muqarnases of the Zisa, although the results are not expected to provide definitive answers to the question.

The muqarnas is a three-dimensional composition created by assembling, in a variety of combinations, simple prismatic elements, comparable to portions of vaults and composed according to precise rules, in overlapping corbelled levels. The disposition of such elements, as well as their size and form, can vary according to geographical location, the historical period to which they belong, the part of the building to which they are applied, and the materials used to build them. The dimensions of the elements can range from just a few centimeters, as in the case of the Moroccan muqarnas, to meters, as in the Iranian Friday Mosque of Isfahan. The size depends not only on the building materials—much larger muqarnases can be created from stone than from wood, the latter ones measuring as little as five to ten centimeters—but also on the period of construction. Sometimes an element is present at different scales in the same composition.

The materials employed for the construction of the muqarnas vary according to the region of the Islamic world under consideration. In Syria, Egypt, and Turkey, muqarnases are made of stone, the predominant local building material, which requires great precision of execution. In North Africa, the muqarnas is made of plaster and wood. In Iran and Iraq, they are made of bricks, sometimes covered with plaster or ceramic. While orthogonal geometry is required to generate a muqarnas from brick, plaster gives greater freedom of composition because it allows for a way to cope with angles that may not necessarily be 45° or 90°. Furthermore, it lends itself to solving difficult junctions and to constructing special details. Muqarnases can be found on vaults, domes, pendentives, cornices, corbels, capitals, and generally anywhere it is necessary to connect two vertical, non-coplanar surfaces, or to solve, as in the case of the dome, the transition between a square and a circle through the fragmentation of the pendentive.

The etymology of the Arabic term muqarnas has not yet been established. In medieval Arabic dictionaries, the word has no architectural meaning. According to Yasser Tabbaa, it appeared for the first time in the twelfth
Several scholars agree that it comes from the Greek word *korōnís*, meaning “cornice,” although, as Tabbaa says, this origin “is not confirmed in any Arabic or Persian source.”

The chronological and geographical origins of the muqarnas are not yet certain. Some scholars date the muqarnas to the end of the eighth century in Syria, others to the ninth century in Iran, still others to the eleventh century in North Africa or Baghdad. What is certain, however, is that by the twelfth century the muqarnas had become a common characteristic in the decorative arts of all territories of the Islamic world, and that different local decorative traditions favored the development of regional variations. Among the oldest examples of muqarnas in the Western world, Fernández-Puertas includes those present in Palermo—on the ceiling of the Cappella Palatina, commissioned by Roger II (d. 1154), and in the Zisa and the Cuba, a palace built in 1180 by Guglielmo II d’Altavilla.

According to one of the most reliable theories, the functional origin of the muqarnas goes back to the corner tripartite squinch, which was used for the first time in domes in Iran in the tenth century to enable the smooth transition from the square base of the walls to the circular dome. Écochard argued that the structure of these early corner squinches anticipated what would later become the muqarnas. The matter of the link between two different forms had already been resolved in Roman architecture through the use of the pendentive. According to Hautecoeur, it was in the Maghreb that the cells that constitute the muqarnas were first detached from the wall, thus abandoning the shape of bas-reliefs, to hang in isolation similar to stalactites. Already in the al-Qarawiyyin Mosque of Fez (expanded to its present size by the Almoravid Sultan ‘Ali bin Yusuf between 1134 and 1143) and in the Tlemcen Mosque (1136) in northwestern Algeria, we see that domes supported by squinches were replaced by a ceiling generated by the combination of overlapping elements similar to squinches and to other portions of vaults.

**THE MUQARNASES OF THE ZISA**

The muqarnases found in Sicily are all in Palermo and primarily in the Zisa. The best-known examples are

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*Fig. 1. The Zisa of Palermo. (Photo: Vincenza Garofalo)*

*Fig. 2. The muqarnas of the central niche of the iwan in the Zisa, Palermo. (Photo: Vincenza Garofalo)*
located in three niches of the iwan, but there are interesting muqarnases on all three levels of the building and in various rooms, all with different configurations (fig. 3). Similar ones are located symmetrically in relation to the transverse axis of the building. They decorate the vaults of niches and the crowning of the windows.

The muqarnas of the central niche of the iwan in the Zisa is a stone composition, founded upon a rectangular geometric plan. According to Écochard, as with the brick muqarnas originally used in Mesopotamia and Iran, the construction of this muqarnas required the use of orthogonal geometry.19 It consists of twelve overlapping corbelled registers, formed by joining elements of the same height (30–40 cm). The niche measures 4.16 x 2.08 x 5.53 meters and the first register is 5.86 meters above ground. From a constructive point of view, each register is created by the superimposition of two rows of sandstone ashlar blocks.20 Unlike other stone examples such as those found in Syria, the Zisa muqarnas has no sharp corners. It was originally covered with plaster, which was removed in 1940 during a restoration campaign because it was wrongly believed to be of a later date than that of the original construction of the muqarnas. On the contrary, the plaster had been used to give a finer definition to details otherwise not attainable with the local porous sandstone. Direct observation, through some of the gaps, leads me to suppose that these muqarnas cells have no structural function; in fact, they have a thin profile, like shells. According to Lucien Golvin and Yasser Tabbaa, they were carved out after the construction of the wall.21 In each corner of the niche, the individual units of the muqarnas are based on horizontal projecting stone slates rotated at an angle of 45°, as is clearly visible in the right-hand corner between registers 3 and 4, and between registers 6 and 7 (fig. 4).

The Zisa muqarnas has eight basic elements—six with rectangular and triangular plans (fig. 5a–c), elements A, D, E, F, G, H), as well as one formed from the dissection of a basic element with a vertical plane (fig. 5a, element B), and one from the combination of two similar elements (fig. 5a, element C).22 The elements are derived from prisms. One prism (element A) has a square plan whose sides are equal to 1. Two prisms with rectangular plans (elements B and C) are portions of another prism with a square plan whose sides are equal to 1. Four prisms (elements D, E, F, and H) have isosceles triangular plans with summit angles of 90°; in each one, two sides of the triangle are equal to 1, while the third side is equal to $\sqrt{2}$. One prism (element G) has an isosceles triangular plan with a summit angle of 45°, two sides equal to 1, and the third side equal to 0.766.

In this study, these basic units were compared with the corresponding units of the Eastern and Western Islamic traditions (figs. 6a–c and 7; also see the Appendix, which, as mentioned above, contains the detailed analysis of the Eastern and Western elements and a glossary of the terms used below).

**Prismatic elements with a rectangular plan**

*Element A*, corresponding to the *t’stiya masdùda* of the Eastern Islamic tradition, or to the first type of *conça*, here referred to as *conça (1)*, of the Western Islamic tradition, is obtained by subtracting a barrel vault from a prism with a square plan, thus creating a half-barrel vault. The element has a rectangular supporting base (fig. 5a).

*Element B*, corresponding to the *t’stiya masdùda* of the Eastern Islamic tradition, or to the *conça (1)* of the Western Islamic tradition, is obtained by cutting element A with a vertical plane parallel to its side faces. It has a rectangular supporting base and its height can be equal to that of two registers (fig. 5a).

*Element C*, corresponding to the *t’stiya masdùda* of the Eastern Islamic tradition, or to the *conça (1)* of the Western Islamic tradition, is obtained by putting together the main faces of either two element As or two element Bs, respectively. The element has two rectangular supporting bases (fig. 5a).

**Prismatic elements with a triangular plan**

*Element D*, corresponding to the *sirwāliyya* of the Eastern Islamic tradition, or to the *atcia* of the Western Islamic tradition, is obtained by subtracting an inclined barrel vault from a right-angled triangular prism. The generatrix of the barrel vault is perpendicular to the hypotenuse of the triangular base. The element has two triangular supporting bases (fig. 5b).
Fig. 3. Location of the muqarnases on the three levels of the Zisa, Palermo. Analysis based on an ideal reconstruction of the plans of the Zisa. (Redrawn from Giuseppe Bellafiore, *La Zisa di Palermo* [Palermo, 2001], tables A, B, and C)
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Element E, corresponding to the *sirwāliyya sha'ira* of the Eastern Islamic tradition, or to the *medio cuadrado* of the Western Islamic tradition, is similar to a squinch. It is generated by subtracting from a prism with a right-angled triangular plan a Roman cross vault with a raised keystone and a square base. The element has two triangular supporting bases on the same level and a rectangular one placed at a lower level than the first two (fig. 5b).

Element F, corresponding to the *medio cuadrado abierto por lo más ancho* (2) of the Western Islamic tradition, is similar to the triangular portion of a cross vault with a square supporting base. It is generated by subtracting from a prism with a right-angled triangular plan a Roman cross vault with a raised keystone and a square base (fig. 5b).

Element G, corresponding to the *lūza* (2) of the Eastern Islamic tradition, or to the *dumbaque grullillo* of the Western Islamic tradition (see Appendix), is obtained by subtracting an inclined barrel vault from a prism with an isosceles triangular plan with a summit angle of 45°. The element has a triangular supporting base (fig. 5c).

Element H, is similar to a squinch or a niche with a curved section. It is generated by subtracting from a prism with a right-angled triangular plan, a hemispherical dome on a cylindrical tambour. Element H has a right-angled triangle supporting base from which a half circle has been subtracted. The element has no equivalent among those described in the Appendix belonging to the Eastern and Western Islamic traditions (fig. 5c). It seems plausible, however, to hypothesize a comparison with element A3 (our fig. 8) in Owen Jones’s study.

Fig. 4. The stone muqarnas of the central niche of the iwan in the Zisa, Palermo. Left) The virtual model. Right) A photograph of the right-hand corner, with registers 3 and 4, and 6 and 7 highlighted in lavender. (Drawing and photo: Vincenza Garofalo)
on the muqarnas vaults of the Alhambra in Granada, although in his two-dimensional diagrams it is not easy to understand the three-dimensional development of that element.\(^{24}\)

Comparing the prismatic elements of the central niche of the iwan of the Zisa with the analogous base elements deduced from the analysis of the Islamic Western and Eastern traditions (see Appendix), we can infer that the units of the Zisa resemble more closely the Western Islamic elements (figs. 6 and 7). This leads me to assert that the artisans who crafted the work originated in the Islamic West (i.e., North Africa). Such a thesis is also confirmed by the fact that some examples of muqarnas in the Zisa (fig. 9) have hanging elements that, according to Al-Asad, are typical of the Islamic West.\(^{25}\) Some muqarnases of the Zisa also feature an octagonal motif that has an eight-pointed star and an eight-petalled flower inside. This kind of pattern is recurrent in Moroccan muqarnases, as well as in Spanish ones, as we can see in the ceilings of the al-Qarawiyyin Mosque in Fez, work on which began in 1134, and in the vault of the monastery of Las Huelgas, near Burgos in Spain, dated 1187 (fig. 10).
THE PLAN OF THE MUQARNAS OF THE CENTRAL NICHE OF THE IWAN IN THE ZISA

To build a muqarnas, two-dimensional patterns are usually used as guides. These patterns are based on a limited number of geometric shapes, produced by joining together specific points that lie along the lines of construction of the patterns themselves. These basic forms, created through repetitions, rotations, and by mirroring, correspond, in plan, to the constitutive prismatic elements of the muqarnas. In these layouts, the spatial conception of the muqarnas depends on the corbelling contours of the levels.

From an analysis of the earliest known drawings of muqarnas, it is evident that the profiles and sections of the muqarnas were not usually drawn, because it was sufficient to relate the height and depth of the units proportionally, as the Timurid mathematician and astronomer Ghiyath al-Din Jamshid ibn Mas’ud al-Kashi explained in 1427 in his treatise Miftāḥ al-ḥisāb (Key to Arithmetic) (see Appendix).

The patterns were often drawn on a square grid; this served a dual function: it helped craftsmen to enlarge the drawings to full scale on site and to compute the amount of required building materials. The scheme could be changed in size but not in terms of the relationship between the individual parts. To build the muqarnas, it was sufficient to enlarge the grid to scale and prepare and assemble all the components. In the patterns known to us, there are sometimes units coded with colors or dots to distinguish the different registers. This codification provides some guidance regarding the
structure of the three-dimensional composition, but it is not enough to give a correct, three-dimensional interpretation of the plan. In fact, if we consider the number of elements that can originate from the same geometrical shape, it is evident that there was never just one version possible. In the medieval period, the process of converting patterns into three-dimensional compositions was a secret closely guarded by craftsmen and known only to members of the guilds.28

The patterns that underlie the construction of a muqarnas can be grouped into a few basic types: patterns with an orthogonal symmetry, based on a grid of intersecting lines that form angles of 45°, 90°, and 135°, which generate shapes by combining, rotating, or mirroring squares, triangles, and other basic geometric figures; patterns with a central symmetry generated by the rotation of a polygon within a circle;29 and patterns with a radial symmetry, whose basic grid consists of concentric circles, divided into equal arches by equidistant radiuses. In this last case, the registers, usually composed of a combination of polygons, can also include stars, inscribed in concentric circles.

Heterogeneous patterns are often formed from combinations of these basic systems. The development and increasing complexity of the patterns show the evolution of the compositions of the muqarnas.

The plan of the muqarnas of the central niche of the iwan in the Zisa has a rectangular pattern whose width is twice its depth (fig. 11). The composition is strictly geometric and is based on an orthogonal grid in which the profiles of the registers are generated through the rotation of several squares, at 45° angles (fig. 12). The centers of such rotations coincide with some points of intersection of the lines forming the basic grid. The plan is symmetrical with respect to the cross axis, the corners, and a horizontal line placed approximately one-third from the bottom of the pattern. Square, triangular, and diamond shapes are the constituent elements. This pattern is among the simplest in Palermo. However, its three-dimensional composition appears complex because each register, except for the top two, is formed by assembling several different components and a variety of combinations among the basic elements (figs. 13[a–c] and 14).30 This type of composition rarely appears in the Eastern Islamic world, where

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<tr>
<th>ELEMENT G</th>
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Fig. 5c.
the muqarnas is usually created through the repetition of the same element on an entire level and often on subsequent levels, too.

Comparing the muqarnases of the Zisa with other extant examples in the Islamic world is not an easy task because over the centuries muqarnas structures have been modified, rebuilt, and in some cases completely covered by other structures. From a careful observation of a side niche, it is clear that the muqarnases of the iwan of the Zisa have also undergone changes that can probably be ascribed to reconsiderations during the construction stage or to works done later on the iwan (fig. 15). The elements of which the muqarnas of the central niche of the iwan of the Zisa is composed show evident similarities with those of the al-Qarawiyyin Mosque in Fez,31 which, as mentioned above, was built in 1134 (about twenty years before the Zisa), as well as with those of the Great Mosque of Tinmal in Morocco, built by the Almohad sovereign ‘Abd al-Mu’min in 1153.32 However, the composition of the elements is different on the whole, as was the construction technique used to build them.

OTHER EXAMPLES OF MUQARNAS IN PALERMO

Near the Zisa is the Santissima Trinità Chapel, which once belonged to the palace itself.33 On the short sides of the rectangular span of the presbytery are two symmetrical cornices with muqarnases that bring the dimensions of the bay to a square configuration on which stands the dome (fig. 16). They are generated by the triple repetition of a composition of elements that jut out gradually and are arranged in three registers, ending with three squinches. The similarity with other compositions present at the Zisa is quite evident, although in this building the muqarnases have a different function—to support the dome.

The most ancient example of a muqarnas in Palermo, datable to around 1131, is represented by the richly painted wooden ceiling of the nave of the Cappella Palatina, situated in the Palazzo Reale (fig. 17). The chapel, which was commissioned by Roger II, has a nave and two side aisles. The nave is covered by a large muqarnas wooden ceiling (fig. 18), whose plan, according to Écochard,34 looks very similar to that of the ceiling of the al-Qarawiyyin Mosque in Fez. The muqarnases are arranged in five registers along the perimeter of the ceiling of the nave. They hold and support three rows—one on each side of the ceiling, along with one in the middle—each containing eleven centric elements disposed lengthwise (small octagonal pavilion vaults and domes inscribed in eight-pointed stars in the two rows along the perimeter, with square elements in the central row), along with two sets of ten eight-pointed stars containing flowers with eight petals (a motif already found at the Zisa). At the vertices of the large octagons that contain the eight-pointed stars there are hanging elements similar to those of the Zisa. The wooden structure, which appears quite poor in quality on the extrados, is made up of wooden lists arranged with great skill and held together with fiber-wood bandages and animal glue.35 This structure was originally self-bearing, but, due to past restoration works, at some points the load now rests on a system of girders with the help of wooden tie-beams. On the intrados, however, the ceiling is richly decorated36 with paintings depicting court life.37 Another example of a muqarnas in the Palazzo Reale is located in the Torre Pisana (fig. 19), where there is a niche in a secondary room with muqarnases quite similar to those of the Zisa, although they appear to have been modified during restoration.

There are other monuments in Palermo from the Norman period that still bear examples or traces of muqarnases, namely, the Cuba, the Cathedral,38 the Castle of Favara in Maredolce,39 and the Scibene Palace (probably twelfth century).40

In the Cuba, there are just a few fragments of a muqarnas left on the southern wall of the hall (fig. 20). It seems to have been plastered and elegantly decorated with motifs resembling woven ribbons. Compared with those of the Zisa, the muqarnas in the Cuba appears more richly chiselled but not as old.41 The few remaining traces do not allow us to fully understand the general development of this refined and unique example of the muqarnas in Palermo. In fact, the only parts of the muqarnas still visible are the lower registers, which have in the right-hand corner a four-level squinch.
Fig. 6a. Corresponding elements of the Eastern Islamic tradition, the Western Islamic tradition, and the Zisa. In each case, the elements are drawn as orthogonal and axonometric projections, accompanied by the description of the planimetric proportions. (Drawings: Vincenza Garofalo)
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<td>Medio cuadrado abierto</td>
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Fig. 6b.
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*Fig. 6c.*

_Lūza (2) Dumbaque grullillo Element G*
Fig. 7. From top to bottom: The geometric genesis of the prismatic elements sirwāliyya shā’īra of the Eastern Islamic tradition, medio cuadrado of the Western Islamic tradition, and the analogous element (E) of the Zisa. (Drawing: Vincenza Garofalo)

Fig. 8. Simple elements of the muqarnas and its composition in five registers. (After Owen Jones, Plans, Elevations, Sections and Details of the Alhambra, 2 vols. [London, 1842], 1: pl. X)

Fig. 9. Stone muqarnas with hanging elements (stalactites) (circled in red), in niche I (see fig. 3) at the Zisa, Palermo. (Photo: Vincenza Garofalo)
In the Castle of Favara in Maredolce, in a room next to the chapel, there are only faint traces of the muqarnas once present there. The ruins of the Scibene Palace reveal a hall similar to an iwan, with a central niche decorated with muqarnas vaults, of which, again, few traces remain.

The latest examples of muqarnas—datable to 1184–85, according to Bellafiore—are in the Cathedral of Palermo. In a niche in the southern apsidal tower is a small vault, covered with plaster, similar to one at the Zisa (fig. 21). It consists of four registers of overlapping corbelled elements culminating in a floral motif that is contained in an eight-pointed star. In the external gallery of the southwestern tower are stone muqarnases generated by the repetition of five groups of elements (fig. 22). These compositions appear as bas-reliefs in the lower part of the structure and they gradually jut out. Like the muqarnas of the apsidal tower, they also culminate with the well-known motif of the eight-pointed star containing a flower with eight petals.

In the course of this research, all the muqarnases of Palermo were organized in a table and catalogued.
Fig. 12. Geometric analysis of the twelve registers of the muqarnas of the central niche of the iwan in the Zisa, Palermo. The left half of each drawing shows simultaneously the upper and lower faces of the registers; the supporting bases are blackened. The right half of each drawing shows, on the other hand, the simplified profile of the register, in which each element is a square, a triangle, or a rhombus. (Drawing: Vincenza Garofalo)
Plan 6, based on a rectangular scheme whose width is double its depth, is a further development of plans 4 and 5. In both the top right- and the top left-hand corner of the composition, we find an octagonal shape containing an eight-pointed star and an eight-petalled flower. In the center of the composition, the octagonal shape is inscribed in a rectangle. Examples of this type of plan are found at the Zisa, in the side niches of the iwan (fig. 24b).

Plan 7, based on a rectangular scheme whose depth is equal to three-quarters of its width, shows a composition generated by the rotation of a large square within an orthogonal grid, at a 45° angle. Inside this figure, there are other square shapes that, when rotated, produce various octagons and generate a star with eight points and a circle in the center of the composition. In the top right- and left-hand corners, octagons circumscribe eight-pointed stars. Two examples of this plan are present in the Zisa (fig. 24b).

Plan 8, based on an elongated rectangular scheme, is formed by a rigid grid of orthogonal lines whose points of intersection are the centers of rotation of the squares that generate the octagonal shapes containing the motif of the eight-pointed star and the eight-petalled flower. The ceiling of the Cappella Palatina in the Palazzo Reale belongs to this type (fig. 24b).

Islamic Examples? Some Open-Ended Questions

In conclusion, it is important to point out that my hypothesis regarding the origin of the workers who built the muqarnases of the Zisa can be based only on the extant evidence. It is quite likely that the key elements required to reach a definitive conclusion have completely disappeared. It is not easy to presume a direct derivation from known Islamic examples, both because Islamic influences in Sicily could have been introduced by craftsmen coming from various places of origin and because the territories included under Islamic rule are farflung, and have not yet been fully analyzed from an architectural point of view, making it difficult to carry out an exhaustive comparison.
Fig. 13a. The location of each element in the different registers of the central niche of the iwan in the Zisa, Palermo. (Drawing: Vincenza Garofalo)
Fig. 13b. Virtual model of the central niche of the iwan at the Zisa in Palermo, showing the location of the elements in the different registers. (Drawing: Vincenza Garofalo)
Fig. 13c. Plan of the central niche of the iwan at the Zisa in Palermo, showing the location of the elements in the different registers simultaneously. (Drawing: Vincenza Garofalo)
A clear origin for the examples of Islamic art found in Sicily has not yet been established, and the studies conducted so far have neither proved the existence of nor uncovered architecture built with certainty during Arab rule. A resemblance to one or more similar Islamic structures is not enough to assert a direct relationship. According to Marçais, there is a strong analogy between the plan of the Zisa in Palermo and those of some buildings in the Berber Qal'a Bani Hammad, the first capital of the Hammadid emirs (founded by Hammam ibn Buluqqin in 1007), in Algeria. As far as the muqarnas is concerned, Marçais finds a great similarity between those of the Zisa and the ones in the North African Tlemcen Mosque. According to Golvin, however, the fragments of plaster found among the ruins of the Qasr al-Salam and the Qasr al-Manar at Qal'a Bani Hammad are comparable to muqarnas. They are similar to the extant examples of Palermo, particularly the muqarnas in the Cappella Palatina, while the muqarnases of the Zisa are undoubtedly more laborious and articulate. Furthermore, for Golvin, Norman art in Sicily was strongly influenced by Fatimid-Zirid art, even though it is not yet clear whether its geographical origin was the central Maghreb or Ifriqiya. Hoag found that Sicilian architecture was more similar to the Zirid architectures of Asir and Qal'a Bani Hammad than to that of Fatimid Egypt. Such a thesis is partially confirmed by Jonathan Bloom, who asserts that the muqarnas vaults used in Sicily and North Africa in the twelfth century appear in Egypt only in the middle of the fourteenth century. According to Michel Écochard, muqarnases were built contemporaneously in Fez and in Palermo, with the same geometric technique: see the stone muqarnas in the Zisa and the wooden ceiling of
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Fig. 16. Cornice with muqarnas in the Santissima Trinità Chapel in Palermo. (Photo: Vincenza Garofalo)

Fig. 17. Left) Muqarnas cornices supporting the painted wooden ceiling of the nave of the Cappella Palatina in the Palazzo Reale, Palermo. (Photo: courtesy of Fabrizio Agnello)
Right) Virtual model of a portion of the wooden ceiling. (Drawing: Vincenza Garofalo)
Fig. 18. The painted wooden ceiling of the nave of the Cappella Palatina in the Palazzo Reale, Palermo. (After Roberto Calandra, Alessandro La Manna, and Vincenzo Scuderi, eds., *Palazzo dei Normanni* [Palermo, 1991], 105)

Fig. 19. The seven registers of the muqarnas of the Torre Pisana in the Palazzo Reale, Palermo. (After Calandra, La Manna, and Scuderi, eds., *Palazzo dei Normanni*, 193)
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Fig. 20. Remaining fragments of the muqarnas on the southern wall of the hall at the Cuba, Palermo. (Photo: Vincenza Garofalo)

Fig. 21. Niche in the southern apsidal tower of the Cathedral of Palermo. (Photo: Vincenza Garofalo)

Fig. 22. The stone muqarnas in the external gallery of the southwestern tower of the Cathedral of Palermo. (Photo: Vincenza Garofalo)
Fig. 23. Classification of the muqarnases of Palermo according to type of plan and the monuments to which they belong. (Drawing: Vincenza Garofalo)
Fig. 24a.

Figs. 24 a and b. Patterns of muqarnases in Palermo. Detailed analysis of an example for each type of plan identified in fig. 23. Left column) The chosen examples. (Photos: Vincenza Garofalo, except the last, which is taken from Calandra, La Manna, and Scuderi, eds., Palazzo dei Normanni, 105)

Right column) Schematic analysis of each plan. Each succeeding register is identified by a deeper shade of gray. The right side of each plan is simplified into squares, triangles, and lozenges, while the left side shows the supporting bases of the simple elements. When viewed vertically, the sequence shows an evolution from a simpler to a more complex type of plan. (Drawings: Vincenza Garofalo)
Fig. 24b.
the Cappella Palatina. The same complex technique was reproduced a few years later in the main portal of the māristān (hospital) of Nur al-Din in Damascus. As Yasser Tabbaa has argued, these muqarnas examples in Damascus are based on Iraqi models from Baghdad. This leads me to assume that there were personal contacts between craftsmen.53

Eugenio Galdieri has raised an important issue that leaves all the possibilities open to further studies, surveys, and excavations in Sicily: he wonders how it could be that after 264 years of Islamic domination there was no trace of building activity carried out during that period. He asks if it might be possible that the Normans, although they tolerated and valued Muslim culture and accepted their lifestyle, destroyed everything, only to rebuild soon after, using the same style and craftsmen. What is certain is that the Arabic legacy in Sicily is still evident today in, for example, the words and phonemes of the dialect, the irrigation systems used in citrus plantation, the cuisine, and the songs of the carters, so similar to those of the Tunisian camel-drivers.

One also has to question whether there existed earlier North African muqarnas examples from the Aghlabid period (800–909), a dynasty that also ruled Sicily and was the vassal of the Abbasid court in Baghdad.55 While these questions remain open to conjecture, this essay has shown that the muqarnas examples analyzed here share a similar geometry with North African models.

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APPENDIX

The elements that constitute the muqarnas are comparable to small portions of vaults, although they have no structural function. Their shape can vary according to the geographic area to which they belong. Therefore, it is possible to distinguish the elements typical of the muqarnas in the Central and Eastern regions of the Islamic world from those typical of the medieval Western Islamic version, traditionally known as the muqarnas (fig. 25[a–d]; figs. 25–30 are grouped together after the glossary).56

THE ELEMENTS OF THE MUQARNAS IN THE EASTERN ISLAMIC TRADITION

The faces of the prismatic elements that make up the muqarnas of the Eastern tradition show a broken profile, which Pauty57 calls “Persian,” made by cutting the base prism with a section that Fernández-Puertas calls the consa.58 The geometric construction of this profile (fig. 26) can be compared with the one described in great detail by Ghiyath al-Din ibn Mas'ud al-Kashi in his treatise Key to Arithmetic.59 The prismatic elements that comprise the muqarnas of the Eastern tradition can have a rectangular, triangular, or rhomboidal base (fig. 27[a and b]). In the rectangular plans, the shorter side is equal to 1 and the longer side is equal to $\sqrt{2}$. The isosceles triangular plans have summit angles of 45° and 90°, respectively; the two like sides are in each case equal to 1, while the third side is equal to 0.766 and $\sqrt{2}$, respectively.

In the following analysis, reference has been made to the guidelines provided by al-Kashi60 for the purpose of drawing the broken profiles of the solids that constitute the basic elements of the muqarnas (fig. 26). The selected elements and their names are deduced from the studies of Paccard and Castéra (see note 27 below). The elements are drawn by subtracting from prisms either barrel vaults or cross vaults of pointed section, obtained by the extrusion of a mixtilinear profile (i.e., one consisting of straight lines and a curve) (fig. 27[a and b]).

Prismatic elements with a rectangular plan

The t’stiya masdiūda is similar to a rectangular portion of a barrel vault formed by the extrusion of a mixtilinear profile with a rectangular supporting base (fig. 27a). It is also generated by subtracting a vault from a prism with a rectangular plan. The generatrix of the vault is oriented in the same direction as the major sides of the rectangular base and the directrix has the mixtilinear profile described by al-Kashi.

The t’stiya maftūha is formed by subtracting a barrel vault, obtained by the extrusion of a mixtilinear profile, from a t’stiya masdiūda (fig. 27a). The generatrix of the vault is perpendicular to the major sides of the rectangular base and the directrix has the mixtilinear...
Prismatic elements with a triangular plan

The danbūq is obtained by subtracting a vault from a prism with a right-angled triangular plan (fig. 27a). The generatrix of the vault is oriented in the same direction as the hypotenuse of the triangular base and the directrix has the mixtilinear profile described by al-Kashi. The element can also be generated by cutting the t’stiya masdūda with three vertical planes. It has a triangular supporting base and is similar to a triangular portion of a barrel vault.

The sirwāliyya, also known as the būja, is obtained by subtracting a vault from a prism with a right-angled triangular plan (fig. 27a). The generatrix of the vault is perpendicular to the hypotenuse of the triangular base and the directrix has the mixtilinear profile described by al-Kashi. The element can also be generated by cutting the t’stiya masdūda with two vertical planes. It has two triangular supporting bases and can also be regarded as the union of two halves of the danbūq.

The sirwāliyya sha’ira (for stucco workers), or the sha’ira (for painters), is used for the corner elements. It is formed by subtracting a cross vault with a square base from a prism with right-angled triangular plan (fig. 27a). It resembles a squinch. The element, which can also be obtained through the union of two sirwāliyyas, has two triangular supporting bases on the same level and a rectangular base placed at a lower level than the first two.

The first type of lūza, here called lūza (1), is generated by subtracting a vault from a prism with an isosceles triangular plan (fig. 27b). The generatrix of the vault is oriented in the same direction as the base of the triangular plan and the directrix has the mixtilinear profile described by al-Kashi. The element can also be generated by cutting the t’stiya masdūda with three vertical planes. It is similar to a triangular portion of a barrel vault with a trapezoidal supporting base. The lūza (2) is generated by subtracting a vault from an isosceles triangle prism (rotated 180° as compared with the previous version) (fig. 27b). In this case as well, the generatrix of the vault is oriented in the same direction as the base of the triangular plan and the directrix has the mixtilinear profile described by al-Kashi. It is similar to a triangular portion of a barrel vault with a triangular supporting base.

The lūza (3) is similar to a triangular portion of a barrel vault with a triangular supporting base (fig. 27b). It is generated by subtracting a vault from a prism with an almond-shaped plan that has two opposite angles of 90°, while the other two angles are, respectively, 45° and 135°. The element can also be generated by cutting the t’stiya masdūda with four vertical planes. According to Paccard, it is used only for the circular dome (tassa) or for the crowning of a central dome (shāshiyya).

The katif is obtained by uniting two different triangular-based lūza-elements (i.e., lūzas [1] and [2]) with a prism with an isosceles triangular plan that has a 45° summit angle (fig. 27b). The element has a triangular supporting base.

The shi’ār is generated by subtracting two pointed barrel vaults from a prism with a rhomboidal plan (fig. 27b). The element has two triangular supporting bases on the same level and a rhomboidal one placed at a lower level than the first two.

THE ELEMENTS OF THE MUQARBAS IN THE WESTERN ISLAMIC TRADITION

The term muqarbas refers to the architectural technique typical of the medieval Islamic West that is the equivalent of the muqarnas in the Central and Eastern regions of the Islamic world. The word muqarbas may derive from the Greek term krēpis, which means “base.” In Spanish, the word evolved into mocárabe, and may also be related to the Arabic mokrab (solid, firm, bound). Under the entry for mukarbas in the Encyclopédie de l’Islam, it is stated that the mocárabe is derived from
one of four prisms (jairas), one of which has a rectangular plan whose shorter side is equal to 1, while the longer side is equal to $\sqrt{2}$. The other three prisms have an isosceles triangle base with summit angles of 45°, 90°, and 135°, respectively; the two like sides of each prism are equal to 1, while the third side is equal to 0.766, $\sqrt{2}$, and 1.848, respectively.

The faces of the prismatic elements that comprise the *muqarbas* of the Western tradition, which Fernández-Puertas calls *adarajas*, are made by cutting the basic prism with a profile, known as a *guillillo*, that derives from a quarter of a cylinder (fig. 28). The *guillillo* is created by drawing on the face of a *jaira* a quarter of a circle with a radius equal to six-sevenths of the width of the *jaira*. The last seventh of the remaining thickness is called the *patilla* (small base) and is the supporting base of the *adaraja*. Fernández-Puertas lists seven primary *adarajas* and seven secondary ones. The elements of the Western Islamic tradition are also described as *mocárabes* in the seventeenth-century manuscript by Fray Andrés de San Miguel. In his work, Fray Andrés wrote about *plantillas*, which are shapes used to produce the single elements of the *mocárabe* (fig. 29); he also described the exact proportions and method for drawing them.

A study by Enrique Nuere analyzes the elements described by Fray Andrés de San Miguel in his manuscript, and introduces others observed in Spanish examples. According to Nuere, all the elementary *adarajas* can be divided into four families: *cona*, *medio cuadrados*, *dumbaques*, and *jairas*. The *conca* family includes rectangular-plan *adarajas* (5 x 7 units), which are all variants of the same basic element. In the *medio cuadrado* family, whose plan consists of an isosceles right triangle with legs (Lat. *catheti*) equal to 5 units and a hypotenuse equal to 7 units, are the *atícia*, the *medio cuadrado abierto por lo más ancho*, and the *medio cuadrado por tabla*. Belonging to the *dumbaque* family, whose plan consists of an isosceles triangle with a summit angle of 45° and sides equal to 5 units, are the *dumbaque*, the *media jaira cortada por la espalda*, the *dumbaque guillillo*, the *guillillo*, and the *almendrilla*.

Finally, the *jaira* family, whose plan consists of a rhombus with consecutive angles of 45° and 135° and sides of 5 units, includes the *jaira*, the *media jaira*, the *jaira ciruelo*, and the *jaira ahorcada*.

In this essay, for the purpose of drawing the prismatic elements of which the *muqarbas* of the Western Islamic tradition is composed, reference has been made to the guidelines provided by Fernández-Puertas. The selected elements and their names are deduced from the study conducted by Enrique Nuere. The elements are drawn by subtracting barrel vaults or cross vaults of semicircular section from prisms (fig. 30[a–e]).

**Prismatic elements with a rectangular plan**

The first type of *conca*, here referred to as *conca* (1) and analogous to the *t’stiya masdûda*, is similar to a portion of a barrel vault with a rectangular supporting base (fig. 30a). According to the classification made by Fernández-Puertas, it is a primary element. It has two other versions (similar to the *t’stiya maftûha*) that have the same name and are generated by subtracting a barrel vault from the *conca* (1). The generatrix of the vault is perpendicular to the major sides of the rectangular base of the *conca*. If the barrel vault and the *conca* have the keystone at the same height, the element is similar to a half cross vault—*conca* (2) (fig. 30a). If the keystone of the barrel vault is lower, the element is similar to a portion of a barrel vault with a lunette—*conca* (3) (fig. 30a). The second and third versions have two rectangular supporting bases and, according to Fernández-Puertas, are secondary elements.

**Prismatic elements with a right-angled triangle plan**

The *atícia*, which is analogous to the *sirwâliyya*, is generated by subtracting a barrel vault from a prism with a right-angled triangular plan (fig. 30b). The generatrix of the barrel vault is perpendicular to the hypotenuse of the triangular base. The element can also be generated by cutting *conca* (3) with two vertical planes. According to the subdivision made by Fernández-Puertas, it is a secondary element.

The *medio cuadrado abierto por lo más ancho* (1), analogous to the *danbûq*, is generated by subtracting a barrel vault from a prism with a right-angled triangular plan (fig. 30b). The generatrix of the barrel vault is oriented in the same direction as the hypotenuse of the triangular base (fig. 30b).
base. It is similar to a triangular portion of a barrel vault with a triangular supporting base. The element can also be generated by cutting the *conça* (1) with three vertical planes. According to the classification made by Fernández-Puertas, it is a primary element. Another version, the *medio cuadrado abierto por lo más ancho* (2), is generated by subtracting a cross vault with a square base from a prism with a right-angled triangular plan (fig. 30b). In this case, it is a triangular portion of a cross vault with a square base and, according to the subdivision made by Fernández-Puertas, it is a secondary element.

The *medio cuadrado*, which is analogous to the *sirwāliyya sha’ira*, is generated by subtracting a cross vault with a square base from a prism with a right-angled triangular plan (fig. 30b). It resembles a squinch.71 The element, which can also be formed through the union of two *sirwāliyyas*, has two triangular supporting bases on the same level and a rectangular one placed at a lower level than the first two.

The *medio cuadrado por tabla* is generated by subtracting a barrel vault from a prism with a right-angled triangular plan (fig. 30b). The generatrix of the barrel vault is oriented in the same direction as the hypotenuse of the triangular base. The element can also be generated by cutting the *conça* (1) with three vertical planes. It resembles a triangular portion of a barrel vault with a trapezoidal supporting base; according to the classification made by Fernández-Puertas, it is a primary element.

**Prismatic elements with an isosceles triangular plan that has a 45° summit angle**

The *dumbaque*, analogous to the *lūza* (1), is generated by subtracting a barrel vault from a prism with an isosceles triangular plan (fig. 30c). The generatrix of the barrel vault is oriented in the same direction as the base of the isosceles triangle. The element can also be generated by cutting the *conça* (1) with three vertical planes. It is similar to a triangular portion of a barrel vault with a trapezoidal supporting base. According to the subdivision made by Fernández-Puertas, it is a primary element.

The *dumbaque grullillo*, which is analogous to the *lūza* (2), is generated by subtracting a barrel vault from a prism with an isosceles triangular plan (fig. 30c). The generatrix of the barrel vault is oriented in the same direction as the base of the isosceles triangle. The element can also be generated by cutting the *conça* (1) with three vertical planes. It is similar to a triangular portion of a barrel vault with a triangular supporting base. According to the subdivision made by Fernández-Puertas, it is a primary element.

The *grullillo* is generated by subtracting an octagonal cross vault, or two barrel vaults, from a prism with an isosceles triangular plan (fig. 30c). It is similar to a triangular portion of an octagonal cross vault with a trapezoidal supporting base. According to the subdivision made by Fernández-Puertas, it is a secondary element.

The *media jaira cortada por la espalda* is generated by subtracting a barrel vault from a prism with an isosceles triangular plan (fig. 30c). The generatrix of the barrel vault is perpendicular to the base of the isosceles triangle. It has two triangular supporting bases and, according to the subdivision made by Fernández-Puertas, it is a secondary element.

The *almendrilla*, which is analogous to the *lūza* (3), is generated by subtracting a barrel vault from a prism with an almond-shaped plan that has two opposite angles of 90°, while the other two angles are, respectively, 45° and 135° (fig. 30c). The element can also be generated by cutting the *conça* (1) with four vertical planes. It is similar to a portion of a barrel vault with a triangular supporting base.

**Prismatic elements with an isosceles triangular plan that has a 135° summit angle**

*Media jaira* is the name that Enrique Nuere gives to three elements with an isosceles triangular plan (fig. 30d). *Media jaira* (1) is generated by subtracting a barrel vault from a prism with an isosceles triangular plan. The generatrix of the barrel vault is oriented in the same direction as the base of the isosceles triangle. The element can also be generated by cutting the *conça* (1) with three vertical planes. It is similar to a triangular
portion of a barrel vault and has a triangular supporting base; according to the subdivision made by Fernández-Puertas, it is a primary element. The *media jaira* (2) is generated by subtracting a barrel vault from a prism with an isosceles triangular plan. The generatrix of the barrel vault is oriented in the same direction as the base of the isosceles triangle. The element can also be generated by cutting the *conça* (1) with three vertical planes. The element has a trapezoidal supporting base; according to the subdivision made by Fernández-Puertas, it is a primary element. (The difference between *media jaira* (1) and *media jaira* (2) is the direction of the prism.)

The *media jaira* (3) is generated by subtracting a barrel vault from a prism with an isosceles triangular plan. The generatrix of the barrel vault is perpendicular to the base of the isosceles triangle. The element is also generated through the union of two halves of a *dumbaque grullillo*. It has two triangular supporting bases and, according to Fernández-Puertas, it is a secondary element.

*Prismatic elements with an almond-shaped or rhomboidal plan*

The first type of *jaira* (*jaira [1]*) , which is analogous to the *katif*, has a rhomboidal plan; it is obtained through the union, along the shorter diagonal of the rhomboidal plan element, of a *dumbaque*, a *dumbaque grullillo*, and an isosceles triangular base with a summit angle of 45° (fig. 30e). The element has a triangular supporting base. A second version, *jaira* (2), is generated by subtracting two barrel vaults from a prism with a rhomboidal plan or by combining two *dumbaques*: it has a hexagonal supporting base (fig. 30e).

The *jaira ahorcada* is generated by subtracting a barrel vault from a prism with a rhomboidal plan or by combining two *dumbaque grullillos*; it has two triangular supporting bases (fig. 30e).

The *jaira ciruelo* (analogous to the *shīra*) is generated by subtracting two barrel vaults from a prism with a rhomboidal plan (fig. 30e). The element has two triangular supporting bases on the same level and a rhomboidal one placed at a lower level than the first two.

A muqarnas can also have floral, polygonal, or star-shaped elements. In the Islamic West, particularly in Spain and North Africa, the vaults sometimes present tapered and suspended elements. It is for this reason that the muqarnas vaults are also known as stalactites.

According to Rosintal, one of the main rules for the construction of a muqarnas is the bifurcation of each element from the top: two other units split off, then another two from each of the latter, and so on, until the composition is completed. The elements that constitute the muqarnas can be assembled in various ways. The orientation of an edge also affects the one close to it, so their profiles must match or should be able to be reconciled. For the sake of consistency, it is important to respect the rules of continuity and ensure that two elements next to each other have their joined edges oriented in the same direction. The variety of elements employed in building a muqarnas also depends on what it is made for: e.g., fewer elements are needed to craft a muqarnas for a cornice than are needed to construct one for a ceiling.
**GLOSSARY**

*Terms based on André Paccard, Traditional Islamic Craft in Moroccan Architecture, pp. 564–76, and transliterated by Roberta Giunta*

**būja**, flower bouquet, a central motif, another term used by plasterers for the *sirwāliyya*

**danbūq** (for Paccard *denbūq*), a main piece of the *muqarnas*, the key piece

**katif, katf** (for Paccard *ktaf, ktef*), a shoulder or rounded shape

**lūza**, almond, used only for the *tassa* (cupola) or the *shāshiyya* (cap)

**sha’ira** (for Paccard *sha‘ira* or *shi‘ira*), a strand of hair, a very fine motif, another term used by the plasterers for the *sirwāliyya sha’ira*

**shāshiyya**, cap (used in reference to a central dome)

**shī‘ar** (for Paccard *charbiyia* or *chiira*), a fine hair

**sirwāliyya** (for Paccard *serwaliya*), a trouser-shaped motif, another term for the *būja*

**sirwāliyya sha’ira** (for Paccard *serwaliya sghira*), small trousers, a name used in particular by plasterers for the angle pieces and as another term for the *sha’ira*

**tassa**, cupola

**t’stiya masdūda** or **tstiya masdūda** (for Paccard *t’stiya mesdūda* or *tstiya mesdūda*), a closed motif

**t’stiya maftūha** or **tstiya maftūha** (for Paccard *t’stiya meftūha* or *tstiya meftūha*), an open motif

* * *

*Terms based on A. Fernández-Puertas, Encyclopédie de l’Islam, s.v. “Muqarbas”*

**adarajas**, the prismatic elements that comprise the *muqarbas*

**consa**, the broken profile of the faces of the prismatic elements that make up the *muqarnas* of the Eastern tradition

**guillillo**, the shape used to cut *jairas* and generate *adarajas*

**jairas**, the four prisms from which *mocárabes* are created

**mocárabe**, the Spanish term for *muqarbas* (the Western version of the *muqarnas*)

**patilla**, a small base

* * *

*Terms based on Enrique Nuere, La carpintería de armar española, pp. 128–250*

**adarajas**, the prismatic elements that comprise the *mocárabe*

**almendrilla**, a prismatic element with an almond-shaped plan

**atacia**, an *adaraja* obtained from a *medio cuadrado* (a triangular prism that is cut perpendicular in the back by a *plantilla*)

**conça** (F. A.), **conza** (L. A.),77 one of the *adarajas* that make up a *mocárabe*, it derives from a rectangular prism cut with a shape in its longest side, forming two legs on the opposite side

**dumbaque**, a triangular prism used to produce *adarajas*
**dumbaque ciruelo** (F. A.), half of a *jaira ciruelo*

**grullillo**, a shape similar to a *medio cuadrado abierto por lo más ancho* but narrower, or an *adaraja* with a triangular plan that starts with a small section at the bottom and looks like a crane

**jaira**, an element consisting of two isosceles triangle prisms, the union of which generates a rhombooidal prism; it has two different versions consisting of two equal or unlike prisms

**jaira ahorcada**, the combination of two halves of a *jaira*

**jaira ciruelo** (F. A.), the combination of two halves of a *dumbaque ciruelo*, or, rather, of two halves of a rhombus

**jaira rubí** (F. A.), a *jaira ciruelo* with the addition of one or two legs in one or both of the vertices of the major axis of the rhombus

**media jaira**, a prismatic element with an isosceles triangular plan that is made up of other similar elements alongside the back

**media jaira cortada por la espalda**, a prismatic element with an isosceles triangular plan

**medio cuadrado**, a triangular prism similar to the *atacia*, from which it differs in the cut of its faces

**medio cuadrado abierto por lo más ancho**, a prismatic element with a right-angled triangular plan cut along its longest side

**medio cuadrado por tabla**, a prismatic element with a right-angled triangular plan

**mocrab**, solid, firm, bound

**plantilla**, a shape used to produce the single elements of the *mocarábe*
Figs. 25[a–d]. Comparison of the architectural elements of the muqarnas of the Eastern Islamic tradition (on the left) with the analogous architectural elements of the *muqarbas* of the Western Islamic tradition (on the right). (Drawing: Vincenza Garofalo)

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Fig. 25a.
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Fig. 25b.
Fig. 25c.

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Fig. 25d.
Fig. 26. Left) The four plans of the *muqarnas* elements, as described by al-Kashi. Right) The method to draw the profile of an element, as described by al-Kashi. (After Mohammad Al-Asad, “The Muqarnas: A Geometric Analysis,” in Gülru Necipoğlu, *The Topkapı Scroll: Geometry and Ornament in Islamic Architecture. Topkapı Palace Museum Library MS. H. 1956* [Santa Monica, Calif., 1995], 353, fig. 2)
Fig. 27a.

Fig. 27, a and b. Classification and geometric analysis of the elements of the Eastern Islamic tradition. From left to right: the planimetric proportions; the elements obtained by subtracting either barrel vaults or cross vaults from prisms; planimetric views of the intersections of the vaults and prisms that generate the elements (in red); the elements obtained by cutting a prism or a basic element with one or more vertical planes, or from the combination of two similar elements; planimetric views of the latter constructions, where broken lines represent the vertical planes. (Drawing: Vincenza Garofalo)
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<th>Lūza (3)</th>
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Fig. 27b.
A METHODOLOGY FOR STUDYING MUQARNAS: THE EXTANT EXAMPLES IN PALERMO

ADARAJA

Fig. 28. Profile and plans of the elements of the *muqarbas*, which are called *adarajas*. (After A. Fernández-Puertas, *Encyclopédie de l'Islam* (Leiden, 1960–2007), s.v. "Mukarbas," pl. XLIV)

Fig. 29. *Plantillas*, the shapes used to draw the elements of the *mocárabe*, as described by Fray Andrés de San Miguel. (After Enrique Nuere, *La carpintería de lazo* [Malaga, 1990], reproduction of a page of the manuscript by Fray Andrés)
Fig. 30a. Classification and geometric analysis of the elements of the Western Islamic tradition. From left to right: the planimetric proportions; the elements obtained by subtracting either barrel vaults or cross vaults from prisms; planimetric views of the intersections of the vaults and prisms that generate the elements (in red); the elements obtained by cutting a prism or a basic element with one or more vertical planes, or from the combination of two similar elements; planimetric views of the latter constructions, where broken lines represent the vertical planes. (Drawing: Vincenza Garofalo)
### Western Islamic Elements

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</tbody>
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Fig. 30b.
### WESTERN ISLAMIC ELEMENTS

| **0.766** | ![Diagram](image1.png) | ![Diagram](image2.png) | ![Diagram](image3.png) |
| **45°**   | Dumbaque               | Dumbaque grullillo     | Grullillo              |

| **0.766** | ![Diagram](image4.png) | ![Diagram](image5.png) | ![Diagram](image6.png) |
| **45°**   | **Media jaira cortada por la espalda** | | |

| **0.766** | ![Diagram](image7.png) | ![Diagram](image8.png) | ![Diagram](image9.png) |
| **45°**   | Almendrilla             |                      |                      |

*Fig. 30c.*
A METHODOLOGY FOR STUDYING MUQARNAS: THE EXTANT EXAMPLES IN PALERMO

WESTERN ISLAMIC ELEMENTS

| Media jaira (1) | Media jaira (2) | Media jaira (3) |

Fig. 30d.
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Fig. 30e.
NOTES

Author’s note: This paper is a result of research undertaken for my doctorate in Surveying and Representation of Architecture and the Environment, completed at the University of Palermo, in association with the University of Reggio Calabria Italy in 2003. I would like to thank Dr. Adele Mormino, Superintendent of the Sicilian Department for Cultural and Environmental Heritage in Palermo, for allowing me to survey the muqarnases of the Zisa and to photograph the Zisa and the Cuba. I would also like to thank the Curia of Palermo for granting me permission to photograph the Cathedral of Palermo and the Chapel of Santissima Trinità alla Zisa. I am grateful to the architects Eugenio Galdieri and Fabrizio Agnello (University of Palermo) and to Professors Giuseppe Pagnano (University of Catania) and Michele Inzelillo (University of Palermo) for sharing my enthusiasm for this research and for their valuable advice. Special thanks to Professor Roberta Giunta of the University of Napoli “L’Orientale,” for the transliteration of the Arabic terms, and to Dr. Fina Cali, for her help with the English translation.

1. Examples of muqarnas from cultures outside of the Islamic world can be found in Spain and Palermo, as well as in Armenian churches. See Armen Ghazarian and Robert Ousterhout, “A Muqarnas Drawing from Thirteenth-Century Armenia and the Use of Architectural Drawings during the Middle Ages,” Muqarnas 18 (2001): 141–54.

2. With the arrival of the Normans in Sicily in 1060, the Muslims lost control of the Western Mediterranean, but this did not lead to a diminishing of their presence in Sicily. The Normans integrated to such a degree with the Muslims already present in the territory that they adopted their organization of government and court traditions, as well as their building typologies and construction techniques. The Norman use of Islamic architectural elements would be attributable, according to Brenk, to the willingness on the part of Roger II to subordinate Islamic iconography to the Normans’ ideology of power: see Beat Brenk, Il concetto progettuale degli edifici reali in epoca normanna in Sicilia, Quaderni dell’Accademia delle Arti del Disegno 2 (Florence, 1990), as quoted in Gianluigi Ciotta, La cultura architettonica normanna in Sicilia (Messina, 1992), 351.


4. The Zisa of Palermo is also known as the Palace, or Castle, of Zisa. For an extensive bibliography on the Zisa and the other monuments of Palermo mentioned in this essay, see Rosario La Duca, Repertorio bibliografico degli edifici pubblici e privati di Palermo, Parte seconda: Gli edifici fuori le mura (Palermo, 1997).

5. Historical sources date the building to 1164, even if in the past it was considered of probable Islamic foundation.

6. During the restoration of the eastern iwan in the Friday Mosque at Isfahan, in addition to the extant Safavid muqarnas, traces of larger Seljukid ones were found. Eugenio Galdieri, Esfahân: Masâhîd-i Ğum’a, Restorations 1, 3 (Rome, 1984), 33, 48, and 50, fig. 50.

7. Innovative materials such as fiberglass and associated advanced technologies are also employed today.


10. Tabbaa, Dictionary of Art, s.v. “Muqarnas.”


14. A squinch is an architectural structure used to provide a transition from a square to a polygonal or circular base on which to construct a dome.


18. Hautecoeur, “De la trompe,” 46. The author numbers the muqarnas of the Zisa among the first examples of this type.

19. Ibid., 76.
20. The study of the Zisa muqarnas was preceded by a topographic survey carried out by the present author with the architects Silvia Sgariglia and Salvatore Giardina. This survey was fundamental to learning about these seemingly complex structures, which are actually made up of simple elements. To draw the topographic survey, the present author conducted an extensive study of the geometry of the muqarnas, which was crucial for understanding its characteristics. See Vincenza Garofalo, “Dal rilievo topografico al modello virtuale. La Zisa di Palermo,” in *Dall’architettura concreta al modello immateriale. Il rilievo digitale nelle sue valenze euristiche*. Atti del seminario di studi, Reggio Calabria, 30 aprile 2004, ed. Valeria Macri (Reggio Calabria, 2005), 46–51; Vincenza Garofalo, “Il rilievo dei muqarnas della nicchia centrale dell’iwan alla Zisa di Palermo,” in *ATTI DEL CONVEGNO: TECNOLOGIE PER COMUNICARE L’ARCHITETTURA* (Ancona, 2004), 333–34.


22. The basic elements are arranged in different combinations in each register. Some of these combinations are repeated in the composition (fig. 14).

23. Rosintal calls this type of squinch a “Byzantine niche.” For further investigation, see Rosintal, *Pendentifs*, 3–47. Other examples of this type can be found in the Church of Santa Maria Maddalena and in the Chapel of San Filippo at the Favara in Palermo.

24. Some of Jones’s drawings of the basic elements are ambiguous: for example, the true shape of elements A3 and C3 is unclear. See Owen Jones, *Plans, Elevations, Sections, and Details of the Alhambra: From Drawings Taken on the Spot in 1834 by Jules Goury and in 1834 and 1837 by Owen Jones, with a complete translation of the Arabic inscriptions, and an historical notice of the kings of Granada from the conquest of that city by the Arabs to the expulsion of the Moors*, by Mr. Pasqual de Gayangos, 2 vols. (London, 1842–45).


26. The oldest known example of muqarnas drawings is a plaster modello virtuale in the Zisa. It was found by chance during the excavations undertaken in 1959 by the German Archaeological Institute of Teheran at Takht-i-Sulayman, in Iran. See Harb, *Ilkhanidische Stalaktitengewölbe*, 9–11.

27. See Gürli Necipoğlu’s interesting study of the Topkapi scroll. Probably created by late medieval Iranian master builders, it belongs to the Islamic scrolls tradition, which was once quite common. The scrolls had several geometric drawings: sketches of vaults, architectural ornaments, and epigraphic panels. The Topkapi scroll provides a catalogue of ideal types that demonstrate late Timurid-Türkmen architectural practice. These geometric drawings are generated by square, triangular, and polygonal grids, and are still used today in Iran, Iraq, and Morocco. Necipoğlu, *Topkapi Scroll*, 9 and 48. See also André Paccard, *Traditional Islamic Craft in Moroccan Architecture*, trans. Mary Guggenheim (Saint-Jorioz, France, 1980), and Jean-Marc Castéra, *Arabesques: Art décoratif au Maroc* (Paris, 1996).


29. Michel Écochard provides some possible combinations that are generated by the rotation—within a half square—of regular polygons around their center of symmetry. Écochard, *Filiation*, 93.

30. According to Jean-Marc Castéra, every muqarnas plan contains “a trick,” an exception to the rule of the composition that allows the structure to be closed. In fact, in the transition from register 10 to register 11 we can see that the vertices of the overlapping triangular elements do not coincide (fig. 11). See Castéra, *Arabesques*, 322–25.


33. Inveges wrote that the chapel was built by Count Roger, probably in 1094. See Patrizia Scafdī, “La cappella della Zisa,” in *Castelli, dimore, cappelle palatine: Inediti e riletture di architetture normanne in Sicilia*, ed. Anna Maria Schmidt (Palermo, 2002), 243–79.

34. Écochard notes the similarity between the ceiling plan of the Cappella Palatina in Palermo and that of the Mosque al-Qarawiyyin in Fez. The reference to the Moroccan muqarnas thus appears again. See Écochard, *Filiation*.

35. An accurate description of the wooden structure and of the last restoration work that affected the chapel is in Mario Li Castri and Tiziana Campisi, “The Muqarnas Wooden Dome: Its Origin and Meaning,” *Muqarnas* 93.


37. The figures painted on the ceiling of the chapel are similar to those engraved in the fragments found at Qa‘a Bani Ham-
mad, datable to the early eleventh century. Some palm-shaped motifs are similar to those present in the Qal’a Bani Hammad and on the ceiling of the Mosque of Kairouan in Tunisia. This led Golvin to suggest similarities between these plaster elements and the muqarnas of the Cappella Palatina.

38. The Cathedral today is the result of many changes and additions made over the centuries. For a bibliography, see Ciotta, La cultura architettonica, 192 n. 2, and Guido Di Stefano, Monumenti della Sicilia normanna (Palermo 1955), 53–58.

39. According to Michele Amari and Vincenzo Di Giovanni, the castle was built during the period of Arab domination, around the year 1000. According to Romualdo Salernitano and Ugo Falcando, it is attributable to Roger II, and datable to about 1150. See Michele Amari, Storia dei Musulmani di Sicilia (Florence, 1854–72), 843; Vincenzo Di Giovanni, “Il Castello e la chiesa della Favara di San Filippo a Mare-dolce in Palermo: Note e svariamenti,” in Archivio Storico Siciliano, n.s., 22 (1897): 301–74; Romualdo Salernitano, “Chronicon,” in Rerum Italicarum Scriptores, 8, 1, ed. C. A. Garufi (Città di Castello, 1935), 232–33; Ugo Falcando, Epistola ad Petrum panormitanum ecclesiae thesaurarium, ed. G. B. Siragusa, Fonti per la Storia d’Italia pubblicate dall’Istituto Storico Italiano 22 (Rome, 1897), 87.

40. See Giuseppe Spatrisano, La Zisa e lo Scibene di Palermo (Palermo, 1982), 63–84. For an extensive bibliography, see La Duca, Repertorio bibliografico.

41. According to Marçais, there is a great similarity between the fragments of the muqarnas in the Cuba and those of the North African Tlemcen Mosque. See Marçais, L’architecture musulmane, 122–23.

42. See Giuseppe Bellaiofiore, La Zisa di Palermo (Palermo, 2001), 110.

43. For an extensive bibliography, see “Bibliografia di Rosario La Duca,” in La Cattedrale di Palermo: Studi per l’ottavo centenario dalla fondazione, ed. Leonardo Urbani (Palermo, 1993).

44. The plans of the muqarnas in Palermo that are examined in this work were not surveyed; rather, they were drawn after being observed directly. The analytical procedure here described can be applied to any muqarnas structure, no matter its actual size, to understand the rules governing its composition.

45. One of these niches shows remarkable similarities with the plan and the layout of the elements on the vault of the Monastery of Las Huelgas, near Burgos in Spain (1187) (fig. 10).

46. See Marçais, L’architecture musulmane, 122–23.

47. See Eugenio Galdieri, “Sull’architettura islamica in Sicilia: Lamento di un architetto ignorante sopra una architettura inesistente,” Rivista degli Studi Orientali 74, 1–4 (2000): 58 n. 37. Galdieri asserts that architecture should be considered in its spatial connotation and that comparisons based only on plans are a misleading “abstraction of convenience.”


53. Ecochard, Filiation, 76.


57. In this essay, Pauty speaks about the Persian profile with regard to Egyptian squinches, which were strongly influenced by Persian art. The images of some examples presented by the author show that the profiles of the cells of the muqarnas appear substantially similar to that described by al-Kashi. See Pauty, “Contribution à l’étude des stalactites,” 129–53.

58. The broken profile distinguishes the Eastern elements from the Western ones; the profiles of the faces of the latter derive from a quarter of a cylinder. Fernández-Puertas, Encyclopédie de l’Islam, s.v. “Mukârbar.”

59. This is the oldest example currently known regarding literature on the muqarnas. A very important drawing by al-Kashi illustrates the method for obtaining the exact profile in elevation of a unit of a muqarnas. According to this drawing, the height of a unit should be approximately equal to twice its depth and units of the same register generally have the same height. See the analysis of the al-Kashi text in Al-Assad, “Muqarnas: A Geometric Analysis,” 349–59; Lisa Golombok and Donald Wilber, The Timurid Architecture of Iran and Turan (Princeton, N.J., 1988), 164; Yvonne Dold-Samplonius and Silvia L. Harmsen, “The Muqarnas Plate Found at Takht-i Sulayman: A New Interpretation,” Muqarnas 22 (2005): 85–94.

60. The geometrical schemes that follow are a part of a more detailed analysis in Vincenza Garofalo, “I muqarnas: Metodoologia per uno studio. La nicchia centrale dell’iwan alla Zisa di Palermo” (PhD diss., Università di Palermo, 2003).
61. A vault with lunettes is obtained by the intersection of two barrel vaults of different sizes that are perpendicular to each other.
62. See Paccard, *Traditional Islamic Craft*.
64. Diego López de Arenas, *Carpintería de lo blanco y Tratado de alarifes y de relojes de sol* (Madrid, 1867).
66. In the seventeenth century, Andrés de San Miguel, a Carmelite friar and architect, wrote a manuscript containing architectural drawings and instructions to build *mocárabes* (the Spanish term used to describe muqarnas, or better, *muqarbas*, as the motif was known in the West). See Enrique Nuere, *La carpintería de lazo: Lectura dibujada del manuscrito de Fray Andrés de San Miguel* (Málaga, 1990), and Enrique Nuere, *La carpintería de armar española* (Madrid, 1989).
67. According to Fray Andrés, to trace the profile we need a shape seven units high, which divides the base of the element into seven or five parts, one of which is the leg. To draw *conjas* and *atacias* we need a profile that divides the longer side of the rectangular prism into seven parts. Two of the parts form the legs and the other five the diameter of the semicircle that creates the profile. To draw the *aira rubí*, *dumbaque ciruelo*, and *media jaira por la espalda*, we need a profile that divides the longer side of the rectangular prism into five parts, two of which constitute the legs of the element. See Nuere, *La carpintería de lazo*.
68. Ibid.
69. The *catheti* of a right-angled triangle are the two sides that are adjacent to the right angle.
70. The explanation of the Spanish terms is found in López de Arenas, *Carpintería de lo blanco y Tratado de alarifes*, 171–83.
71. In the church of San Giovanni degli Eremiti in Palermo there is an example of this type of squinch. Rosintal counts this type among the Byzantine ones, which derive from the Persian types. See Rosintal, *Pendentifs*, 3–47.
72. For an explanation of the Persian techniques for building a muqarnas, see ibid., 57–71.
75. According to Paccard, *Traditional Islamic Craft*, 564, “[t]he transcription of these words is very close to the one, more phonetic, of the maallems [sic].” Roberta Giunta is Professor of Archaeology and History of Islamic Art at the University of Napoli “L’Orientale.” It should be noted that Professor Giunta’s transliterations were slightly revised to conform to the system followed in *Muqarnas*.
76. Nuere developed a glossary that contains several terms used in carpentry, citing the sources consulted for each term, e.g., Diego López de Arenas (here abbreviated L. A.) or Fray Andrés de San Miguel (here F. A.).
77. See n. 76 above.