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An Essay on the Classification of Muqarnas: Geometric Foundations Based on Application in Practice

Mukarnasların Tasniflenmesine Dair Bir Deneme: Uygulama Pratiğine Dayalı Geometrik Temeller

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Abstract

The main objective of this paper is to introduce a new approach to analyzing muqarnas units. Although there are many studies in this area, most of them are not comprehensive and treat the subject from a narrow perspective. The basic approach consists of using al-Kashi's work as a point of reference. But, since examples of units of the muqarnas technique are many and varied, a new approach needs to be developed to define them. This article consists of three sections. The first covers etymological discussions in the field; the second explains the methods that have been used to analyze muqarnas units. Finally, the third section will present a way of classifying muqarnas units on geometric foundations. It is believed that this article will contribute to the field by creating a way of classifying muqarnas units in historical context and adding a new perspective to the debates in this field over their origins.

Keywords: Muqarnas, Islamic Art and Architecture, Geometric Pattern, Islamic Ornament.

Mukarnasların Tasniflenmesine Dair Bir Deneme: Uygulama Pratiğine Dayalı Geometrik Temeller

Öz

Bu çalışmanın ana odağı, mukarnas çözümlemelerine yeni bir yaklaşım getirmektir. Mukarnasın çözümlenmesi ve tasniflenmesi ile ilgili yapılan çalışmalarda temel yaklaşım Al-Kaşi'nin çalışmalarına referans alarak oluşturulmaktadır. Bu çalışmalar kapsamlı olmayıp, sınırlı bir bakış açısı ile ele alınmışlardır. Mukarnas birimlerinin çok ve çeşitli birimlerden oluşmasından ötürü yeni bir yaklaşım geliştirilmesi gerekmektedir. Bu çalışma üç ana bölümden oluşmakta olup, ilk bölüm alandaki etimolojik tartışmaları aktardıktan sonra mukarnas birimleri üzerinde yapılmış çözümleme yöntemleri aktarılacaktır. Son bölümde ise geometrik temellere uygun bir şekilde bir mukarnas tasniflemesi verilecektir. Bu çalışmanın alana katkısı tarihsel çerçeveye uygun bir şekilde mukarnas tasniflemesinin oluşturulması ve alandaki köken tartışmalarına yeni bir bakış açısı kazandırmasıdır.

Anahtar kelimeler: Mukarnas, İslam Sanat ve Mimarisi, Geometrik Desenler, İslami Süslemeler.

1. Introduction

The study aimed to present a new approach to analyzeing and classifying muqarnas units, an important element of Islamic Art and Architecture, based on geometric foundations suitable for practical application. This system should be considered as methods that can be used and applied in practice. Analyses of muqarnas units that try to turn 2D drawings into 3D models usually draw conclusions by conducting analyses based on al-Kashi's definitions. Al-Kashi only explains the simple muqarnas units in his book, however, does not explain other more complex muqarnas unit designs such as Shirazi. As a result, the general approach used in studies analyzing muqarnas to date have used simple muqarnas designs having angles of 90°,45°,22,5° with visuals made using 3D software.

Two main approaches have been observed in studies made in this field. The first approach explains the social, political, and theological significance of muqarnas while the other explains its geometrical originality (Dinçer and Yazar, 2021). In general, when the studies are evaluated, they are seen to be descriptive, analytical, and interpretative in scope (Alaçam et al. 2017). Researchers such as Arseven (1973), Grabar (2004), Tabbaa (1985), Dold-Samplonius (1992), Bloom (1988), Özdural (1990), Uluengin (2018), Uluçam (1990) have obtained descriptive results from their studies while Yaghan (2000), Notkin (1994), Samplonius and Harmsen (2005), Al-Asad (1995), Sakkal (1988), and Alaçam (2017) have obtained analytical and interpretive results by creating 3D models from 2D drawings.

The earliest known work on muqarnas was the plan and section of the muqarnas dome of the Twin Sister Hall in the Al- Hamra Palace conducted in 1834 by the Englishman Owen Jones and the Frenchman Jules Goury. This research was later analyzed by Jean-Marc Castera and a 3D model was made. The dome, which was consist of 5,000 parts, was made useing the muqarnas construction technique seen as the style in the North African region and still used today (Castera, 2006).

This study shall first examine the metods of analyzing muqarnas as well as the discussions over language and origin in the field before revealing the classification derived from the practical geometric foundations of muqarnas.

2. Language and Origin Discussions

Muqarnas is defined as stalactite vault (Güzelcï and Alaçam, 2019). Al-Kashi, on the other hand, defined muqarnas as a laddered roof and stated that each unit joined at 90° or 45° (Dold-Samplonius and Harmsen, 2005).

When we look at the Arabic language, although there is no information about the term of muqarnas, the origin of the word has been associated with "qirnas" derived from the root "q-r-n-s". As a noun, qirnas is a geographical

term meaning an outcrop on a mountain; as a verb its meaning is to make something that protrudes. In Syriac, “qarnes” is used to mean hammer. The word is referred to as “mocarabe” in Spanish dictionaries, and is interpreted as “decorative fasteners on the curved surfaces of cornices and vaults” (Güzelcï and Alaçam, 2019). Some researchers have associated the root of the word with the Greek for "cornice" (Dold-Samplonius, 1992).

In his dictionary of art, Arseven states that the word ‘’karnas’’ which means protrusion in Yakut Turkish, comes from the term “muqarnasat” derived from Arabic. In Yakut Turkish, ‘’karnas’’ means a spur that protrudes from the mainland into lakes or the sea (Arseven, 1973). In addition to its Yakut Turkish meanings, "Krns" has the meanings of curved knife, hunting falcon/hawk in “Lisan-ı Arab [Arabic Leanguage] (1291)” and the Farsi dictionary Dehkhoda.

In addition to the etymological discussions, studies have also been made to date the use of muqarnas in buildings. Oleg Grabar suggested that muqarnas emerged simultaneously in northeastern Iran and North Africa but Yasser Tabba declared that muqarnas came from northern Samarra/Iraq, citing the Shrine of Imam al-Dur. Henri Terrasse, on the other hand, said that muqarnas existed in Iran before it was seen in Morocco between 1135- and 140 (Senhaji and Benslimane, 2019). Muqarnas pieces in the Samarra Style are on display in the Islamic Museum in Cairo and are thought to be examples from the 9th and 10th century Abbasid Period (Dold-Samplonius, 1992). Iran, Iraq, Egypt, and Morocco all come to the fore in chronological discussions. Muqarnas elements can be seen in the Great Mosque of Isfahan in Iran dated 1088, the Imam al-Dur Tomb in Iraq dated 1090 (Tabbaa, 1985), the Badir al-Jamal Minaret (Fig. 1) dated 1085 in Cairo, Egypt, and the Great Mosque Minaret in Aleppo, Syria dated 1090 (Fig. 1.) (Bloom, 1988). However, there are some difficulties in dating the muqarnas elements. These difficulties are compounded by the fact that the dates of the structures are too close. In addition to these dating problems, it would be appropriate to consider that these structures were not completed in a short time and that artistic effects could have been added at any time during the construction process. Another point that needs to be considered when carrying out dating is that the buildings in question would have been subject to repair and renovation work that may or may not have been recorded in the 10th century.

For example, Uluçam states that the muqarnas dome of the Imam al-Dur Tomb belongs to the 13th century. He stated that such tombs were built in the 13th century in the styles of the "Kıbabü'l-Mil, Kıbabü'l Mahruttiye’’ and ‘’Kıbabü't Tirazi's Selçuki" (Seljuk Tarzi Tomb) tombs (Uluçam, 1990).

Muqarnas was not only used in Muslim structures, but also in Christian’s structures in the Iberian Peninsula. The earliest known examples of muqarnas in Europe are found on the ceiling of the nave of the Palette Chapel, built in Palermo/Italy in 1154, and in the Zisa and Cupa Palaces, built by Gugliemlo II

d'Altavilla in 1180 (Garofalo, 2011). It is thought that the muqarnas came the peninsula during the Almohad period (1146-1248), but in the written texts of al-Udhri, found in the Santa Clara excavations in Murica, show that muqarnas were used in Almeria during the Mu'tasim Period (1051-91). Based on this text, researchers think that muqarnas came from North African influence and spread to the Iberian Peninsula via Almeria (Carrillo, 2014).

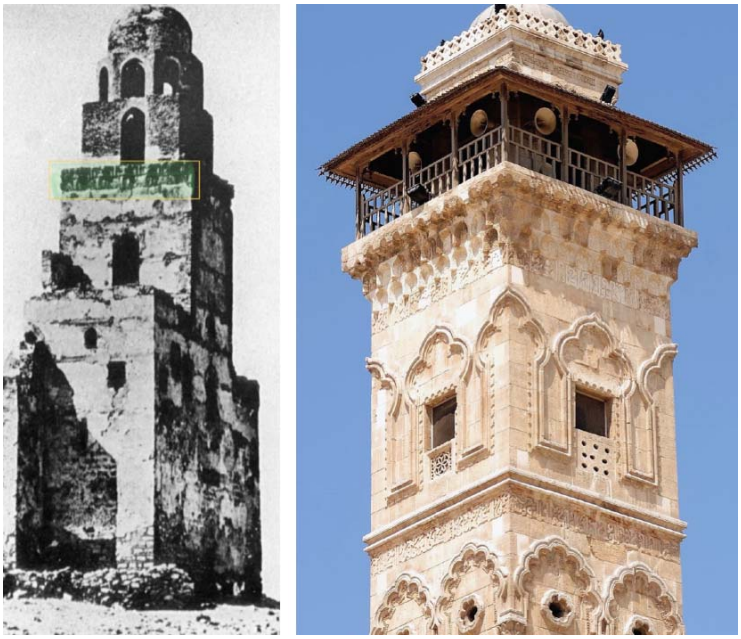

Fig. 1. Minaret of Bedir al-Cemal (Bloom, 1988) (left), Minaret of the Grand Mosque of Aleppo (Minaret of Grand Mosque of Aleppo) (right)

Another branch of evaluations is based on drawings and documents. The first known document was found in Taht-ı Süleyman (1271-76) (Fig.2), which used as seasonal palace by the Ilkhanate State. The document is a 50 cm plaster tablet. The drawings on the tablet are the plan of a quarter of the muqarnas dome covering one of the halls in the Palace (Dold-Samplonius and Harmsen, 2005).

The stone tablet, dated to the same period as the Taht-ı Süleyman tablet - approximately 20-25 years later- was found in the Astvatsankal Monastery in Armenia (Fig. 3). The drawing found in the "Gavit", the main vestibule of the monastery, is almost a quarter muqarnas of the plan a reduced to 1:5 scale. The middle section of the monastery's main vestibule is covered with a muqarnas dome (Fig. 4) and a similar type of cover is used in many monasteries in this region.

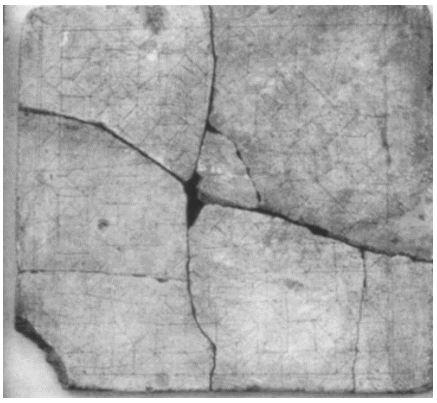

Fig. 2. Tablet of Taht-ı Suleyman (Dold-Samplonius and Harmsen, 2005)

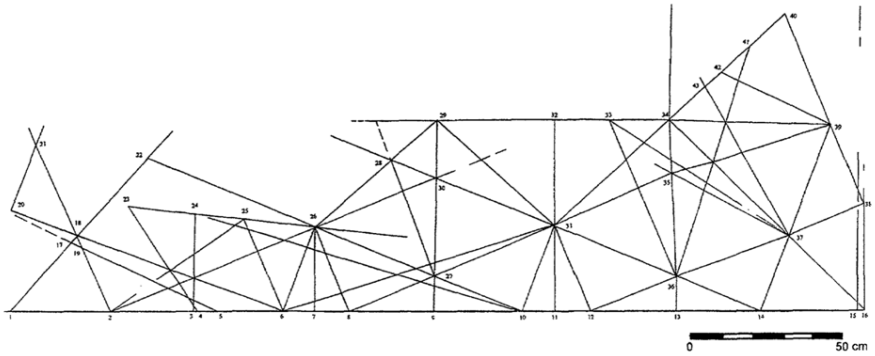

Fig. 3. Tablet drawing of Astvatsankal (Ghazarian and Ousterhout, 2001)

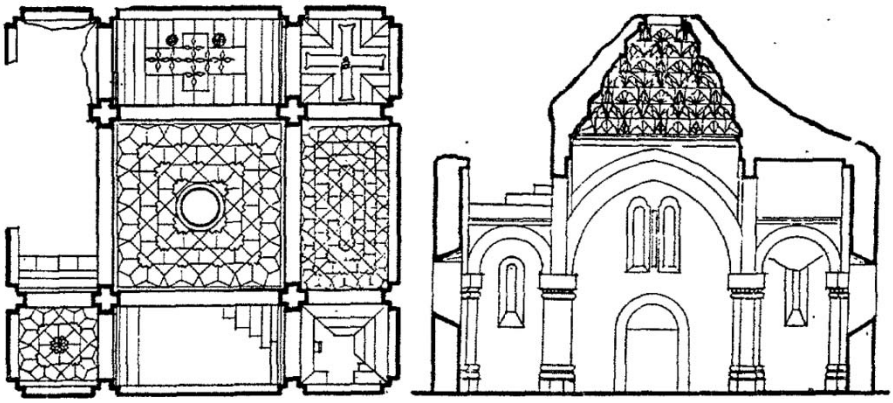

Fig. 4. Plan and section of Astvatsankal Monastery (Ghazarian and Ousterhout, 2001)

The Topkapı Scroll from the 14th century (Necipoğlu and Al-Asad, 1995) and the Samarkand Scroll from the Timurid Period, 16th century, are rich sources for muqarnas and geometric drawings (Dold-Samplonius and Harmsen, 2005).

Finally, one of the most important trains of thought in the discussions over origin is to examine the problem of transitioning from a square space to a dome. Since it is known that the domes were first used by the Sassanids, resolving the transition from the square space to the dome is an inherited knowledge in this part of the world. It is reasonable to think that since the vault and variations on the vault were used in this region before the pendentive, this would give rise to muqarnas solutions.

3. Classification and Solution Methods

Classification methods are generally based on the simple muqarnas given by al-Kashi. Researchers such as Samplonius and Harmsen (2005) and Yaghan (2000) have created solutions using this system. Shiro Takahashi, on the other hand, went and sketched existing buildings and created classifications based on the square, star, and triangle (Ghazarian and Ousterhout, 2001).

Ödekan points out one striking structural feature of muqarnas. This point is that muqarnas also exhibits console properties within the established structural system. Therefore, the elements in this system can be classified according to their first- and second-order console properties (Ödekan, 1975).

Apart from the classifications based on the muqarnas unit, those made by taking into consideration the created entirety by the muqarnas units divide the surface that is to be decorated into three main groups – the start, the middle, and the end sections While the start and end sections can be created using simple designs, the middle section is used as a space where stars and more complex geometrical patterns are employed (Notkin, 1994). Yaghan, for his part, systematized the muqarnas decorated surface, and divided it into three classes based on point, line, and composite designs (Yaghan, 2000) (Fig. 5).

Another classification method is based on geographical content. Muqarnas found in regions such as Turkey, Syria and Egypt are generally made of stone while those in North Africa samples are made of wood or plaster. The other examples came from Iran and Iraq are plaster or ceramic applications on brick. While the muqarnas units in North Africa and Andalusia are measured in centimeters, those from Iran and Iraq are measured in meters (Garofalo, 2011) (Fig. 6)

In Andalucia, the earliest information about muqarnas dates back to the 17th century. Diego Lopez de Arenas (1633), a builder from Seville in the 17th century, gives information about the muqarnas construction technique in his book. The definitions in the book are compatible with the art of the Nasri Period

(1232-1492) and state that the muqarnas (mocaraba) consists of four basic prisms (jairas). The first is the square-based prism, and the others are derivatives of the right angle triangular prism (Carrillo, 2014).

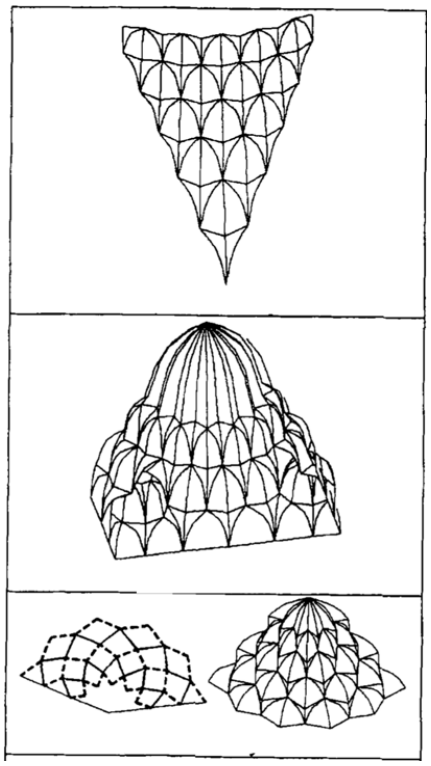

Fig. 5. Example of muqarnas surfaces, top to bottom, point base , line base and composite base (Yaghan, 2003)

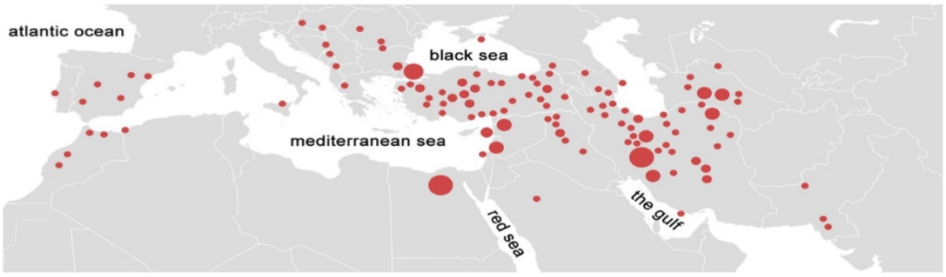

Fig. 6. Geographic distribution of muqarnas in from the 11th to the 17th century (Güzelcï and Alaçam, 2019).

Based on the muqarnas samples in the Iberian Peninsula, some researchers have said that the muqarnas types in the east and west are different. They state that there are various types of muqarnas units in the east, but there a total of

eight formulaic motifs in the west. Among these muqarnas, three are basic motifs, namely, Serwal, Dembouq and T'stiya, and the others are derivations of them (Gonzalo and Alkadi, 2018) (Fig. 7).

Finally, when we look at the definition by al-Kashi, which is taken as the baseline, he divides muqarnas into four different types in his book ''Miftah al-Hisab''. He divides them into simple (muqarnas al-sazij), curved (muqarnas al-muqavas), clay (muqarnas al-matiin), and Shirazi (muqarnas al-Shirazi). Al-Kashi created his work by taking considering examples in the Khorasan region (Özdural, 1991). Al-Kashi calls a single muqarnas unit "bayt" and a row of muqarnas "tabaqa". Based on their geometric plans, the units were called square (murabba), rhombus (muayyen), almond (loze), and goose foot (zevat er-rijleyn) (Özdural, 1990) (Fig. 8).

When al-Kashi calculates the area of the muqarnas, proceeds based on the line formed by the simple muqarnas section with an angle of 30° (Dold-Samplonius, 1992) (Fig. 9). Three other types of muqarnas are excluded from this calculation. The main purpose of Miftah al-Hisab is to help those who calculate the building surfaces to determine the material costs correctly and to apply it in practice (Özdural, 1990).

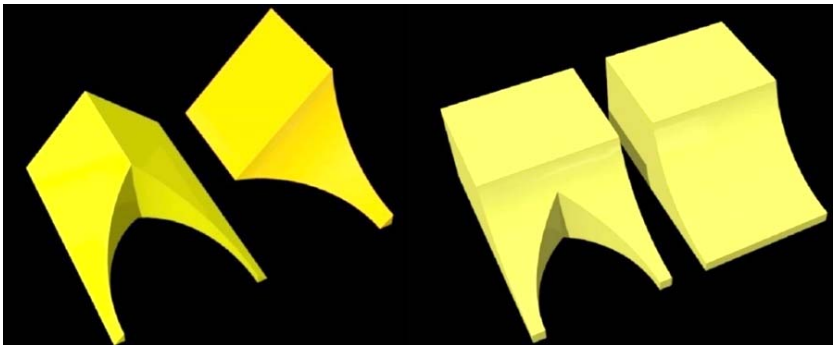

Fig. 7. From left to right: Serwal, Dembouq, T'stiya and the other versions (Gonzalo and Alkadi, 2018)

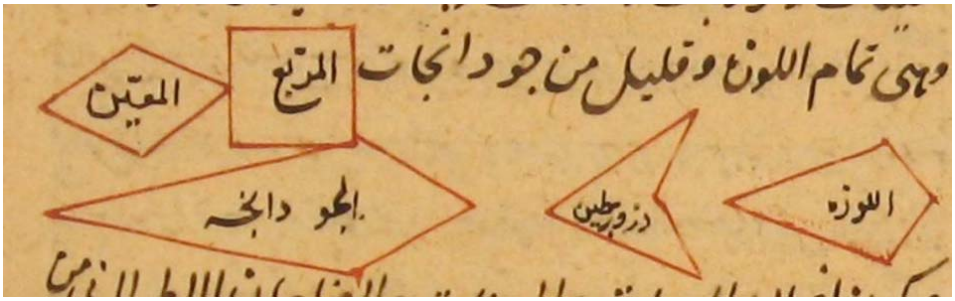

Fig. 3. Plans of Muqarnas in Miftah al-Hisab (Kāshī et al. 2020)

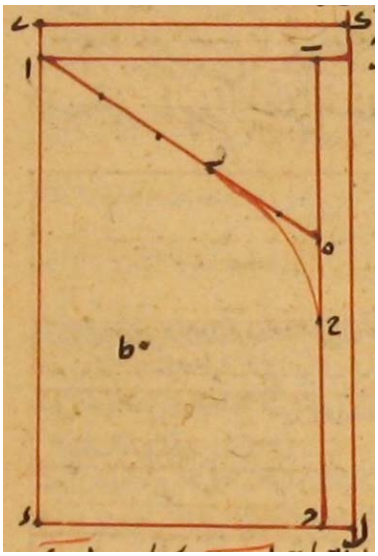

Fig. 9. Section of muqarnas in Miftah al-Hisab (Kāshī et al. 2020)

4. Usage and Meaning of Muqarnas

Depending on the material used, muqarnas can function as a carrier or just an ornamental element. Muqarnas is generally used in the entrance sections of mosques, the crown gates of madrasahs, or in caravanserais. Areas where muqarnas can easily be applied may be found on mihrab and minaret cornices, the pendentives of mosques, and flat or curved surfaces where ornamentation is desired. This wealth of areas where it can be applied has enabled the widespread use of muqarnas throughout the Islamic geography. It is important that examples of muqarnas domes, which occupy a rare place in the use of muqarnas, include new buildings. The Shrine of Imam al-Dur in Iraq was destroyed by ISIS in 2014. The Twin Sisters dome in the Al-Hamra Palace is considered to be an elegant example of muqarnas.

One important points that should be mentioned in addition to the much-cited technical methods of applying muqarnas to the building or decoration unit is the meaning of muqarnas in Islamic art and architecture. The concepts that emerge in the studies on the meaning of Islamic art are "unity in multiplicity, multiplicity in unity" (Burckhart, 2019). This concept is based on the belief of tawhid (unity), and it is the understanding that everything is one and united in the creator. In addition, it should be considered that the use of depictions in Islamic Art is limited. With the use of depictions being so limited, an attempt has been made to form a visual language using abstract shapes or stylized motifs, avoiding the exact reflection of nature (Mulayim, 2006). An important part of this visual language consists of geometric motifs and muqarnas units.

Since muqarnas is the spilling or removal of geometric shapes into the third dimension, the level of underlying meaning level can be sought here.

The fact that endless geometric motifs and muqarnas units can be derived and that different forms come together to form unlimited textures can be associated with the perception of the atomic universe. The universe and matter are formed by the collision of atoms, which are the smallest structural unit of any structure, their being combined in different ways and being reproduced forever. Transferring this cosmic order to the field of art in an abstract way can be done by using geometric and muqarnas units. Muqarnas also allows light and shadow plays due to its being three-dimensional. Muqarnas units create different visual perceptions as the angle of light changes during the day.

5. Classification Using Geometric Foundations Based on Application in Practice

The application of geometry in Islamic art and architecture started in the 9th and 10th centuries, and the Islamic world's acquaintance with geometry dates back to the 8th century. Khwarezmi's algebra (780-850), al-Biruni's new approaches in geography (940-998), and the geometric studies of Abu'l Vefa are known throughout Islam. In Abu'l Vefa's Geometric Foundations for Artists, he tried to explain how simple geometric forms could be produced (Güzelcï and Alaçam, 2019). In the fourth chapter of the book, he explained how the technicians created the shapes out of the circle, but he did not approve of their methods and explanied pentagons, hexagons and decagons can be easily derived from the circle (Haddad, 2015).

In the light of the origin studies, it is estimated that mukarnas emerged after the 9th or 10th century. Considering that these data and muqarnas practices are spread over a wide region, it is not possible to describe each muqarnas unit on parchment or tablets. Even if it is assumed that there are drawings and tablets for every muqarnas application, an attempt has been made above to show that different muqarnas compositions can be derived from the same drawing. For these reasons, it is thought that practical methods for applying muqarnas, which is widely used in Islamic Art, and known by the masters in the construction field should exist, and therefore, a new proposal for these application methods needs to be put forward.

The basic principle in this new method has been shaped by the methods of analyzing and applying the geometric decorations that have been used in Islamic Art and Architecture since the 8th century. It seems appropriate in terms of both historical conditions and practice that the circle-based approaches are used in the solution and classification of muqarnas.

A muqarnas master can predict which units and options can be formed from the bases such as octagon, hexagon, and decagon obtained from a circle. For example, motifs derived from octagons are the most commonly used units

since they give 90°, 45°, 22.5° angles. Muqarnas units derived from octagon have been used extensively as they give more freedom to form units than motifs derived from hexagon and decagon. This methods of classification and solution created provides leeway in terms of material and technique and lets muqarnas masters adopt original approaches (Fig. 10 and 11).

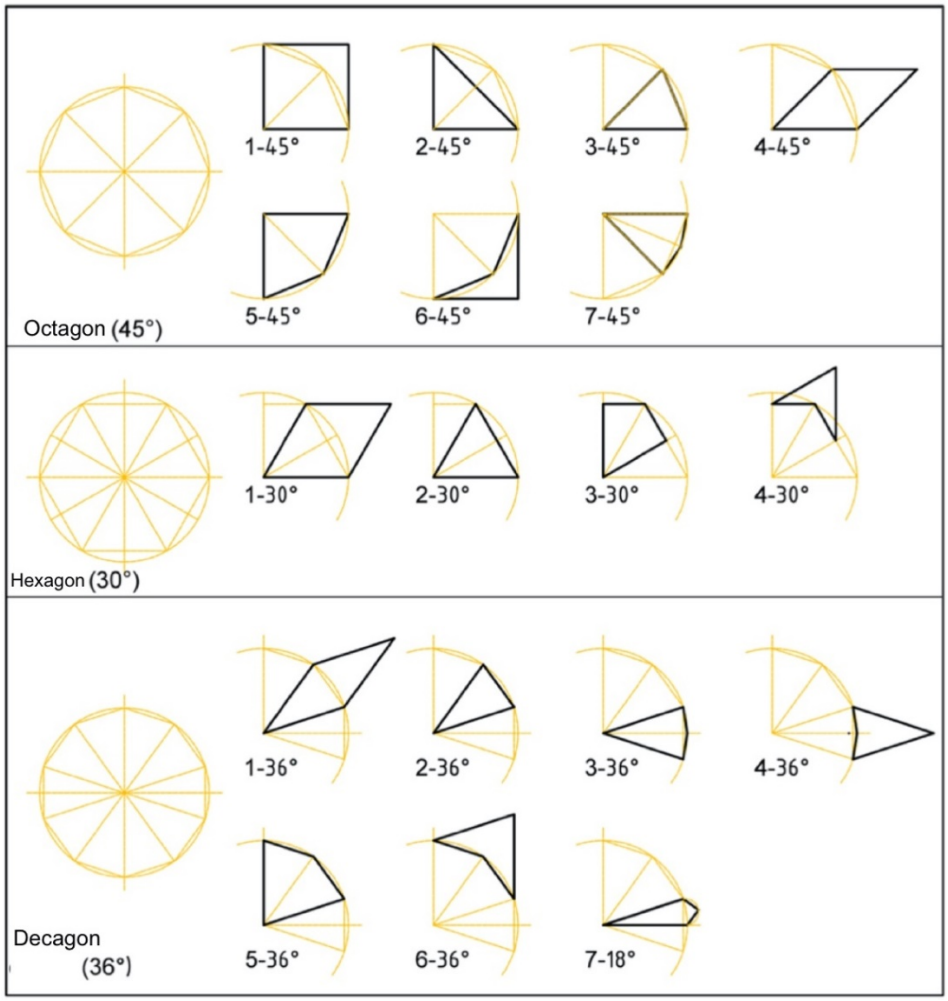

Fig. 10. Plan of muqarnas units derived from a circle.

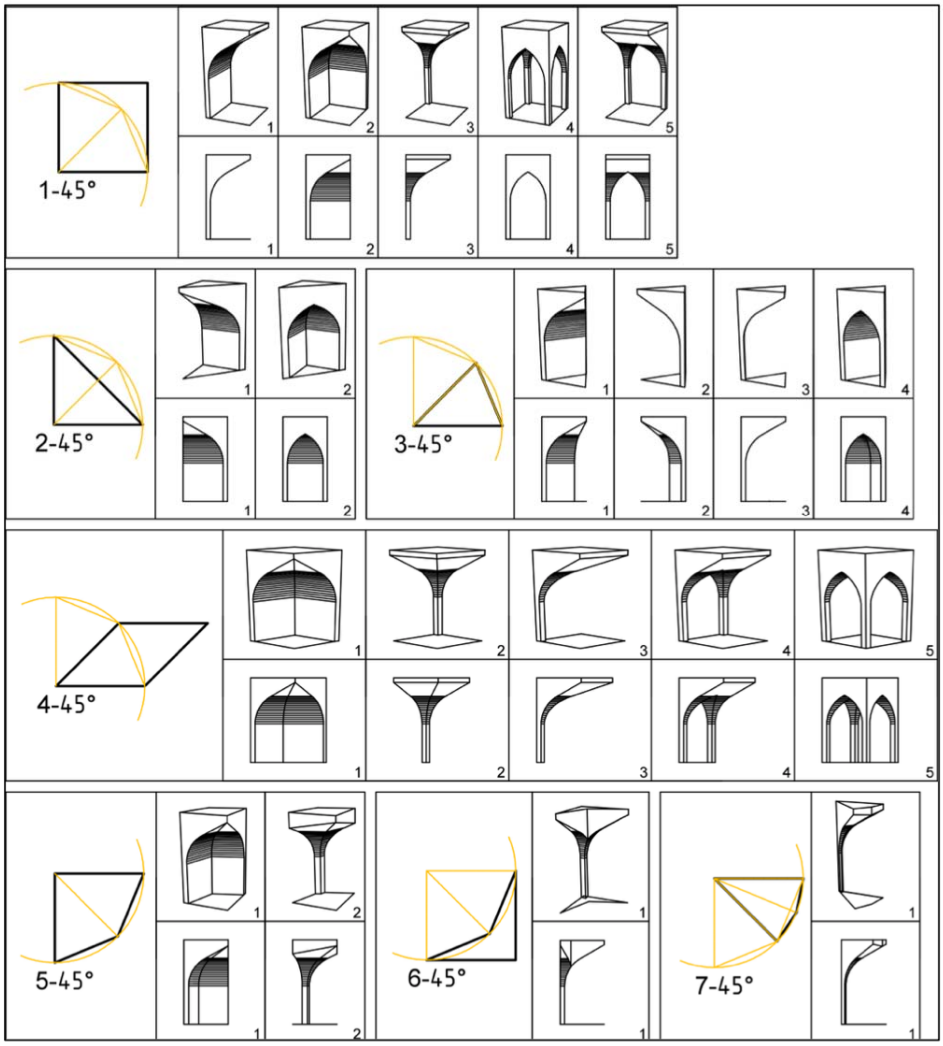

Fig. 11. Plan and perspective of muqarnas units base an octagon

It is easy to determine where the muqarnas unit came from when we use this methods of classification. If we see a 12-pointed star or 16-pointed star in a muqarnas design, we can readily to say "this muqarnas unit design basically uses a hexagon or octagon base and its principal angle is 30° or 45°." This allows us to see the mathematical aspects in muqarnas designs and the complex construction in muqarnas units. The tiny details found in muqarnas may be further classified as subdivisions of principal groups such as octagon, hexagon, and decagon.

6. Conclusion

Although muqarnas is acknowledged by all researchers as an original product of Islamic Art and Architecture, it is thought etymological approaches that define muqarnas using Greek terminologies are misleading. It is considered more appropriate to make sense of the invented product in the language and understanding of the civilization and community where it originated.

One of the main reasons for the inability to reach a definite conclusion in studies based on dating is the mass movement of people that occurs every years in Islam with Hajj, the pilgrimage to Mecca.

Monuments and accommodation places from different culture can be found along the pilgrimage routes. This led to a regular exchange of customs and information. For example, in one of the anecdotes of Ibn Jubayr on his pilgrimage in 1183, he stated that the dome in the annex of the Ibrahim Gate, built by Muhammad Ibn Musa in the Masjid al-Haram, had "magnificent plasterwork and "qarnasi" carvings (Bloom, 1988). In addition to the duty of pilgrimage, trade routes are another reason that needs to be considered. In addition to these reasons, the proximity of construction dates cited for the emergence of muqarnas domes make it hard to determine the source.

In the approaches to determine the regional source, since the problem of transitioning from square to dome has been solved since the time of the Sassanids, it is reasonable to think that the source of muqarnas may have been the Iranian region.

Some key points came to fore in the transition from two dimensions to the third dimension in Muqarnas analysis. These can be listed as the muqarnas unit, the means of transitioning from 2D to t 3D, the horizontal (Büyükdiğan, 2001) and vertical connections of the muqarnas unit, the choice of material and the construction technique to be applied. The type of material to be used can be the pre-determiner of the construction technique and muqarnas units. Three different construction techniques stand out in making muqarnas -- overlapping, gluing, and hanging (Nasri et al. 2011). In the overlapping technique, the muqarnas units are built by stacking them on top of each other, and the muqarnas units also serve as carriers. In the gluing method, the surface of the muqarnas unit is affixed to the carrier surface. This technique is similar to the method applied in coatings such as ceramics. In the hanging method, wood or chains are used to connect the muqarnas surface to the carrier surface. This method resembles the construction of suspended ceilings.

Many muqarnas classifications are generally based on al-Kashi's book Miftah al-Hisab, which he completed in 1427. The purpose of this book is help in calculate material and building construction costs and although its explain that there are four types of muqarnas units, it only details the simplest type. It is thought that since the study was written in the 15th century and was based on

only one muqarnas unit, this will create a classifying problem in muqarnas units, which are spread over a wide geographical region and use different construction methods.

Considering the widespread use of muqarnas, the differences in application, and the fact that drawings and tablets can create different products, it is thought that muqarnas masters used a common method in practice. For this reason, it is assumed that geometric decoration solutions, which have been widely used in Islamic Art and Architecture structures since the 8th century, can also be used in the classification of muqarnas, revealing a practical line in terms of application. It seems that it is appropriate in terms of both historical conditions and practice that the circle foundations in geometric patterns should be used to analyze and classify muqarnas.

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7. References

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