DETERIORATION PROBLEMS AND PIGMENT ANALYSES OF THE QAJAR PERIOD WALL PAINTINGS FROM SHAH BATH IN ISFAHAN

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ABSTRACT

Throughout history, Iranian painting has encountered heterogeneous cultures and traditions of the East and West. Different kinds of paintings have been seen in Iran but one of the most common is wall painting. In Iran, one of the most impressive period of wall painting decoration was the 15th century Qajar period. In this period, the style of Qajar paintings is a combination of wall painting style in the Safavid period and classical European painting. At the beginning of Qajar period, Iranian inspiration was more prominent than the follow-up times. At the end of this period, the influence of the European style becomes more dominant on Iranian paintings. In Qajar period, even the baths were also covered with wall paintings. In this study, one of the best examples of bath, Shah Bath, was examined in terms of architectural, historical, archaeological, material characteristics and their deterioration problems. In addition, the chemical analysis has been applied to the wall paintings to determine the type of pigments. The wall paintings were also investigated in terms of construction techniques. As a result, the effects of the deterioration of the wall paintings and the damages caused by different reasons and the effects on the paintings were evaluated.

Keywords: Iran, Tempra, Gypsum, FTIR, Spot Tests

KAÇAR DÖNEMİ İSFAHAN ŞAH HAMAMI DUVAR RESİMLERİNDE BOZULMA PROBLEMLERİ VE PİGMENT ANALİZLERİ

ÖZET

Tarih boyunca İran resmi, Doğu ve Batı'nın heterojen kültürleri ve gelenekleriyle karşılaşmıştır. İranlı ressamlar, her şeyi en basit çizgilerle ve ikna edici görünen en saf renklerle göstermişlerdi ve Batı geleneklerinin adaptasyon döneminin aksine, İran resimlerinde naturalizmin belirtisi bulunmamaktaydı. İran'da, duvar resmi dekorasyonunun en etkileyici dönemlerinden biri de, 15. yüzyıl Kaçar dönemi idi. Bu dönem, Qajar duvar resimlerinin tarzı, hem Safavi döneminin hem de klasik Avrupa resminin birleşimini içermektedir. Kaçar döneminin başında İran etkisi, dönemin ortasında ise Avrupa etkisi daha fazlaydı. Bu sürecin sonunda, Avrupa resim stilinin etkisi İran resmi üzerinde daha baskın bir hale gelmiştir. Kaçar döneminde hamamlar bile duvar resimleriyle kaplanmıştır. Bu çalışamada, Kaçar dönemi hamamların en güzel örneklerinden biri olan Şah Hamamı, mimarisi, tarihi, arkeolojisi, maddi özellikleri ve bozulma sorunları açısından incelenmiştir. Bununla beraber, hamamın duvar resimlerinin pigment türlerinin belirlenmesine yönelik kimyasal analizler de uygulanmıştır. Ayrıca duvar resimleri yapım teknikleri açısından da incelenmiştir. Sonuç olarak, söz konusu duvar resimlerinin bozulmalarının kaynağı ve farklı nedenlerden kaynaklanan zararları ile resimler üzerindeki etkileri bu çalışmada değerlendirilmiştir.

Anahtar Kelimeler: İran, Tempra, Alçı, FTIR, Spot Testler

1. INTRODUCTION

Wall paintings are one of the most important decorations in historical monuments and perhaps the flourishing periods of this art are the products of thoughtful adaptations and new innovations. However, despite all the transformative effects, there is a kind of inner affinity in the historical developments of Iranian paintings (Pakbaz, 2001, p.30). The apparent resemblance to the surviving episodes of the pre- and post-Islamic Era, including the similarity of the hunting session, in the three Parthian periods, the Umayyad, and the Safavid, suggests the formation of surviving episodes from a certain pattern, although surviving episodes reflects different tastes and desires (Pakbaz, 2001, p.31).

This similarity is due to the continued prolongation of artistic traditions in Safavid period in Iran. The Iranian artist has been focusing on idealizing prototypes and has been keen to portray the world of his imaginations. When it comes to the world around him, he will not want to imitate the three-dimensional space, light and shadow, form, and the color of objects.

The Iranian painters show everything with the simplest lines and the purest colors, which seems convincing, and in contrast to the period of the adaptation of Western traditions, there is no sign of naturalism in Iranian paintings. In return, abstracting and symbolizing have been common since the oldest times in the visual art of this land. The basic aesthetics of Iranian painters have also been shaped and developed on the basis of this abstract understanding of the world (Pakbaz, 2001, p.32). In the approach to pure aesthetics, the Iranian painter has never forgotten to notice human and human values. Also, heroes and events have emerged from the depths of collective memory.

2. HISTORICAL AND COMPARATIVE STUDIES

2.1. History of Isfahan

History of Isfahan dates back to the history of Iran. The construction of Isfahan is attributed to Tahmooreth, the third king of the Pishdadiyan dynasty. Isfahan was named (Gay) in ancient history in Persian. The city was the intersection of major roads and the royal residence of the Achaemenid kings.

The Greek geographer Strabon, 2000 years ago, referred to Isfahan as the center of the country of Iran. The Muslims named this city (Jay) and throughout history it was called the Ispahan or the city of riders, as well as Safahan and Safahoon. The entrance of Islam and its expansion, the deep impact of Islamic culture on the construction of the city of Isfahan, and existence of Iranian artists in this city made Isfahan one of the most beautiful religious cities in the world with valuable cultural displays, including mosques, minarets, and religious Islamic schools. In the Deylamian period, Sahib bin Ebad turned Isfahan into a center of science and art and brought scientists and scholars there. At the same time, a Baro was built with 21,000 steps in Isfahan. During the Seljuk period, Isfahan flourished by the mosques, palaces, gardens, and majestic mansions. Mogul invasion brought many injuries to this city and its boom was diminished (Westerman, 2004).

2.2. Isfahan During the Qajar Period

After the Qajars took Iran, Aqa Muhammad Khan chose Tehran as the capital, and the ruined and forgotten Isfahan remained in a halo of forgetfulness (Loti, 1993, p.20). Even Mirza zel al-Sultan, who ruled and resided in Isfahan, did not do much to organize it. From time to time, the Qajars were only paying attention to repair or restore the buildings which they settled in.

Several of the Qajar Revolutionaries relied on repairs of mosques, schools, etc., and even occasionally constructing these buildings, including Mohammad Hussein Khan Sadr Isfahani, Chahar Bagh Sadr street, which is imitated from Chahar Bagh Shah Abbasi, Sadr high school in bazar, and Paye Ghale school (Loti, 1993, p.20).

2.3. History and Architecture of Shah Bath

Shah Bath is located at the beginning of the bazaar and close to the Mullah Abdullah school. There is no historical inscription in the Shah Bath, however, according to the sources, it seems that Shah Abbas I Safavid commanded to build this bath (Honarfar, 1971, p.470). No information is available about its creators. Jean Shardin mentioned in his travel letter to the bath that Shah Abbas I had built this bath for bathing and allowed the public to use it on some days (Chardin, 1995, p.1420).

Shah Bath has been built during the Safavid period and probably at the same time with the Mullah Abdullah school which is near it (Honarfar, 1971, p.471). This building has been restored in the contemporary period and has been used till a few years ago (Honarfar, 1971, p.472).

Shah Bath, like most baths, consists of two main spaces: the Sarbineh and the Garm khaneh. The Chal hoz is beside the Garm khaneh, which is a big part of the building. The base of the Sarbineh is octagonal shape, which is covered by a formal arc. On the four sides of this space, large platforms are located above the floor, which have a shorter ceiling. In this way, there are separated places on the four sides of the Sarbineh. Lighting of the middle space of the Sarbineh comes from the light platform at the middle of its roof and other platforms have separate lighting. The base of Garm khane is also octagonal shaped and has booths around. On the north-east side of the Garm khaneh, there was a space called the Kise kesh khaneh, where the water was coming from a large pool which was located in the next area. On the opposite side, there is a space with a vast pool in the middle. Also, on the south-east of Garm khaneh, Khazineh of the bathroom is located and the Tun is behind it. The entrance to Khazineh is through a small entry that is blocked today.

The bath has two entrances in different directions. The main entrance is located next to the bazaar (Fig. 1). On top of the main entrance door there are painting on the gypsum and tiling. In the Hashti part of this bath, paintings can be seen on the gypsum.

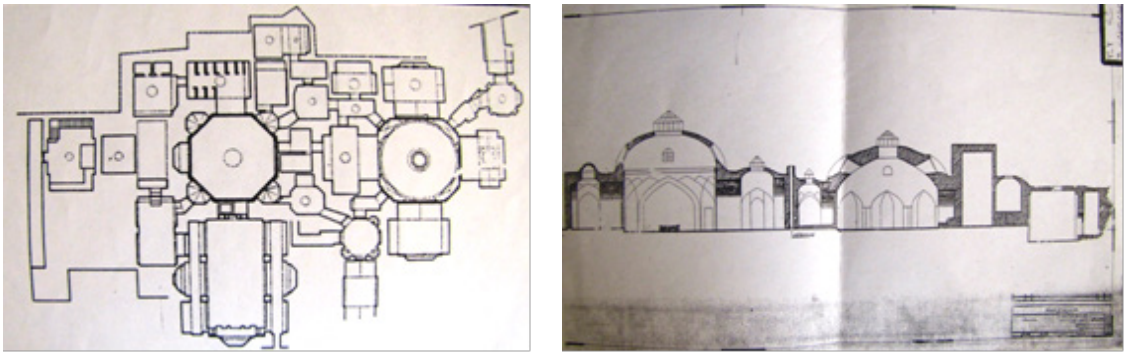

Figure 1. Plan of Shah bath in Isfahan (on the left), view of Shah bath in Isfahan (Cultural Heritage Documentation Center in Isfahan)

2.4. Decorations in the Shah Bath

Various decorations have been used in the Shah bath (Fig. 2a-2g). These decorations are related to different historical periods. In the Hashti part of the bath that leads to the Sarbineh, there are two decorative layers: the later layer is painting and the older layer is decoration with lime (Fig. 2c). This decoration with lime belongs to the Safavid era. It has flowers and bush motifs and is made of dark blue (Fig. 2e). On this decoration with lime there is another layer of painting on the gypsum that shows a sitting hero who is related to the Qajar period (Haji Ghasemi, 2004, p.5).

In the western part of the Shahneshin, there are also three layers of painting (Fig. 2d). The latest layer is related to the Qajar period and depicts heroes. It cannot specifically be determined which period the two older layers are related to. However, since this bath was built during the Safavid period, it can be said that

the older layers may be related to the Safavid period. There is also a painting on the gypsum in the eastern side of Shahneshin, which was hidden behind a wall. This painting behing the wall was discovered during excavations and studies (Fig. 2g). The design of this painting is in Slimi motif which is drawn by arch lines and is similar to the paintings in Ali Gholi Agha bath (Fig. 2f).

There are carvings in the Sarbineh which is the place of shoes and dresses of those who took a shower in this bath. At the top of these carvings, there are tiles that are blue and yellow. Under the dome of the Sarbineh, there are also slimi motifs that most likely belong to the Safavid period. These slimi motifs are known as snake slimi. Beside these slimis, there are paintings which depict angels who have interconnected eyebrows. Interconnected eyebrows show that this painting is related to Qajar period. There were numerous decorations in the Shah Bath, some of which were repaired by Mr. Aqajan. On top of these Slimi, there are tangled motifs around the dome of the Sarbineh some of which have been restored (Fig. 2c).

Finally, on top of the main entrance of this bath, there is also a painting on the gypsum which is related to the Qajar period. In this paper, this painting will be evaluated.

2.5. A Brief Description of the Qajar Period Paintings

The style of Qajar paintings includes a combination of wall painting style in the Safavid period and classical European painting. At the beginning of Qajar period, Iranian influence is more dominant. In the middle of Qajar period, Iranian source is equal to European source. Finally, at the end of this period, gradually the influence of the European style becomes more than Iranian source to the point of causing Iranian painters making copies of Renaissance paintings. The reign of Mohammad Khan Qajar has not left good paintings, but in contrast, many oil paintings from the reign of Fath Ali Shah and Mohammed Shah have remained. In the reign of Fath Ali Shah, the painters of the court drew many portraits of him. Now more than twenty portraits remain. Examples of those portraits can be seen in Iranian museums from painters such as (Mirzababa) and (Mehr Ali) (Sharif Zadeh, 1996).

The style of painting in this period at the beginning was similar to the oil painting of Zandieh period, and many painters of the court of Zandieh also painted in the court of Fath Ali Shah. The greatest differences between Qajar and Zand paintings are in the colors of these images. The dominant colors in Zandieh era were green and other colors that are in harmony with green. In Qajar era the dominant colors were different tones of red (Pakbaz, 2001, p.51).

2.6. The History of the Paintings on the Gypsum in Iran

The painting on the gypsum dates back to a much earlier time. The first example of gypsum painting dates back to the Achaemenid period and in the Persepolis, with no traces remaining and only speculation. There are also some paintings in the Dahaneye Gholaman in the province of Sistan and Baluchestan, which are on the gypsum substrate (Seyf, 2000).

a)

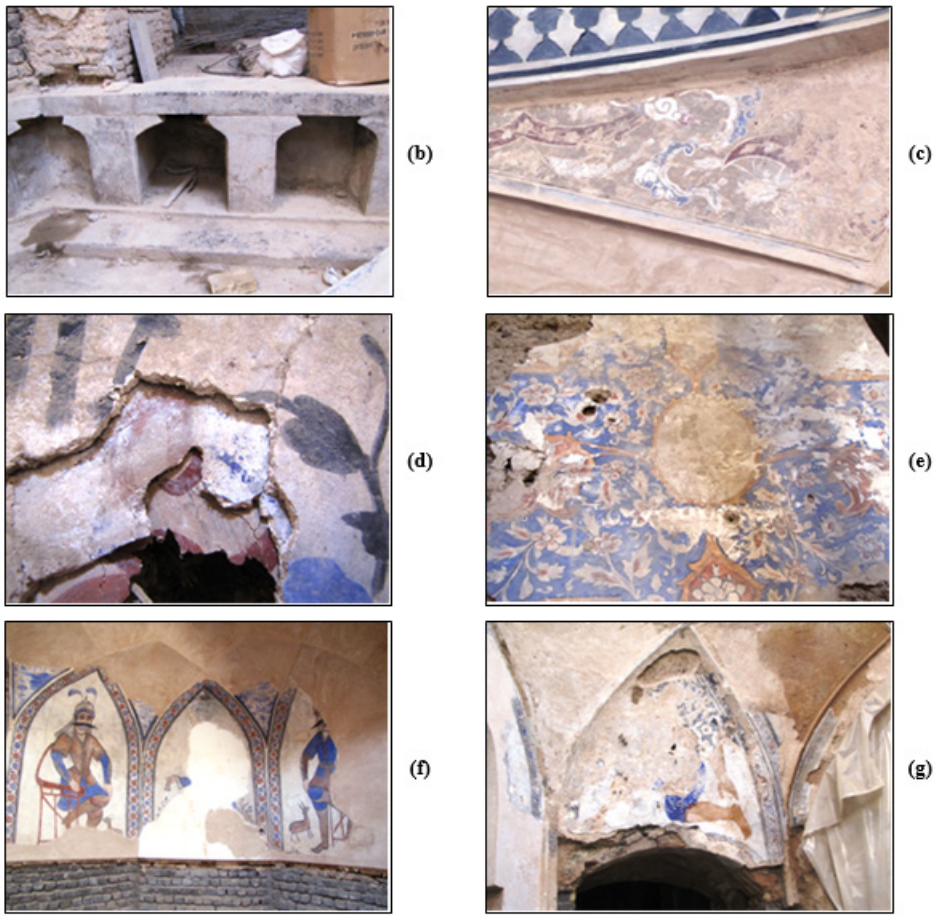

Figure 2. Decoration of Shah Bath; general view (a), entrance (b), slimi motif (c), layers of the wall (d), decoration on gypsum plaster (e), figures on the gypsum plastered wall (f) and details of the wall paintings (g).

After that, valuable paintings have remained from the era of Partian that were affected by Achaemenid art. These paintings are generally related to Khajeh Mount. During the Sassanid period, the use of gypsum in the construction of the building and the decoration was very expanded. Gypsum also provides a wide, flat surface that makes a perfect flat for painting. Like the walls of Doraropus from the reign of Shapur I which were decorated with paintings (Fig. 3).

Figure 3. Wall painting of Doraropus

At the beginning of the Islamic era, especially in the first two centuries, no wall paintings were created in Iran, due to the intellectual transformation of the people and the ban on the portrayal and iconography of Islam. Previously, with the exception of paintings of Mani, paintings in Iran were created by the images of man and nature, which limited the work of painters after Islam. The first paintings on the gypsum after Islam, are located in the palace of Khalife Mu'tasim Abbasi near Samaria. But in Iran, the rebirth of plastering after Islam dates back to the Samanid era, which can be seen in Neyshabur and Khorasan. However, over time, the use of tiles in buildings was developed and led the painters to focus on the visualization of books. But again, during Safavid period, wall paintings have been created based on the imitation of commonly painting methods on gypsum and in costly buildings by foreign and Iranian painters.

In Zandieh era, painting on gypsum and carving were improved together. This process continued in the following periods till painting on canvas was entrenched in Iran and after that there was no longer any interest in painting on gypsum.

2.7. Introduction of the Paintings above Shah Bath Entrance

The mentioned painting is on the gypsum substrate of Shah bath in Isfahan. The Shah bath is located on the northeastern side of the Naghsh -e- Jahan Square and at the end of the Ghannadha Bazaar. This bathroom is next to the Caravansarai and the Shah Zarab Khaneh. The Shah bathroom has two entrances: the first entrance from the Shah bazaar and the second entrance from the Davat Garaha bazaar (Haji Ghasemi, 2004, p.5). This painting is located at the entrance to the Shah bazaar and belongs to the Qajar period.

The design of this painting is a combination of blue Slimi motif, angel, and bird motifs. The angels are symmetrically arranged on both sides of the painting, creating a hypothetical square. One of the angels has been repaired in the past incorrectly (Fig. 4).

Figure 4. Paintings above Shah Bath entrance

2.8. A Comparison Between the Paintings above Shah Bath Entrance with the Roof Paintings of the Vasigh al-Dawleh House in Isfahan

The common theme of these two paintings is the use of the angel motif in both. So, angel motifs which are used in these two paintings will be compared. The angels that have been painted on the roof of the Vasigh al-Dawleh house are females with long black hair and interconnected eyebrows. However, the angels that have been painted above Shah bath entrance are male. The wings of both angels are green, and the shape of their wings are roughly the same. Only the wings of angels in the Vasigh al-Dawleh house are bigger and the tip of these wings are narrower and sharper. The angel's wings of the painting in Shah Bath are smaller and the tip is wider. The angel's hands in the Vasigh al-Dawleh house are locatedon the same side of the body, but the angel's hands that have been drawn in Shah bath are open and express a flight condition. The shapes of the legs of both angels are slightly bent and apart. Only the angel's legs in the Shah bath are

(a)

more open than the other angel. Eventually, the form and motion of the angel in the Shah bath is smoother and more realistic than the angel in the house of Vasigh al-Dawleh (Fig. 5).

Figure 5. Paintings above Shah Bath entrance (on the left) and roof paintings of the Vasigh al-Dawleh house (on the right) in Isfahan.

3. ARCHAEOMETRIC STUDIES

3.1. Sulphate Test

The first step in conducting laboratory studies of the painting was the identification of the substrate. Since the substrate was similar to the gypsum, sulfate test was used (Feigl, 1966).

Steps to perform the sulphate test:

1. A small amount of the substrate sample was powdered.

2. The sample was poured in a test tube.

3. The sample was dissolved in distilled water.

4. Barium chloride ($BaCl_2$) was added to the sample.

5. Observing white sediment shows that sample is gypsum.

The result of the sulfate test was positive. So, the substrate of the painting has been determined as gypsum.

3.2. Identification of Pigments Used in the Paintings

The pigments were identified by wet chemical analyses. This method is a qualitative identification method and specifies the type of pigments.

3.2.1. White Pigment

The following two tests were performed to identify the white pigment:

1. The effect of the Sodium hydroxide (NaOH) on white pigment:

A small amount of the white pigment was dissolved in distilled water. After that some Sodium hydroxide (NaOH) was added to the sample and had no effect on it.

2. The effect of the Hydrochloric acid (HCl) on white pigment:

A small amount of the white pigment was dissolved in distilled water. After that a few drops Hydrochloric acid (HCl) was added to the sample and it was observed that the sample was dissolved in Hydrochloric acid and Carbon dioxide gas was released and started to boil.

From these two tests, it was concluded that white pigment was calcium carbonate white ($CaCO_3$).

3.2.2. Red Pigment

Two tests were performed to identify red pigment:

1. The effect of the Sodium hydroxide (NaOH) on red pigment:

A small amount of red pigment was dissolved in distilled water. After that some Sodium hydroxide (NaOH) was added to the sample and had no effect on it.

2. The effect of the Potassium ferricyanide $K_3[Fe(CN)_6]$ on red pigment:

A small amount of red pigment was dissolved in distilled water. After that a few drops of Nitric acid was added to the sample in order to create acidic medium. At the end, a few drops of the potassium ferrocyanide was added to the sample and it was observed that Prussian blue sediment was created which indicates the presence of Iron cations. According to these two tests, it can be concluded that the red pigment was Indian red.

3.2.3. Blue Pigment

The following test was performed to identify the blue pigment:

A few drops of dilute acid was added to the sample, the pigment was dissolved, and the Hydrogen sulfide gas was released. Also, at the bottom of the test tube, the sulfur sediment and a silica residue remained. The release of hydrogen sulfide gas can be detected due to its specific smell. This particular smell reflects that the blue pigment was Lapis lazuli.

3.2.4. Green Pigment

The following two tests were performed to identify the green pigment:

1. The effect of the Potassium ferricyanide $K_3[Fe(CN)_6]$ on green pigment:

A: A small amount of green pigment was dissolved in distilled water.

B: A few drops of reagent of potassium ferrocyanide $K_3[Fe(CN)_6]$ was added to the sample.

C: In the presence of iron cations, the solution becomes Prussian blue color.

For this sample, the test was answered positively.

2. The effect of the Ammonia (NH_3):

A: A small amount of green pigment was dissolved in distilled water.

B: A few drops of ammonia solution was added, and white gelatinous sediment was created.

According to these two tests, it can be stated that the green pigment was silo green.

3.2.5. Black Pigment

The following two tests were performed to identify the black pigment:

1. The effect of Aqua regia (HNO_3+3HCl) on black pigment:

A small amount of black pigment was poured into Aqua regia and after some minutes it was observed that the sample was dissolved in Aqua regia.

According to this test, it can be said that the sample was not soot, because the only black pigment that is not soluble in the Aqua regia is soot.

2. The effect of Ammonium Thiocyanate (NH_4SCN) on black pigment:

To the dissolved sample in aqua regia, some ammonium thiocyanate was added, and the solution turned to red color which indicated that the sample has some quantity of iron cationic (Fe^{3+}).

3.3. Checking the Painting Layers

Checking of the painting layers was done to determine which layers the painting is made of. To check the painting layers, first of all, the thin section of painting was prepared, and this thin section was assembled by resin and hardener (Araldite).

First, a drop of Japanese glue was poured onto the sample and after drying, the sample was placed in a small mold and 50.50% resin and hardener were poured onto it to cover the sample. After 24 hours, the surface of the resin was flattened with a soft sandpaper to reach the surface of the sample. At this time, the sample was prepared for examination under the microscopy of metallography.The sample was examined under a metallographic microscope and it was concluded that the sample contains the following layers: paint layer, intonachino layer, and substrate layer (Fig. 6).

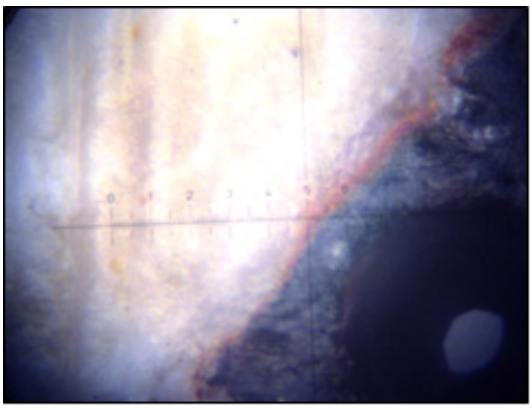

Figure 6. Painting layers (paint layer, intonachino layer, and substrate layer)

3.4. Identification of Binder

Wet chemical analyses did not respond to the identification of the paint binder. For this reason, FTIR analysis was used. FTIR analysis was used to determine the paint binder which was used in the Lapis lazuli pigment. FTIR analysis shows that the binder is gum arabic.

4. TECHNOLOGY

4.1. Technique of Wall Paintings

The wall paintings on the gypsum, both on the wall and on the ceiling, were not so easy to paint. First, the wall or the ceiling for painting were covered with a mortar which is made of clay and straw. This mortar

covered the surface of the bricks. The ceiling or the wall, which was covered with clay and straw mortar, then was covered with additional layers of gypsum. When the gypsum dried, the wall or the ceiling was covered by an oil which is made of linseed oil and sandarac resin. The wall or the ceiling was covered by this oil two or three times. Sometimes for more consistence, glaze of tragacanth plant gum was used.

To keep the paint on the wall or ceiling, when the painter intended to use watercolor instead of the oil painting, he often mixed the tragacanth plant gum and starch together and covered the gypsum surface. After the completion of these steps by a hard-working expert, painter started to draw the motif or pattern on the wall or ceiling—but before, he drew it on the paper. After that the design was pierced with a needle and the design paper was attached onto the wall or ceiling. At this time, the pollen of charcoal was rubbed on paper which revealed the original design. Then, as a final work, the painter painted and applied the colors to his taste. The painters generally used the three main colors, which were red, blue, and yellow. The combination of these three colors also created other colors. Pigments were all natural. Pigments were also divided into two categories from the viewpoint of the painter: the first group was physical pigments and the second group was transparent pigments.

Nontransparent pigments came from the earth, like mineral colors. Examples of transparent pigments which came from the ground are Lapis lazuli, that was a special stone which was found in Badakhshan, Afghanistan; and pigments found in mountains and foothills such as Acre or Golmashi; as well as other natural pigments that the painter used which were beautiful and delicate. Because of the application of these physical and transparent pigments and their vibrant and freshness, even after one or two centuries, viewers think that these painting on the wall or ceiling are new (Plenderleith, 1997).

4.2. Different Layers of Paintings

The paintings on the wall, including watercolor and oil paintings, have a special technique. To paint on the wall, you must first prepare the layers and then do the painting.

4.2.1. Brick (Support)

Support or wall is a part which painting layers are applied on. Generally, the support in the murals were clay, brick, and stone. The support layer which is used in the painting above the Shah Bath entrance was brick.

4.2.2. Clay and Straw Mortar

The layer of the liners is called a layer, which makes the support surface flat and, in this way, making the other layers easier and better. Lining layer could be clay or gypsum mortar.

The lining layer which was used in the painting above the Shah Bath entrance was a clay and straw mortar. The main material of this mortar was clay and added straw to improve its strength and quality.

4.2.3. Gypsum

The substrate layer is the connection between the support layer and the paint layer. The substrate layer also helps to smooth the lining layer.

The substrate layer in the wall paintings is thinner than the lining layer, and the fineness is smaller. In some cases, the substrate layer is also divided into two layers which are called under- and over-layers. For applying the substrate layer, first, lining layer was humidified and then the gypsum mortar was applied on it.

The substrate layer which was used in the painting above the Shah Bath entrance was gypsum.

4.2.4. Intonachino Layer

After the substrate layer has dried completely, the intonachino layer is applied. The intonachino layer is a combination of binder and fillers. The most common binders which are used in Iranian paintings are: herbal binder such as Arabic Gum, tragacanth plant gum, Date Sap, Grape Juice, and Animal binders (protein) such as gelatin of rabbit and fish, and egg yolk.

The most common fillers used in intonachino layer are the calcium carbonate, calcium sulfate, zinc oxide powder (white zinc), and white lead. This layer causes the work to be easier with the brush on the wall surface, reducing the amount of suction paint and binder by gypsum, as well as maintaining transparency.

4.2.5. Preparatory Drawings

The transfer of the drawing was applied in two ways:

1. Directly using brush and paint.

2. Piercing the design paper with a needle and attaching the design paper onto the wall or ceiling while applying pollen of charcoal on paper. Finally, the original design is revealed.

4.2.6. Painting Layer

The painting layer contains pigments, binders, fillers, and additives.

Pigment: A fine-grained colored material that is suspended in the binder. Pigments are used as inorganic and organic. Mineral pigments are more stable and more transparent than organic ones. Mineral pigments have chemical compounds such as oxides, sulfates, carbonates, etc.

The pigments are used in the mentioned painting are as follows:

1. White calcium carbonate: The chemical composition is $CaCO_3$ and it has natural and mineral sources.

2. Indian red: The chemical composition of this pigment is $Fe_2O_3.NH_2$ or Fe_2O_3, and it has natural and mineral sources. Indian red has been used since the prehistoric times.

3. Lapis lazuli: The chemical composition is $3Na_2O.3Al_2O_3.6SiO_2.2Na_2S$ and it has natural and mineral sources.

4. Silo green: The chemical composition is k $[(Al, Fe^{3+}). (Fe^{2+},Mg)] (AlSi_{39} Si_4) O_{10} (OH)_2$. It has natural and mineral sources and has been used since ancient times.

Paint binder: Through the FTIR analysis of the Lapis lazuli, it was determined that the binder of the pigment of the painting was gum arabic.

Filler: It is a material that reduces the cost of pigments and increases the coverage power and durability of pigments. The most common fillers are zinc oxide and magnesium silicate (talcum powder).

4.2.7. Protective Layer

After finishing the painting, a protective layer is applied on the painting that makes the painting more beautiful, creates harmony at the painting surface, and deepens the painting (Plenderleith, 1997, p.211).

The protective layer protects the painting layer and prevents direct contact with dirt, contaminants, etc. However, protective layer also needs to be restored after a while because it is gone and cracked. The most common material which used as a protective layer is egg whites. The mentioned painting was devoid of protective layer.

5. DETERIORATION PROBLEMS

All damages on the painting were the results of physical, chemical, and biological factors. First step for pathology is documentation. For this reason, photographs were taken of all painting damages, and then the damages and the causes were investigated.

5.1. Damages Caused by Technical Weakness

This type of damage is due to inappropriate material use which ultimately leads to chemical changes and internal mechanical pressures (Beyrami, 2008).

In the painting, the lower layer was found under the gypsum mortar layer, which is a technical weakness, because a mixture of straw and clay mortar was used, and straw absorbs moisture and gets inflamed. By creating mechanical pressure on the next layers (gypsum, painting, etc.) these layers will drop over the years. The other problem of straw is the termite attack.

5.2. Damage Caused by Moisture

Due to absorbing moisture in various forms, evaporations from the surface, crystallization of soluable salts or underlying surfaces, the paint became weak and dropped. The absorvance of moisture in the paint has happened in 3 ways: ascending, descending, and sweating.

5.3. Anthropogenic Damages

5.3.1. Knocking a Nail on the Painting

Due to knocking a nail on the painting, the painting layers were pierced. The perforation of the painting surface results in weakening of the paint, penetration of moisture, dust, atmospheric pollution, and microorganisms (termites) and all of these factors can damage the paintings (Fig. 7a).

5.3.2. Sticking a Card Plaque on Paintings

The municipality has stuck a card plaque on the right side of the painting which caused damages and destruction. The card plaque was stuck to the painting with the gypsum mortar that initially caused part of the painting to be hidden under the card plaque, and secondly, the mortar on the painting damaged the paint layer. Even to remove the card plaque from the painting, part of the paint layer will be remove unwantedly and damage the painting (Fig. 7b).

5.3.3. Pouring the Paint on the Underlying Parts of the Painting During Paints Upper Part of the Paintings

The green paint was poured on the lower part of the painting while the painter was painting the wing of angel green and it remained in the form of green spots on the painting (Fig. 7c).

5.3.4. Improper Restoration

One of the angels of the painting has been restored in a way which did not respect the principles of restoration. For example, the color used is not suitable, and the design of the angel is different from of the original angel (Fig. 7d).

5.3.5. Cracks

Cracks are caused by internal mechanical pressures (generally related to the intrinsic process of selected materials), and external pressures such as effects of temperature, humidity, and heat (Fig. 7e).

Contraction cracks are created during the drying of the paint layer. Drying a paint layer may take years or

centuries. Extending traction forces the paint layer to form contraction cracks. These cracks are irregular and like branches, and they extend from the surface to the first layer of the painting.

Aging cracks, these cracks are caused by the passing time, the moisture fluctuations, external mechanical forces, the support motion due to the drift of the earth, the dryness and fragility of the paint, and substrate layers. Aging cracks are like straight line and are spread evenly.

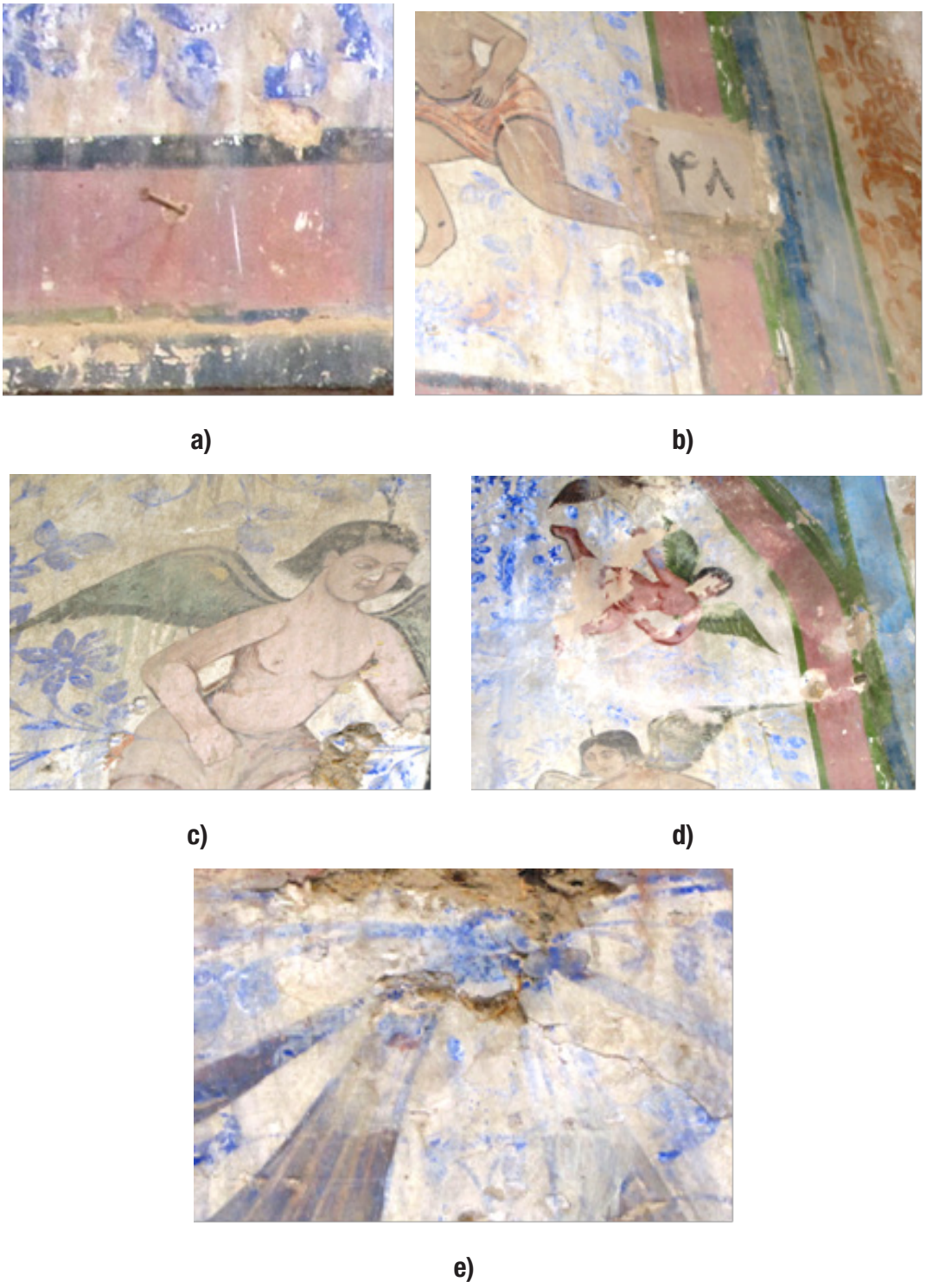

Figure 7. Deteriorations of the wall paintings; Knocking a nail on the painting (a), sticking a card plaque on painting (b), pouring the paint (c), improper restoration (d) and cracks (e).

5.3.6. Damages Caused by Atmospheric Pollution

On the painting, there is a layer of dirt and pollution that is formed from the dust in the air. It has more dust on some part of the surface which results in darkening of the colors and also eliminates the transparency of the colors (Fig. 8a, 8b).

5.3.7. Loosing of the Paint Layer

Loss of pain binder results in loss of paint on the substrate layer. The binder causes the paint to stick to the paint layer, losing its adhesion to the substrate, and its removal from the surface of the substrate (Fig. 8c).

5.3.8. Loosing of the Paint and Substrate Layers Together

Due to the absorption of moisture (ascending, descending and sweating) by the straw in the mortar, this layer is swollen and pushes the next layers of the painting like substrate and paint layers by internal mechanical pressure and causes the layers to drop. Drift of the earth causes a waste of the bond between the layers and, as a result, the layers are separated and fall. External mechanical pressure by humans, such as knocking down the nail, cause the layers to fall (Fig. 8d).

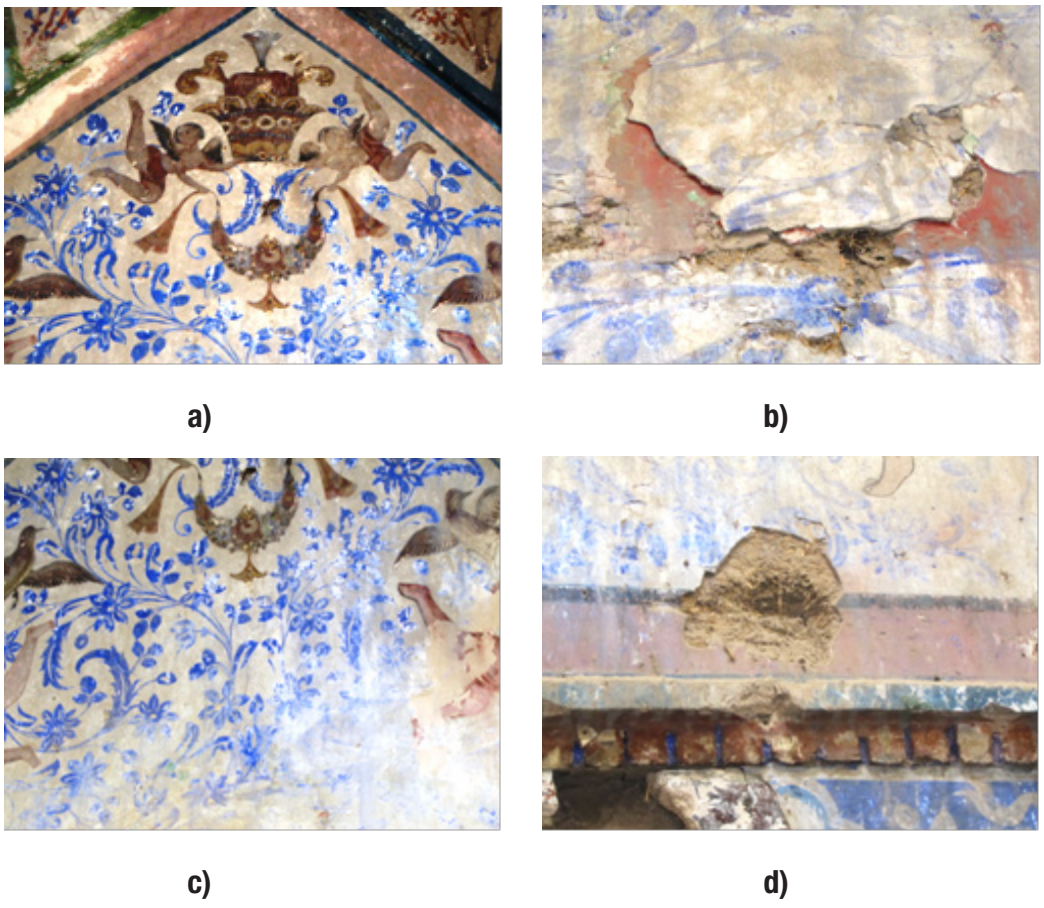

Figure 8. Deteriorations of the wall paintings; damages caused by atmospheric pollution (a and b), loosing paint layer (c) and loosing paint and substrate layers together (d)

6. CONCLUSION

Among the massive collection of humanity and their products, those monuments that remain from the past generations, have cultural and artistic values and play a useful role in the development of the life of today and future. In order to keep these artifacts, the two categories of conservation and restoration are mutually effective, and it is clear that conservation and restoration must be sustained; otherwise, access to the restoration goals are not possible.

Among the remained artifacts from the past, the wall paintings have a special place. Based on the studies, the substrate of the painting in this study was determined to be gypsum. According to the analysis technique (tempra on gypsum), the substrate has been affected by several factors and has been damaged, which must be quickly restored and conserved.

Also, according to laboratory studies (wet chemical and FTIR Analysis), pigments and paint binder have been identified, which are mostly natural and mineral pigments. Also, different layers of painting were examined under a metallographic microscope. After analyses it was proved that the substrate of mentioned wall paintings was gypsum. In Qajar period using gypsum as a substrate was common. Also, it was proved that the white pigment was calcium carbonate white. Red pigment was Indian red and blue pigment was Lapis lazuli. Furthermore, green pigment was silo green and black pigment was iron cationic.

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