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RESEARCH ARTICLE

# The Study of Jahangir Dome and Guriye Stucco Decorations: With an Emphasis on Applied Geometry

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## Abstract

This paper tries to survey the use of geometric patterns in stucco decorations as an important identity and cultural element in the Sasanian era building designs. Seven frieze patterns were used in order to understand the practical geometry in Sasanian stucco. The studied stuccoes were found during archaeological excavations conducted between 2015 and 2017 at Jahangir Dome and Guriye Stuccos in Eivan, Ilam province. In this article, the discovered stuccoes have been examined, results of which indicate that stuccoes can be divided into three categories based on their features and applications: geometric patterns, vegetal patterns, and animal patterns. Comparing these stuccoes with those found elsewhere such as Qale Yazdegerd, and Ctesiphon shows that the buildings of Jahangir Dome and Guriye were noble houses in the Sasanian period, with their vegetal motifs and mythological animals being e formed under the influence of religious and ritual elements. The survey of motifs on the base with seven frieze patterns shows artists' adherence to the principle of symmetry and repetition.

**Keywords:** Sasanian; Stucco; Symmetry; Repetition; Geometric.



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## Introduction

Plaster is a versatile and inexpensive decorative material, which can be used to cover the exterior and interior surfaces of a building and has been popular in Iranian architectural decorations since ancient times, because of its workability and relatively low cost. At first, plaster was used to cover mud-brick walls to protect them from the weather, but gradually it was started using for decorative purposes due to its strength, sound absorption and high decorative properties. In the ancient world, the ornamentation was an inseparable part of architecture. In ancient Persia as well, it played a significant role as one can find the importance of ornament during Achaemenids, Parthians, and Sasanians and later during the Islamic period. In the Achaemenid period, the palaces of Persepolis had brick walls covered with a fairly thick layer of plaster. Also the wooden columns of the Treasury Room there were covered with plaster. In this period, palaces were decorated with reliefs and glazed bricks, and simple plaster was used to cover the wall and columns means the use of stucco was not common and decorative plastering was obtained in later periods (Schmidt, 1937: 19-54). But since the first century AD, the use of carved stucco on buildings became popular in Mesopotamia and Iran which saw a combination of classical and Near Eastern motifs (Simpson *et al*, 2012: 209). This form of ornament came to Iran as a Parthia tradition through Greece and Rome, and over time, it regained its Eastern qualities. The remains of Parthian stuccoes in Iran have been discovered in the places such as Kuh-e Khajeh, Qale Yazdegerd, Qale Zahhak, and Khorheh Mahallat (Rahbar, 2023: 56). Therefore, Sasanian architects benefited from the experiences gained by the Parthians. On the other hand, in the ancient world as Babylon, Egypt and Greek, the practice of geometry served as an intellectual means to conceive the order of the universe (Lawler, 1982) and it was used in various fields including architecture. The science of geometry is a powerful expression that allows architects to measure the proportions of space and create balance, order, and beauty in the building. So geometry became a tool for architects to develop sacred vegetal and animal forms and applied geometry was used for designing surfaces. Iranian architects were no exception to this rule. During the archaeological excavations at Jahangir Dome and Guriye, there discovered examples of stucco with different topics. The aim of this article is to introduce the stucco objects found on these sites and survey their patterns based on the applied geometry. To understand the seven frieze patterns or an infinite strip with a repeating pattern, three principles have been considered that include recovering the underlying transnational lattice of the pattern, classifying

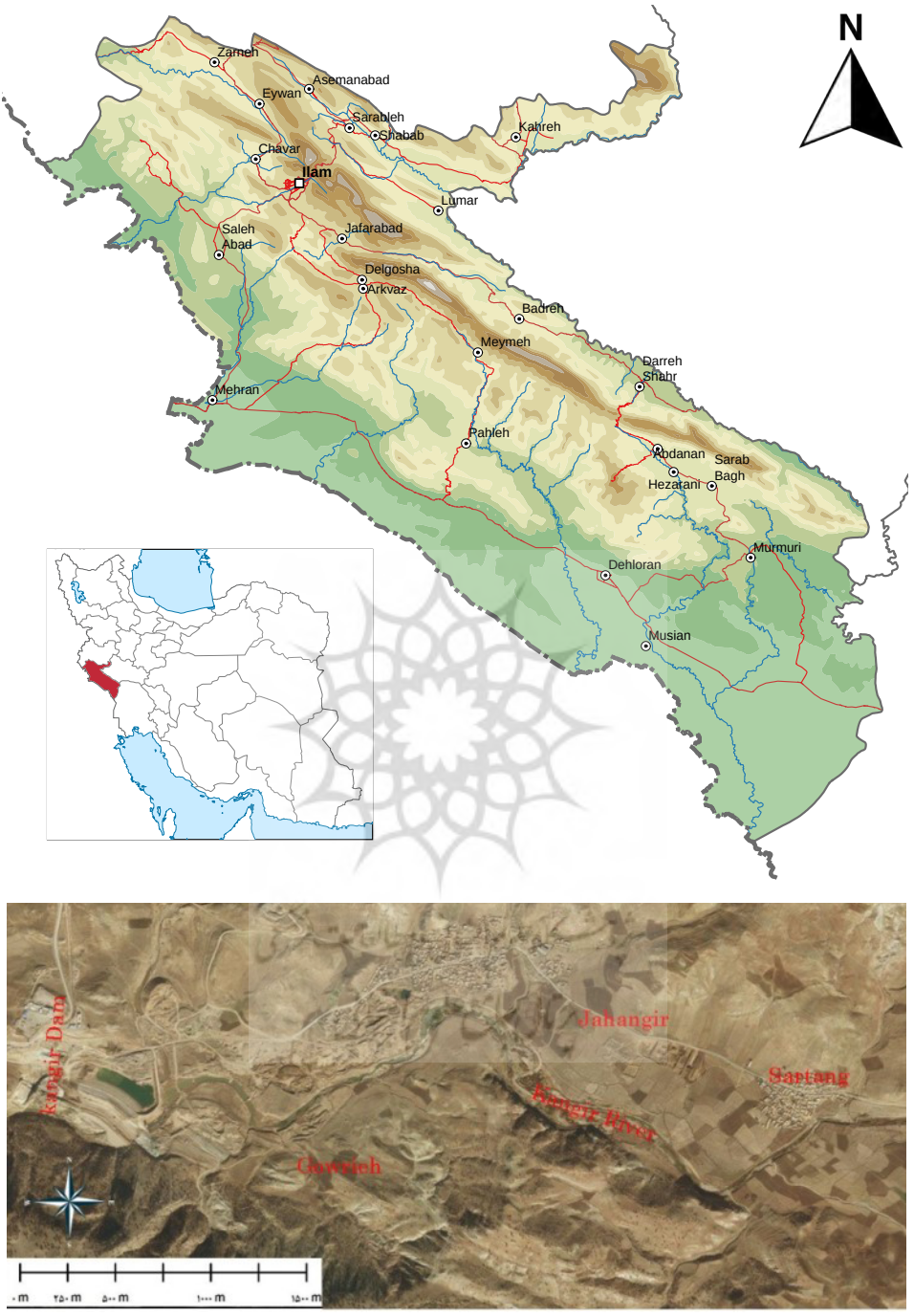


Fig. 1. The Map Showing the Geographical Location of Jahangir Dome and Guriye.
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the symmetry group of the pattern, and identifying a representative motif that perceptually characterizes the pattern. Therefore, figures and shapes

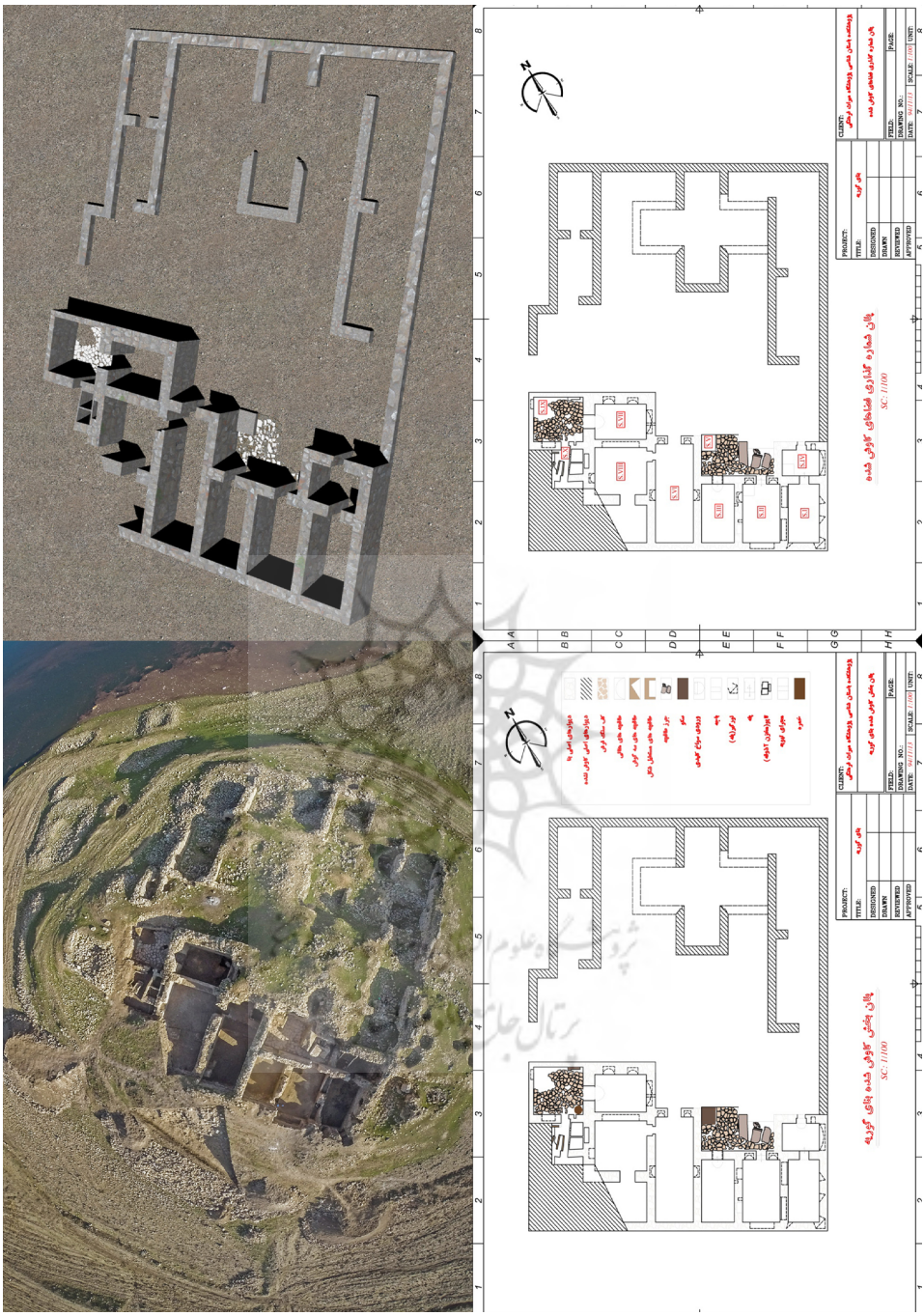


Fig. 2. Aerial Photos and Plan of Guriye

will be studied from simple to more complex ones. The geometric analysis of the stuccoes has been taken into consideration based on the design of decorative motifs, pattern repetition, and pattern extension.

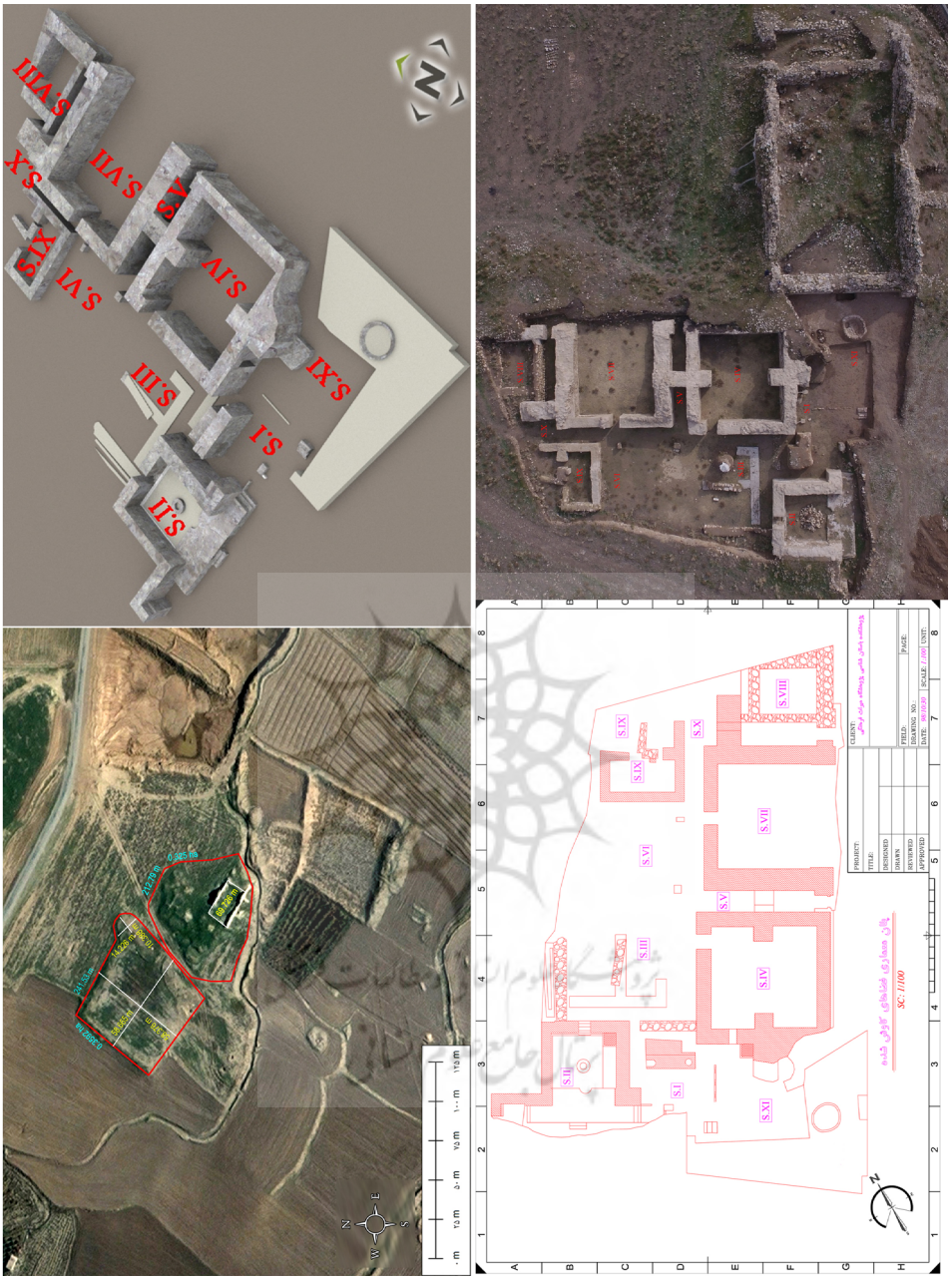



Fig. 3. Aerial Photos and Plan of Jahangir Dome (G.J)

## Description

Jahangir Dome and Guriye are located 50 km northwest of Ilam, in Eivan County and at a distance of 800 km from Sartang Village, on either side of Kangir River, facing each other (Fig. 1). This area is located in the middle of Zagros and is part of a road network with Mesopotamia.


Fig. 4. A View of Jahangir Dome Building, Floor, Walls, and Columns Covered with Plaster

The site is approximately 170000 square meters and is registered in the 2003 database of Iran's Ministry of Cultural Heritage, Handicrafts, and Tourism. Archaeological excavations were conducted between 2015 and 2017. During the three-season excavations by Leila Khosravi at Guriye sites (G) several large buildings with a square–rectangular plan and in west-east direction came to light at sections B2, B3, C2, and C3. The architecture included halls, porches, and rooms around courtyards, and plaster decorations were used for arches and doorways (Fig. 2).

Based on the excavation, Jahangir Dome (G.J) was a large building with a rectangular plan in the west–east orientation. On its southeastern side, there was a rectangular hall measuring 11×19 meters, and on the west and northwest, there was a square-shaped building of approximately 58×58

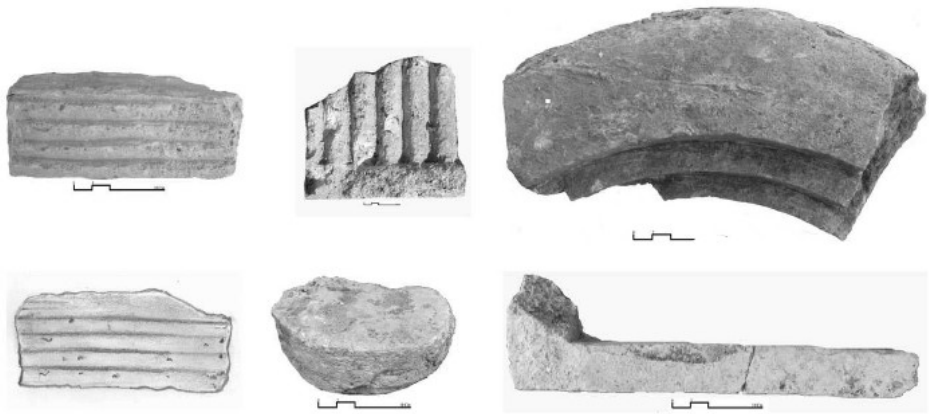


Fig. 5. Some Plaster Stuccos found in Jahangir Dome and Guriye

meters, with four round-shaped towers, each 14×10 meters in size. In the center, the plan of some parts of an enormous building with an area of 832 square meters was revealed that included 11 Spaces. The building contains a hall, porch, rooms, and a courtyard. Round or square walls, columns, domes, and stucco are some of the features of this structure where e mortar is in the form of semi-fired and semi-printed rubble and stucco (Fig. 3). The walls are varied in height, and are covered with a layer of plaster (Fig. 4).

One of the architectural features of the Sasanian period is the use of stucco in the decoration of buildings. Stuccos found at Jahangir Dome and Guriye are divided into two groups: 1. Stucco ornamentations related to architecture and used in arch, cornices of walls, and niches (Fig. 5). 2. Stuccoes used to cover surfaces. Their motifs include geometric, plant, animal, and human patterns used individually or in combination.

## Typology of Stuccos

Examination of the stuccos shows they can be divided into three categories: a) geometric patterns, b) plant patterns, and c) animal patterns. Geometric figures contain a large number of stuccos has geometric designs, with most of them being molded. Interesting patterns are lines, curves, and angles and sometimes vegetal ornamentations like floral and leaf motifs shown in a linear way (Baltrušaitis 1938). Geometric samples include intricate rhombuses, and interference T-shaped lines or Greek meanders, intricate triangles, intricate lozenges with a circle in the center, consecutive circles, and S-shape motif (Fig. 6). Similar decorations have been obtained from the sites of Tepe Hesar in Damghan (Schmidt 1937: pl. LXXIII, H1403) and Hājīābād in Fars Province (Kroger, 1982: Fig. 76), Chāl Ţarkhān in Rey (Thompson 1976: pl.XVI, Figs. 4–8), and Tepe Mil in Varamin (Ayyazi and Miri, 2006: 64).

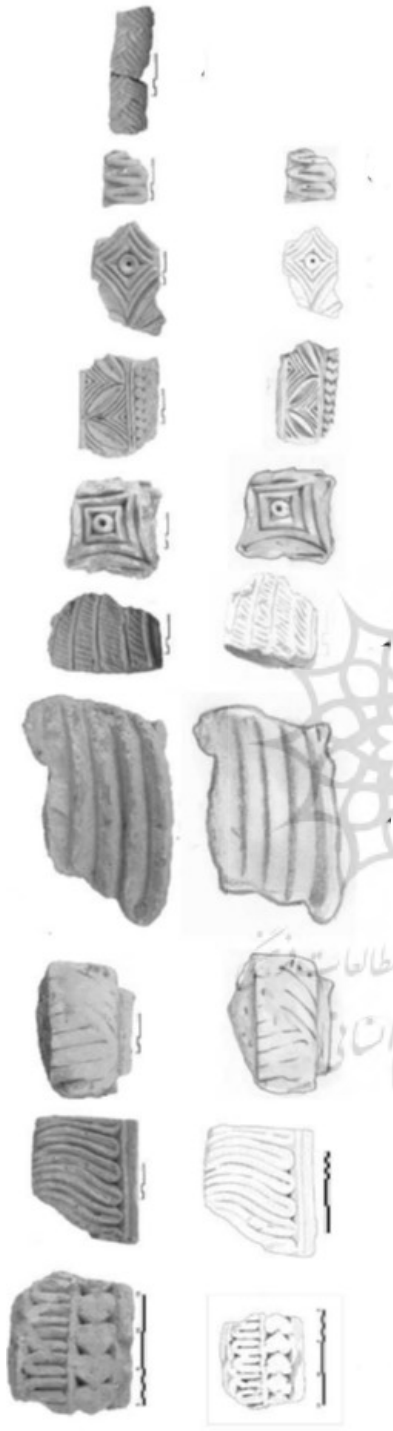


Fig. 6. Stuccos in Geometric Designs

Also, forms of stucco panels may be divided into four groups: 1. Circular forms, 2. Rectangular for decorative bands, 3. Square forms, 4. Semi-cylindrical forms.

## Circular Form

Circular plaques, most often depicting floral designs, were especially popular in the stucco decoration of the Sasanian period. It seems that such forms were produced from circular molds. In some cases, circular plaques might have been applied to stucco tiles of other shapes. Circular plaques weren't found in the stucco of Jahangir Dome and Guriye.

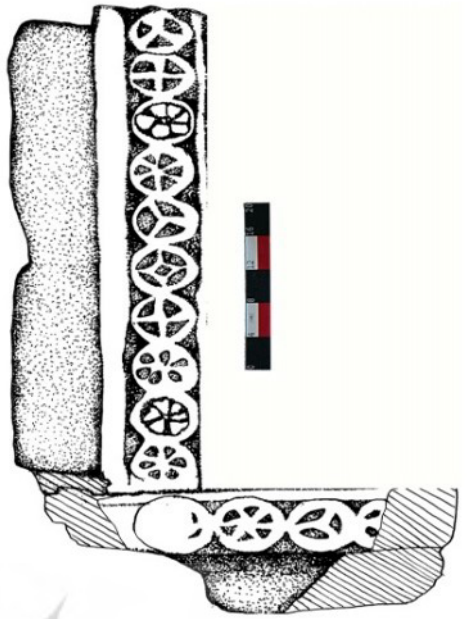
## Rectangular Form

Rectangular panels were mostly used to create decorative bands, often with repetitive designs. Such stucco bands were attached to the flat surface of the walls. A decorative frame was obtained measuring approximately 83cm long and 45cm wide, inside the circles. There are four-leaf flowers, six-leaf flowers, and a rhombus motif which are located in a rectangular frame (Fig. 7). Examples of this decoration are observed in Ctesiphon (Schmidt, 1934), Qale Yazdegerd (Keall *et al.*, 1980), Chāl Ţarkhān(Kroger, 1982) and Dastowā Shoshtar (Rahbar, 2023: 67).

## Square Form

Square panels were decorated with various representations including flo-

ral and geometric designs. A square form stucco frame was discovered measuring approximately 19 cm high, 14 wide, and 11cm in diameter, in the SII Guriye space and the motif is the spiral line (Fig. 8). Another stucco motif seen in Jahangir Dome with square form is a row of three-leaved flowers (Fig. 9). Examples of this decoration are observed in Ctesiphon, and Qale Yazdegerd with geometric, vegetal and animal motifs.



## Semi-cylindrical Form

Semi-cylindrical stuccos were applied in the corners of interiors. This type usually depicted floral designs with long stems and leaves. The stucco discovered measures approximately 53.5 cm in length and 30 cm in width, that include S-shaped motifs and are connected (Fig. 10). Examples of this decoration are observed in Qale Yazdegerd (Keall *et al.*, 1980).

## Motif Meander

A decorative frame was obtained measuring approximately 24.5 cm long and 17 cm wide, from the space of S.IV of Jahangir Dome, which is a combination of a lotus and decorative square-rectangle (Fig. 11). Meanders are one of the oldest orna Mazdayasna mentations of Greek complexes by inserting squares at regular intervals, the motif is expanded vertically and horizontally (Kruger, 1982: 99). This motif comes from Greek Maian-

Fig. 7. Stucco with Consecutive Circles in Jahangir Dome

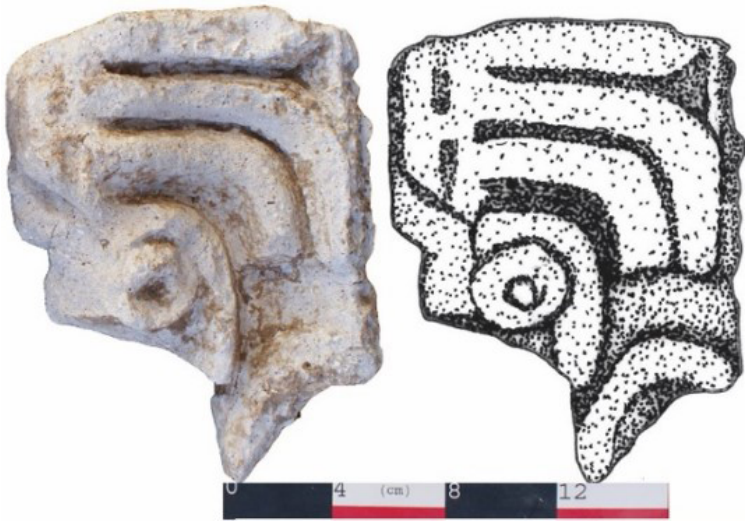



Fig. 8. Spiral Stucco from Guriye

dros, an old name for a winding river in Asia Minor that is now known as the Menderes. Apparently, this pattern, like some other motifs, entered Iranian art during the Seleucid era (Rahbar, 2023: 60). The meander motifs were considered decorative in the Parthia period and obtained in Kuh-e Khajeh and Qale Yazdegerd. Also, this motif was used by Sasanian architects and has almost always been used as a frame for decorations and sidelines in stuccos.

## Vegetal Motifs

Vegetal motifs obtained at Jahangir Dome and Guriye include motifs of a pomegranate, grapes, a three-leaf flower, and a lotus. The stucco frame with a lotus motif is seen in different forms at Jahangir Dome. The lotus motif is concentric, sometimes seen in the form of 6-petal or 8-petal shapes. These stucco motifs can be compared with lotus shapes on Sasanian stuccos from Mesopotamia; there is also similar stucco observed at Chāl Ţarkhān (Kroger, 1982: 152). The lotus motif in the stuccos of Jahangir Dome is shown with meander (Fig. 11), examples of which are observed in Qale Yazdegerd (Keall *et al.*, 1980), Dastowā Shushtar (Rahbar, 2023: 61), Chāl Ţarkhān and Kish (Watclin, 1938). In Iranian mythology, the lotus is the symbol of Anāhitā (Bundahišn, 2001, Section 9, Paragraph 119). Also, it is stated that "Every flower belongs to Amschāspandān and lotus belongs to Ābān" (Bahar, 2001: 88). Lotus is one of Xwarrah's symbols that point to the generation myth of the saviors of the Zoroastrian fire manifested and in the Sasanian thought and art. The stucco of lotus in the Sasanian era is due to the importance of this flower in the Zoroastrian religion and its significant status. It emphasizes its im-

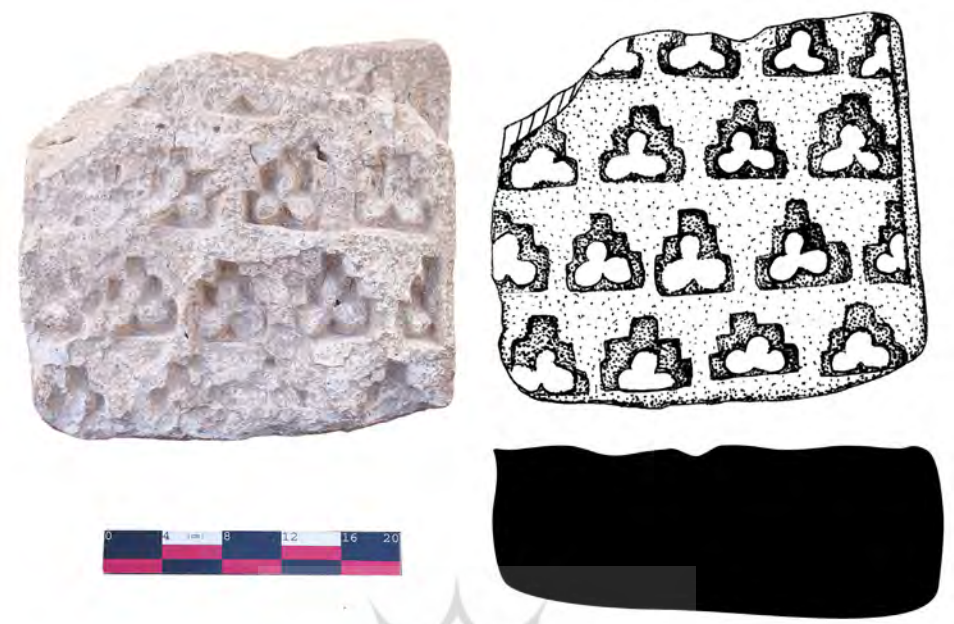


Fig. 9. Stucco Frame with Rows of Three-leaved Flowers at Jahangir Dome

portance and position as one of the religious elements during this period as "Xwarrah" (Rostami and Aryamanesh, 2020).

Also, a stucco frame measuring approximately 29 cm high and 25cm wide was found in the mansion in Guriye where four pomegranates found hanging from the branches and under it can be seen two branches with broad leaves (Fig. 12). There is similar evidence of this type of motif from the Sassanian site of Kish (Kroger, 1982: 67), Tepe Mil in Varamin (Ayyazi and Miri, 2006: 62), Hājjābād (Azarnoush, 2010: 42, Fig. 5) and Tepe Hesar in Damghan (Schmidt, 1937: pl. LXXIII, H1432).

The pomegranate tree is sacred according to the Mazdayasna religion and Zoroastrians as they used its branches and fruits in rituals. According to late Zoroastrian texts; Bersom is made of the pomegranate tree and is a symbol of immortality and fertility (Oshidari, 1992: 128). The pomegranate is mentioned several times in Pahlavi texts. This religious text has stated that the smell arising from the burning of the pomegranate wood drives away demons, and pomegranate wood is offered to the fire temple along with three other vegetals as atonement for sins (Pourdavood, 2006: 247, Avesta, 1995: 147, 146 and 139).

## Grapes and Ivy Motif

The grapes and ivy motif were observed at Guriye and Jahangir Dome stuccos.

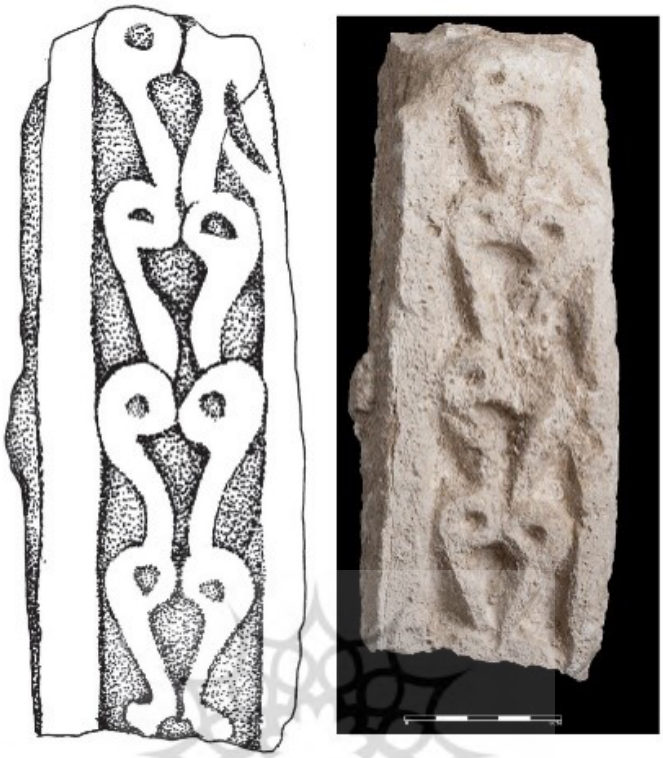


Fig. 10. Stucco with S-shape Motif

These motifs, arranged in a row with a particular order, are connected to each other by curved branches of this plant (Fig. 13) In ancient Iranian myths, grapes emerging from blood of a cow meant the attack of the devil. In the legends, it is said that fifty-five types of seeds and twelve types of medicinal plants grew in the place where this cow was killed (Warner, 2006: 367). Ivy is a symbol of fertility and abundance (Chevalier and Gerbran, 2008: 107). The samples are observed at Chāl Ţarkhān, and Ctesiphon (Kröger, 1982: 103.3, 96.4,94.6, 103.4), Qale Yazdegerd (Kaell, *et al.*, 1980: pls. Va, b, VIa, c P.33, Fig. 22-1) and Barz Qavaleh (Mansouri, 2011: 176, Fig. 51).

## Winged Horses Motif

The other discovered stucco pieces from Jahangir Dome and Guriye is animal motif such as winged horses. A stucco frame measuring approximately 83 cm long and 45 cm wide was discovered at Jahangir Dome, which shows two winged horses with their tails curled backward like a lion's and with a wing in flight (Fig. 14). Also, another stucco frame was discovered measuring approximately 29cm long and 5.15 cm wide showing a winged horse with an elongated body and flying (Brunner, 1978: 81).

A similar pattern of winged horses was observed on Sasanian textiles.

The winged horses are shown in profile, similar to ornaments with flowers and pearls (Panjehbashi and Mohazzab Torabi, 2022).

A survey of religious texts shows winged horse was considered holy. In Aban Yašt, it is stated that the beautiful arms of Anāhitā are like the shoulder of a horse (Yašt, 1998; 5/7) and are remembered Anāhitā as the giver of horses (Yašt, 1998, 5/86, Mosavi Kouhpar and Aryamanesh, 2018: 301). Also, in Bahram Yašt, paragraphs one to twenty-eight are about the incarnation of God Vartharghaneh. It was shown to Zarathustra in the form of wind, bull, horse, camel, young boy, bird, ram, deer, and man (Yašt, 1998 1/28).

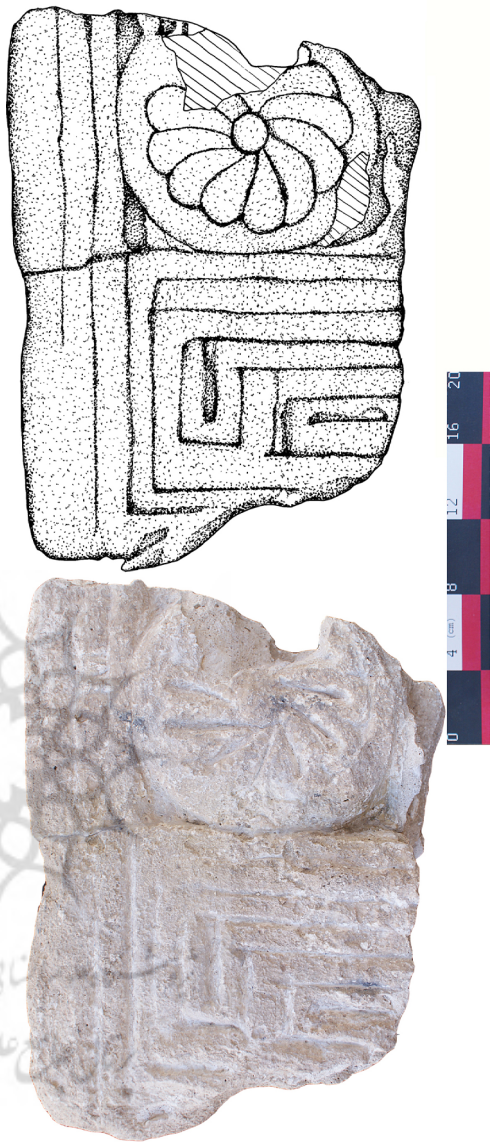


Fig. 11. Stucco with Meander Motif at Jahangir Dome

## Discussion

The science of geometry is a powerful expression that has allowed architects to measure the proportions of space and create balance, order, and beauty in buildings. Conceptually, geometry means the size and shape that allows us to imagine objects in a given space. The science of geometry, like all other sciences, originated from observation. Proportion is a mathematical concept meaning the proper relationship between the components and the work as a whole. Almost all works of art are based on some kind of proportion that expresses the harmonious relationship of its constituent elements (Bamanian, 2008: 15). These ratios are geometric that have an immaterial origin and show sanctity that follows spiritual and supernatural principles and has symbolic language and spiritual properties. Traditional geometry refers to spatial combinations and symbolic shapes which can be seen in

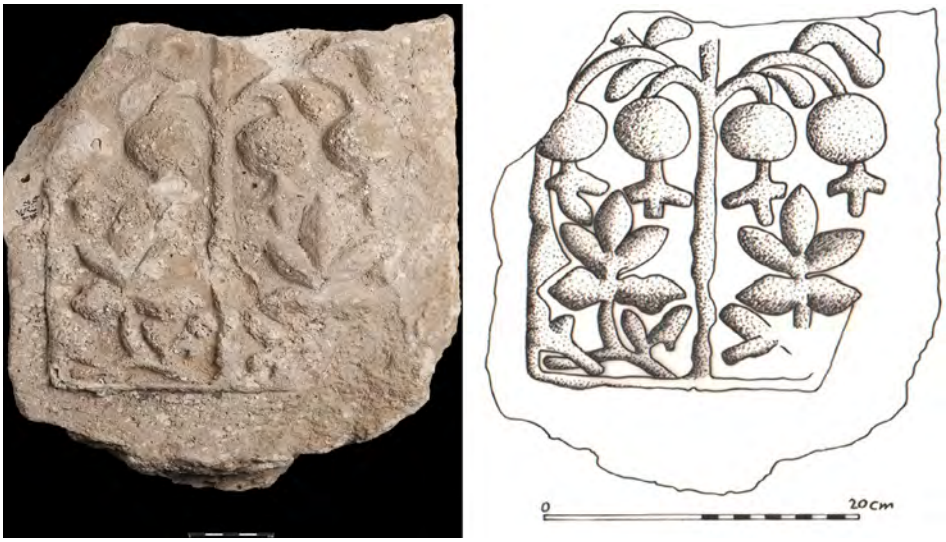



Fig. 12. Stucco with Pomegranate Motif at Guriye.

Fig. 13. Stucco Frame with a Grapes Motif at Jahangir Dome.

the form of shapes such as triangles, squares, various regular polygons, spirals in traditional perspective, and circles (Mansuori, *et al.*, 2023: 1-14). For a better understanding of ratios used in decorative stuccoes of Jahangir Dome and Guriye, they are to be investigated from the perspective of frieze patterns. In geometry, a frieze pattern is a two-dimensional design that repeats in one direction. Such patterns are common in architecture and decorative arts. Frieze patterns can be classified into seven types according to their symmetry and are two-dimensional line groups that repeat only in one direction, and crystallographic groups classify patterns that repeat in three directions (Coxeter, 1969: 47-49, Cederberg, 2001: 165-171). Therefore, a frieze is a repeating pattern with symmetry in one direction. A repeating pattern

can have rotational, reflective, or sliding reflective symmetry. Each stucco pattern is associated with one of seven symmetry groups and thus it has a unique characteristic. In the following, seven frieze patterns are summarized and introduced with icons (Table 1) (Liu *et al.*, 2004: 357, Kharazmi, *et al.*, 2012: 230-247). The frieze pattern can have different types of symmetry which includes: 1. Horizontal translation, 2. Fold rotation (rotation by 180 degrees), 3. Horizontal reflection (reflection axis is horizontal), 4. Vertical reflection, and 5. Horizontal glide-reflection composed of a half-unit translation horizontally followed by a horizontal reflection (Liu *et al.*, 2004: 357). In order to recognize the patterns, the first step is to identify links based on visual similarity or a parametric model (Hamey and Kanade, 1989: 1076-1088, Leung *et al.*, 1996: 546-555, Schaffalitzky and Zisserman, 1999). A more traditional image-processing approach to detect global pattern repetitions uses autocorrelation (Lin, Wang and Yang, 1997: 433-443). Due to the fact that the periodic pattern of the cycles was few in the studied stucco (two to three cycles), we have found correlations based on visual observation.

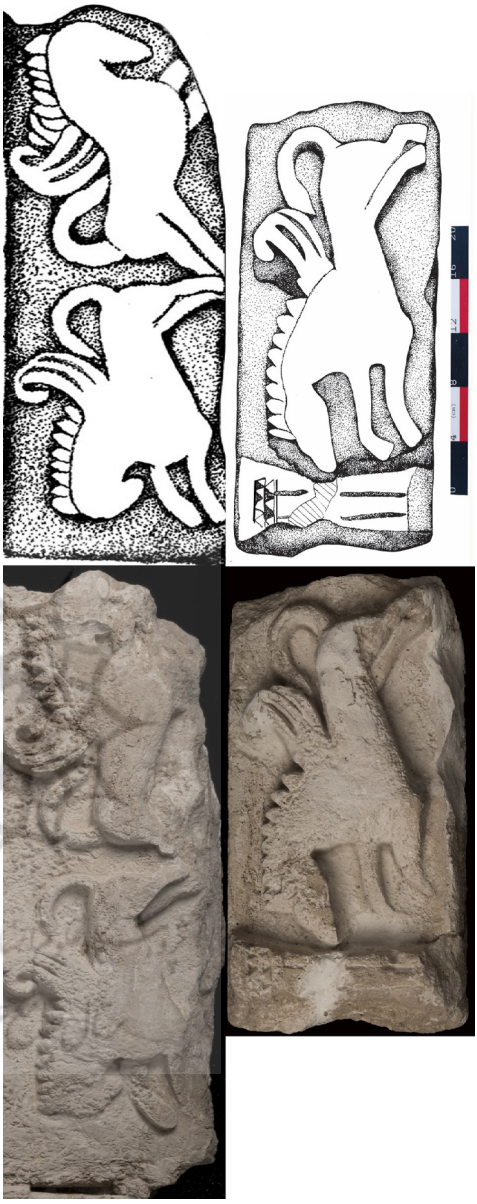


Fig. 14. Stucco with Winged Horses Motifs at Jahangir Dome

The stuccos of Jahangir dome and Guriye were studied based on Table 1 and the result show:

1. This sample has a simple repetition of one single motif drawn in an introductory module. This motif is drawn in a basic module and the subdivided lines are based on arcs of concentric circles. This pattern can be classified in the first frieze group, F1 as it contains only symmetry (Table 2).

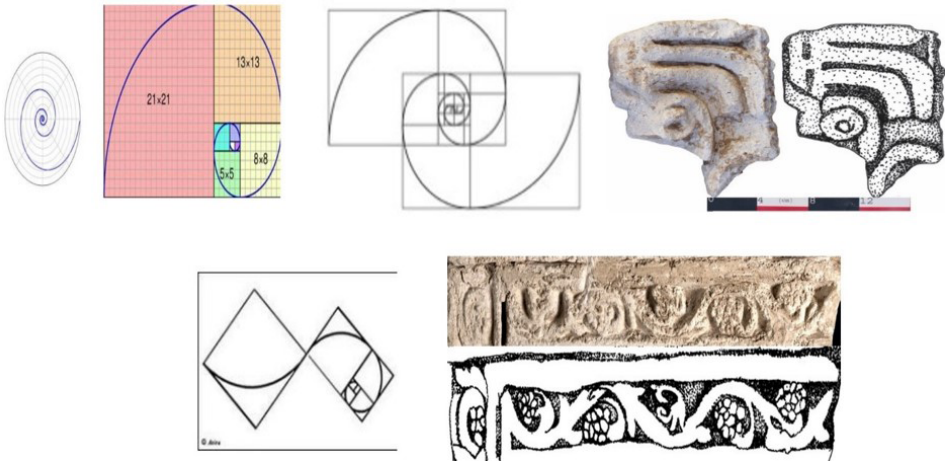



Fig. 15. The Spiral Pattern in the Stucco Decorations of Jahangir Dome and Guriya

2. In the second style stucco shows the whole panel comprising of two different motifs repeated in an alternating rhythm. The structure of the design shows that all motifs in this frieze are put in accurate places emerging from a geometrical dividing system. In order to surround two symmetrical parts of the motif, this frieze is based on a basic square frame, which is divided into two sections. By dividing each side of the square and by drawing the same square inside and also by drawing two tangent circles based on these subdivided lines, the motifs can be placed in an accurate form (Table 3). Therefore this group contains vertical reflection symmetries.

3. The frieze pattern that can be considered the fourth frieze group, F4, contains translation and rotation (by a half-turn) symmetries. that perhaps was created under the influence of Greek-Parthian art from the previous period (Kharazmi, *et al.*, 2012: 237) and it was very common in the Sassanian period. This design is found in the Jahangir dome in a combined form with a rosette (Table 5).

4. The fourth style of stucco shows the seventh frieze group, F7, which contains all symmetries, translation, horizontal and vertical reflection, and rotation (Table 4).

Studies show that Sasanian artists, in addition, used seven frieze patterns, including spiral ones in the decorations. The spiral pattern is based on the *phi* rule of mathematics, and this pattern was used in Parthian and Sassanian art. This number 1618 is equal and is closely related to the Fibonacci number and can be found in many examples in nature which in ancient Greece was called Divine portion (Duan, 2019). Through this, the artists created beautiful forms in which rhythm, movement, repeti-

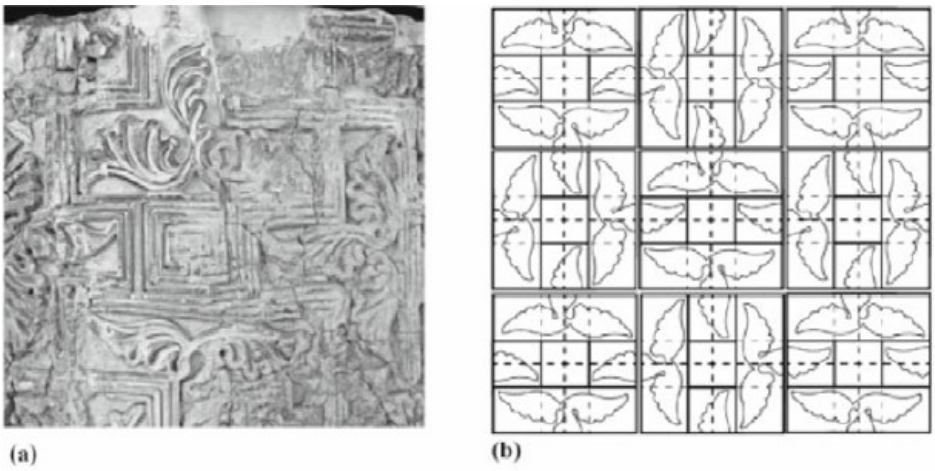



Fig. 16. Stucco of Sassanian at Ctesiphon with Combine Motif (Vegetal and Geometric Motif)

Table 1. The Symmetry of the Seven Frieze Patterns (Lui *et al.*, 2004)

| Symmetry Group | Arrangement | 180° Rotation | Horizontal Reflection |
|---|---|---|---|
| F1 | | No | No |
| F2 | | No | No |
| F3 | | No | No |
| F4 | | Yes | No |
| F5 | | Yes | No |
| F6 | | No | Yes |
| F7 | | Yes | Yes |

Table 2. A Simple Repeating Pattern of stuccos of Jahangir Dome and Guriye

| Symmetry Group | Sample of Stucco of Jahangir Dome and Guriye |
|---|---|
| | |

Table 3. Pattern of Mirror Image and Vertical Reflection

| Symmetry Group | Sample of Stucco of Jahangir Dome and Guriye |
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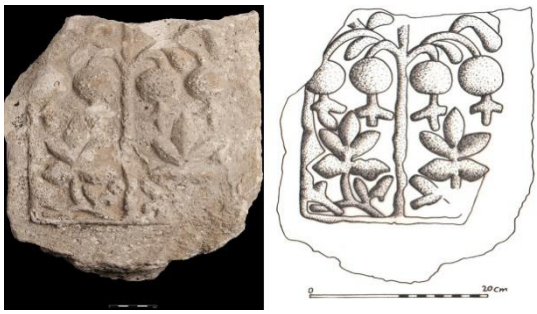
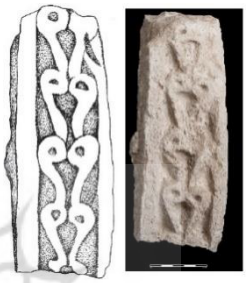
| ꟻ ꟻ ꟻ ꟻ |  |
| ꟻ ꟻ ꟻ ꟻ |  |
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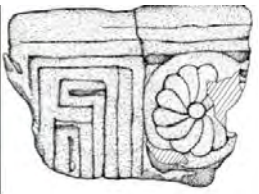
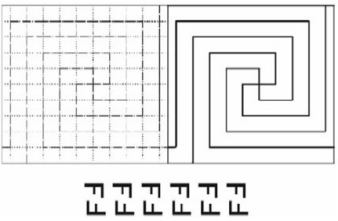
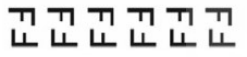
tion, and symmetry interlock. In early designs, this type of spiral was used only in simple lines with simple decorations such as small circles, and gradually, they used spiral bands (Fig. 15).

## Comparative Studies

For the interpretation of practical geometry and geometric frieze groups as organizing elements in the design of Sasanian stucco ornamentation, stuccoes obtained from Jahangir Dame and Guriye, Ctesiphon's Palace, and Qale Yazdgerd were used for comparative studies (Table 6). Comparative studies suggest that there are strong relations between the whole and parts, and architects paid significant attention to rhythm as the main element of design of stuccos. The one frieze group, F1 shows a simple repetition of one single motif. The third frieze group, F3 repeated different motifs in an alternating rhythm and containing translation and vertical reflection symmetries. The fourth frieze group, F4, contains a translation of half-turn symmetry and the seventh frieze group, F7, contains all symmetries, translation, horizontal and vertical reflection, and rotation. Investigations show that the stuccos of Ctesiphon Palace had more variety and com-

Table 4. Stucco based on the Pattern of Reversals with a Half Turn

| Symmetry Group | Sample of Stucco of Jahangir Dome and Guriye |
|---|---|
|  |   |
|  |  |
|  |  |

plexity than Jahangir Dome and Goriye. Sasanian architects created new and varied rhythms from simple rhythms. They created new and diverse forms by combining vegetal, geometric, and animal motifs, and with a rotational dividing system, created an ornamental panel. To create a decorative panel, designers shaped a quarter of a pattern to transform the negative area of square corners into new positive forms after the repetition of modules in the whole panels. In these samples, we can see relations between main circles and their role in forming secondary lines in the design (Fig. 16).

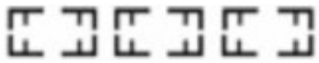
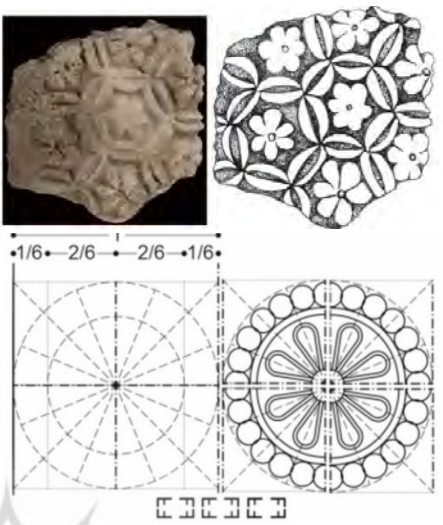
## Addendum: TL Dating of Jahangir Dome

Two pottery samples and two brick samples from Jahangir Dome have been dated using the thermoluminescence method. This method is used to obtain some information about materials containing crystalline minerals to a specific heating event which is useful for ceramics and silica-based materials. It determines the date of the last firing, as well as for flux or even sediments that were exposed to substantial sunlight (Michels, 1973). The dates of these samples are recorded somewhere between 549 and 650 AD (±60) (Table 7).

## Conclusion

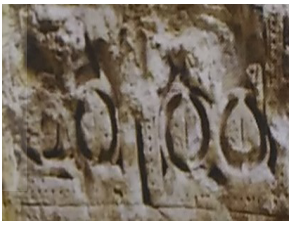
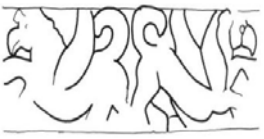
The findings of this research can be divided into two categories: 1. Sample stucco motifs from Jahangir Dome and Guriye are similar to those found in the Sassanian sites of Ctesiphon, Chāl Ţarkhān, Dastowā Shushtar, Tepe Mil Varamin, and Hājīābād Fars. Thus,

Table 5. Stucco with Flower Design based on the Pattern of Symmetry and Rotational Reflection

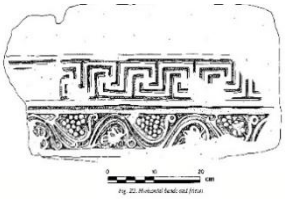
| Symmetry Group | Sample of Stucco of Jahangir Dome and Guriye |
|---|---|
|  |   |

based on the similarity of these stuccos, it can be said that these sites belong to the Sasanian period but these stuccos are simpler compared to those at Ctesiphon palaces and Qale Yazdegerd, this shows that this building was a noble house. By examining the symbols based on religious texts and mythology, it can be stated that the vegetal motifs and mythological animals were carved under the influence of religious and ritual elements. 2. In designing the patterns, the Sasanian artists used repeating units in such a way that we can categorize them into seven frieze patterns and these features show the Sasanian architects' understanding of geometry and the practical use of geometry in stuccos. Finally, comparing the designs of Jahangir Dome and Goriya, Qale Yazdegerd in Iran, and Ctesiphon Palace in Mesopotamia, results show that the architects used rhythm as the main element of design and by using simple rhythms created multiple rhythms and new ones. Thus, there observed the creation of new motifs with the repetition of primary motifs. Also using sinusoidal forms created the ornamental panel that was the basis of the reverse repetition of motifs. The designers first used a quarter of the design and then transferred it and in this way made a whole design with the help of rotational symmetry. They used the synchronization of polar geometry with rectangular geometry to create more complex patterns. The results of the TL dating showed sites date back to the late Sasanian era.

Table 6. Comparison of Plasterwork of Ctesiphon Palace, Yazdgerd Castle, Jahangir Dome and Guriye

| Symmetry Group | Stuccos of Jahangir Dome | Stucco of Ctesiphon (Pope, 1938). | Stuccos from Qale Yazdegerd (Keall *et al.*, 1980). |
|---|---|---|---|
| F1: Translation and Symmetries. Simple Repetition of Motifs |  |  |  |
| F3: Vertical Symmetry |   |  |  |
| F3: Vertical symmetry |   |  |  |
| F3: Vertical Symmetry |  |  |  |

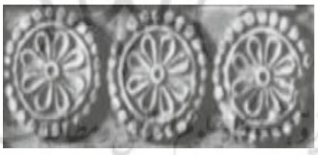
F4:



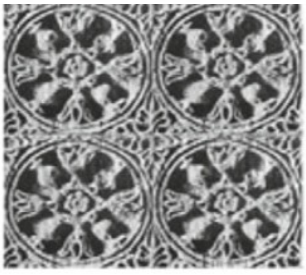
F4: Translation and Rotation Symmetries (by a half turn)

F4: Translation and Rotation Symmetries (by a half turn)

F: Translation and Vertical Reflection Symmetries



F7: Translation, Horizontal and Vertical .Reflection, and Rotation Symmetries



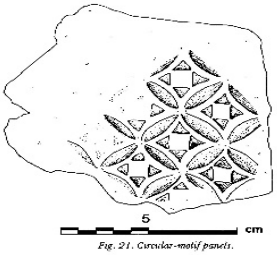



*Fig. 21. Circular-motif panels.*

Table 7. Chronology of Potteries and Bricks, Jahangir Dome and Goriye

| Number | Type | Depth (cm) | $K_2O$ (wt.%) | Thorium (ppm) | Uranium (ppm) | Chronology (AD) |
|---|---|---|---|---|---|---|
| 1 | Pottery | 180-250 | 2.07 | 3.21 | 40.04 | 551 -606 |
| 2 | Pottery | 25 | 50.77 | 3.52 | 5.97 | 549 -689 |
| 3 | Brick | Surface | 1.96 | 2.27 | 4.94 | 557-631 |
| 4 | Brick | Surface | 1.75 | 2.88 | 4.66 | 569-612 |

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