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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Conservation of Calligraphy by Calligrapher Hayrettin Bey

Hattat Hayrettin Bey'e ait Hat Levhanın Koruma ve Onarım Çalışmaları

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Abstract

In this study, the conservation stages of the Jeli thuluth Zerendüd plaque, made by calligrapher Hayrettin, dated 1310 AH (Muslim calender) and 1892 AD (Gregorian calender), were carried out. The line plate was first examined by visual inspection with visible (VIS) light, raking light (RAK), ultraviolet light (UV) and infrared light (IR). These examinations were occasionally supported by light microscopy. Deteriorations and damages were determined with the obtained data and appropriate legends were created and processed on the line plate's picture with the help of the Adobe Photoshop program. In addition, samples were taken and analyzed with SEM-EDX in order to understand whether gold and silver leaf were used in the text part and its frame.

In light of the information obtained in the documentation, the conservation-restoration process has been started. The surface of the artwork, which was determined to have been repaired before, was first cleaned from the very thick and haphazardly applied old varnish. Thus, the inward concave-shaped deformation of the picture caused by surface tension has been eliminated. Then, respectively; firstly, the blistered parts of the paper support were consolidated. After the filling, retouching and varnishing processes, the frame was restored and the conservation work was completed.

Keywords: Calligraphy, conservation, jeli thuluth, restoration, zerendud plaque

Öz

Bu çalışma H 1310/ M 1892 tarihli Hattat Hayrettin Bey'e ait Celi sülüs Zerendüd levhanın koruma-onarım aşamalarını kapsamaktadır. Hat levhanın ilk olarak görünür (VIS) ışık, eğimli ışık (RAK), ultraviyole ışık (UV) ve kızılötesi ışık (IR) ile görsel incelemeleri yapılmış, bu incelemeler yer yer ışık mikroskobu ile desteklenmiştir. Elde edilen verilerle bozulma ve hasarlar tespit edilerek uygun lejantlar oluşturulmuş ve Adobe Photoshop programı yardımıyla levhanın fotoğrafı üzerine işlenmiştir. Ayrıca hattın yazı kısmında ve çerçevesinde altın ve gümüş varak kullanılıp kullanılmadığını anlamak amacıyla örnekler alınmış ve SEM-EDX ile analizleri yapılmıştır.

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Belgelemede elde edilen bilgiler ışığında koruma-onarım süreci başlatılmıştır. Daha önce onarım geçirdiği tespit edilen hat levhada ilk olarak çok kalın ve gelişi güzel sürülen eskimiş vernik yüzeyden alınmıştır. Böylece levhanın yüzey geriliminden kaynaklı içe doğru konkav biçimli deformasyonu giderilmiştir. Ardından sırasıyla kâğıt desteği ile birlikte kalkan boya tabakalarında sağlamlaştırma, dolgu, rötuş, vernikleme işlemleri ve çerçevenin onarımı yapılarak, koruma ve onarım çalışmaları tamamlanmıştır.

Anahtar Kelimeler: Celi sülüs, hat sanatı, koruma, onarım, zerendüd levha

Genişletilmiş Özet

Suriye ve Sînâ yarımadasında İslamiyet öncesine ait Arapça yazıtlar üzerinde yapılan araştırmalar, Arap yazı sisteminin (hurûfü'l-hicâ) Fenike alfabesiyle bağlantılı olan bitişik Nabat yazısının devamı olduğunu ortaya çıkarmıştır. Kuzey Arabistan'dan Hicaz bölgesine nakledilen Nabat yazısının farklı karakterlere sahip iki üslubu olduğu bilinmektedir. Bu tip yazıların Cahiliye devrinde "cezm" ve "mesk" olarak anıldığı rivayet edilmektedir. İslam dinini kabul eden hemen hemen tüm kavimler tarafından benimsenen Arap yazısı, birkaç yıl sonra İslam'ın ortak değeri hâline gelmiştir. "Arap çizgisi" kelimesi zamanla "İslam çizgisi" niteliğini kazanmıştır.

Emevî, Abbasî, Fatımî, Eyyubi, Memlük, Selçuklu, İlhanlı, Timur, Safevi, Akkoyunlu gibi devlet ve hanedanlar dönemlerinde daima ilgi çekici bir sanat olarak görülen Hüsn-i hat sanatı, ilgiyle yükselişini sürdürmüştür. Hükümdarların veya devlet adamlarının hat sanatının öncülüğünü üstlenen ve bunu yaklaşık beş asır sürdüren Osmanlı hükümdarları arasında II. Bayezid, IV. Murad, II. Mustafa, III. Ahmed, II. Mahmud, Sultan Abdülmecid ve Sultan Reşad hat sanatıyla aktif olarak meşgul olmuşlardır. İstanbul'un hat sanatındaki müstesna yeri İslam dünyasında "Kur'an Hicaz'da indirildi, Mısır'da okundu, İstanbul'da yazıldı" ifadesiyle tescillenmiştir.

Arap yazı sisteminde harflerin çoğu kelimenin başına, ortasına ve sonuna göre değişmektedir. Harflerin yan yana gelince kazandığı görünüm zenginliği, aynı kelimeyi veya cümleyi çeşitli kompozisyonlarla yazabilme imkânı, sanatta aranan yeniliğin ve sonsuzluğun kapısını da açmıştır.

Çizgiyi sanata dönüştürmede en önemli görev kaligrafiye, is mürekkebine ve kamış kaleme düşmektedir. Kalemin tutulması, kalemin dönmesi, buna göre çizgiyi dolu kalem ağzı veya ince ve dikey olarak tutarak kâğıda yaslanması ile ortaya çıkan harf veya yazının mükemmelliğini sağlamaktadır. Çizgiler ve satır sonları da nokta hesabıyla belirlenmektedir. Bunun için "mıstar" adı verilen bir araç kullanılmaktadır. Uzun bir süre boyunca güzelliği arama çabaları sonucunda harf boyutları nihayete ermiştir.

Hattatlık İslam tarihi boyunca en önemli sanat dallarından biri olmuştur. Özellikle matbaanın yaygın olarak kullanılmadığı dönemlerde önemli bir meslek kolu

hâline gelmiştir. Hat sanatında öğrencileri hocalarını taklit ederek geliştiğinden bu sanatla uğraşanlar, tıpkı hocaları gibi yazmayı ve üsluplarını bu şekilde korumayı ilke edinmişlerdir. Ancak daha sonraki yüzyıllarda taklit durumuna farklı bir yorum yapılmıştır. Her yeni hattat, bu konuda yetişkin ve yetkin olduğunu kanıtladıktan sonra kendi sanat yorumunu ortaya koymuştur. Arapça konuşulan ülkelerdeki hattatların okumada fazla zorluk çekmemeleri sebebiyle istiflenmiş yazılarda harflerin sergilenmesine uymadıkları görülmektedir. Anadolu hattatları ise ayet ve hadislerin hatalı okunmasına sebep olmamak için teşrihlere büyük önem vermişlerdir.

Bu çalışmada 19. yüzyıla ait hat levha ve çerçevesinin koruma-onarımı yapılmıştır. Hattat Hayrettin imzalı, celi sülüs müsenna zerendüd levha hicri 1310, miladi ise 1892 tarihlidir. Siyah zemin üzerine altınla çekilmiş celi sülüs hat levhada "Besmele" yazılıdır. Hattat Hayrettin Bey'in hayatı ile ilgili çok az bilgi bulunmaktadır. Ünlü hattat Çarşambalı Mehmet Arif Bey'in (1828-1893) öğrencisi olduğu bilinmektedir. Çeşitli kaynaklarda Hayrettin Bey'in, Talik hattı Çarşambalı Mehmet Arif Bey'den meşk ettiği yazmaktadır. Hat eserde barok dönem etkileri görülmekte olup çiçek motiflerinde ise rokoko üslubu ön plandadır. Türk rokokosu olarak da bilinen çiçek motifleri açık kompozisyon olup devam edilebilecek izlenimi vermektedir. Altın ve gümüş varak kullanılarak yapılan çerçevede ise birbirini tekrar eden iç içe geçmiş çiçek motifleri bulunmaktadır.

Oldukça hasarlı durumda olan eserin bozulmalarının tespiti için belgeleme çalışmaları yapılmıştır. Belgeleme aşamasında eser sırasıyla görünür (VIS), eğimli-yandan (RAK), mor ötesi (UV) ve kızıl ötesi (IR) ışıklarla incelenerek bozulma durumu ve eserin yapım aşamaları hakkında bilgi elde edinilmiştir. Bu incelemeler yer yer ışık mikroskobu ile desteklenmiştir. Hat levhanın görünür ışık (VIS) ile de tespit edilen daha önce geçirdiği onarımlar morötesi (UV) ışık ile daha belirgin hâle gelmiştir. Yapılan incelemeler doğrultusunda tespit edilen bozulmalar uygun lejantlarla ve Photoshop programı yardımıyla hat ve çerçevenin fotoğrafları üzerine işlenmiştir. Ayrıca SEM-EDX analizi ile Besmele'nin yazılı olduğu kısımda altın kullanıldığı saptanmıştır. Çerçevede ise yaldızla birlikte gümüşün de kullanıldığı tespit edilmiştir. Altının safa yakın, gümüşün ise düşük değerde olduğu analiz sonuçlarındaki bakır ve malahit oranından anlaşılmıştır. SEM-EDX analizi ile aynı zamanda pigment tanımı da yapılmaktadır. Hat levhada bu analiz sonuçları tek başına yeterli olmasa da baryum beyazı, siyah demiroksit, az miktarda ultramarin, titanyum beyazı, litopon, demir oksit, fazla miktarda organik malzeme, alçı ve kil saptanmıştır. Pigmentlerin belirlenmesi, rötuş aşamasında uygun renklerin seçilmesi açısından oldukça önemlidir. Belgelemede elde edilen bilgiler ışığında koruma-onarım sürecine başlanmıştır.

Bu aşamada önceki onarımlarda spreyle kalın bir şekilde verniklenen hat levhanın yüzey gerilimini azaltmak için vernik temizliğine başlanmıştır. Verniğin spray olarak

uygulanması sebebiyle, levhanın yüzeyinde noktasal, düzensiz, pütürlü/pürüzlü bir görünüm oluşturmuştur. Mikroemülsiyon yöntemi kullanılarak yapılan temizlik işleminden sonra hat levhanın kabaran, kalkan alanları Evacon-R ile sağlamlaştırılmıştır. Son yıllarda özellikle kâğıt ve deri konservasyonunda kullanan Evacon-R; asitsiz, pH değeri nötr, çekme yapmayan, geri dönüşümlü esnek bir yapıştırıcıdır. Evacon-R ile kalkan, kabaran kısımlar yapıştırıldıktan sonra içe konkav şeklindeki deforme olan kısımlar düzleştirilmiştir. Hat levhanın zayıflayan taşıyıcısının güçlendirmesinde orta kalınlıkta asitsiz petek karton kullanılmıştır. Burada yapıştırıcı olarak Plextol B 500 tercih edilmiştir. Eskimeye karşı dirençli (*ageing*), yüzeye homojen bir şekilde nüfuz edebilen ve uygun ıslatma özellikleri sebebiyle tercih edilen Plextol B 500 termoplastik akrilik bir reçinedir. Bu şekilde hem hat levha sağlamlaştırılmış hem de düz bir satıh oluşturulmuştur. İnce kâğıt hamuru metilselüloz ve Evacon-R 1:1 oranında karıştırılarak boya tabakasındaki kayıp alanlara dolgu yapılmıştır. Rötuş aşamasında ise uygun renkte saf ezme altın ve Paraloid B-72 içeren Kremer marka restorasyon boyası kullanılmıştır. Vernikleme işlemlerinin ardından çerçeve onarımı ile çalışma tamamlanmıştır.

Introduction

The word "*Hat"* in Ottoman Turkish or "Khatt" in Arabic, which correspond to "Islamic calligraphy" in their respective languages, can be defined as writing, line, era or path. As the complete term "*Hüsn-i Hat*", the word is defined as the art of writing nicely; adhering to the aesthetic standards of the Arab-Islam writing. In short, "*Hüsn-i Hat"* is the name of Islamic nice writings that have artistic value[1]. While artisans who write nice writings were called "*kettab*" before, the word "*hattat"* started to be used following the works of the nice writing master Yakut. In the beginning, two very distinct types of wordings named "*Meşrik*" and "*Mağrib*" dominated throughout the art of calligraphy. Later, many pieces of art were made in nations such as Great Seljuk, Anatolian Seljuk, Mameluke, Timurid, Ayyubid, Umayyad, Abbasi, Fatimid, Akkoyun, Artuqid, İlhanlı, Safavid and Ottoman. This allowed Turks to advance significantly in the art of Islamic calligraphy.

Thousands of calligraphies in around 160 different styles were made by Turkish artists onto books, inscriptions written on monuments, Hüsn-i Hat plaques and "muraqqa"[2] (compilations of sample nice writings in an album form).

Since the art of Islamic calligraphy is subject to strict rules, beginners start practicing by imitating the experts. A calligraphy learner makes an effort to learn how to write identically to his master. After acquiring competence and taking permission from his master by proving his skill, the calligrapher can only then put forth his interpretation and designs; under the condition of not violating the basic principles of the art. Despite there being absolute rules a calligrapher must follow, the flexibility provided by the writing system and the form of the letters caused many different compositions (stackings) to appear. This dilemma made it possible for the talented calligraphers to develop their schools of interpretation, bring the calligraphy art to excellence and especially contribute to the creation of new variations of Celi stackings. Although the pen thickness sets absolute rules for the art, Celi writings offer complete design freedom to the artists.

The dictionary definition of the word "*Celi*" is "obvious, appeared". In Islamic calligraphy however, the word more or less has a different, more specific meaning: it defines the larger shapes of the writings which are written using a wider tipped pen than the commonly used Handam pen; which is the type of pen used through the learning process of any writing style. Each style of writing has its width measurements. The tip of the reed pen is cut according to these measurements. Writings written wider

1 İlhan Özkeçeci, *Hat Sanatını Tanımak* (İstanbul: Yazı Gen Press, 2017), 12.

2 The oldest samples dating back to the 15th century, muraqqa were prepared in the form of books at first. This allowed the compilation and preservation of various other kinds of artworks such as miniature, kat'ı and gilding; remaining undamaged for long periods. For detailed information, see Mustafa Uğur Derman, "Murakka" *TDV İslam Ansiklopedisi*, v. 31 (Ankara: Türkiye Diyanet Foundation Press, 2020), 204-205.

than the Sülüs pen tip width (2,5-3 mm) are named "*Celi Sülüs*". Sülüs and Celi Sülüs letters don't differ in terms of structure and form. In Celi writing however, stacking is emphasized and letters are written slightly thicker. While Sülüs is usually written in lines, words are stacked together in Celi Sülüs.

The First samples of Celi Sülüs were seen during the Seljuk era. Seljuk Celi Sülüs can be found in three types: intricate, skinny and flat. The common attribute of all three types of Seljuk Celi Sülüs is that the vertical letters are thicker at the top and thinner at the bottom. Therefore, the vertical letters resemble swords. Ottoman Celi Sülüs was under the influence of Seljuk Celi Sülüs until the 14th century. It was used frequently in plaques, paintings and architecture.

In Celi Sülüs, it is difficult to maintain measures of beauty and proportion of the letters while taking standard Sülüs writing principles into account. Therefore the writing is first written on a different, preferably black piece of paper with yellow ink and flaws are corrected using black ink. This way, the writing is turned into a template which another piece (or pieces) of paper is later placed under and pierced with a needle; allowing the ink to move to the empty paper and copy the writing. The paper with the original writing is called "the top template" and the paper on which the writing is copied is called "the bottom template". Later, the bottom template is aligned with the surface on which the writing is intended to be written. Depending on the colour, either a piece of chalked broadcloth or a pack filled with powdered willow charcoal is moved over the pierced bottom template. The powder moves through the holes and transfers the writing to the surface. Finally, when the powder is traced with paint, the calligraphy is written[3].

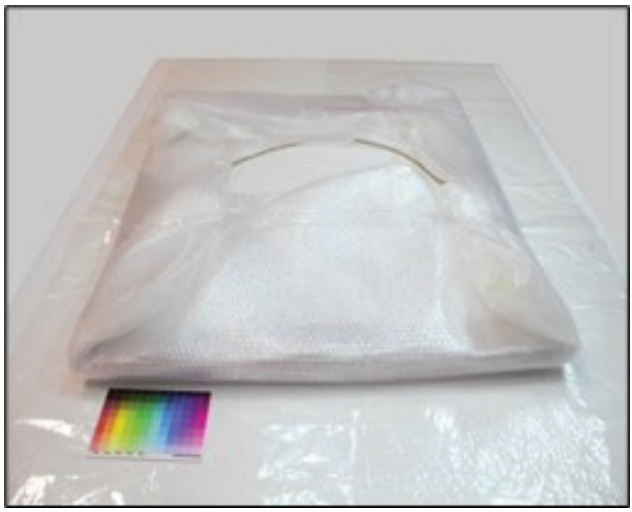
In addition to plaques, Celi Sülüs was used in architecture from time to time. It was drawn onto gates, inscriptions, walls and inside the domes of various structures; harmonizing with their architectural character and contributing to their beauty element. Side by side stance of the vertical letters harmonizes especially with the ascending form of large religious structures[4].

1. Materials and Methods

This artwork was delivered to Istanbul University Faculty of Letters- Department of Conservation and Restoration of Cultural Property, Oil Painting Conservation and Restoration Laboratory by the Gülder Emre **(F. 1)**.

3 Ali Alparslan, *Osmanlı Hat Sanatı Tarihi* (İstanbul: Yapı Kredi Press, 2016), 149.

4 Ali Alparslan, *Osmanlı Hat Sanatı Tarihi*, 149.



F. 1: The first condition of the hat when it comes to our laboratory (Gülder Emre, 2019)

1.1. Artwork Description

78 x 79 cm Zerendud[5] plaque fixed on 83 x 80 cm cardboard with double-sided tape, in a 100 x 98 cm gold leaf frame with bright-flat glass **(F. 2)**.

F. 2: Ketebe (sign) Hayrettin, Celi Sülüs, 1310/1892 (Gülder Emre, 2019)

5 The Persian word *Zerendud* is usually defined as follows: the term Zer-endud is derived from the words "*zer*" which means "gold" and "enduden" which means "to coat". The word Zerendud is usually defined in many dictionaries as coated with gold, gilded, with gold water, writing written in gold. These plaques written in Arabic, Ottoman and sometimes Persian, are made to invite people to have integrity, doing good, worshipping and resign to God; similar to other variations written in ink. For detailed information, see Gülsüm Tuba Acar, "Türk Hat Sanatında Zerendud Levhalar" (MA Thesis, Fatih Sultan Mehmet Vakıf University, 2014).

Celi Sülüs Müsenna Zerendud plaque[6], dated 1310 AH or 1892 AD and signed by the student of Çarşambalı Hacı Arif Bey (El-Hac Mehmed Arif Bey) (D. 1310/1892), Hayrettin. It was made during the Abdul Hamid II era (1876-1909). On the Celi Sülüs plaque, "Basmala" is written in gold over a black background.

Besides the baroque influences in the Hayrettin signed artwork which dates back to the 19th century, the rococo style is highlighted in the flower motifs that form the patterns. The open composition of the flower motifs, also known as Turkish rococo, gives the impression of continuity beyond the frame[7].

In the patterns in the outer corner, C and S folds are also observed in addition to spiral folds. As in the classical period, the motifs were placed in an aesthetic order by dividing them into geometrical sections (such as seats inner and outer moldings / rulers, edges and borders) in a measured symmetric manner. While the proportion in the motifs that follow each other on the work allows the work to breathe, depending on the tradition, the effect of size and smallness in the pattern adds depth to the motifs of the work.

There is the direction of the branches and lines in the motifs that make up the outer and inner edge patterns, and the turning rules are observed in order not to spoil the composition in the corners. The work dominated by halkar[8] composition in the 19th-century Rococo style. In its fully stylized form, it is enriched with motifs such as daisies, carnations, roses, large toothed acanthus leaves, bunches of flowers tied with ribbons, wheat ears, straight and curved lines, ropes and ribbons[9].

The calligraphy, written on Zerendud plaque, has a dark black background and is made using different hues of polished gold that are painted side by side and on top of each other. A gold frame is drawn around Basmala. Different gold application methods are used in the frame's inner and outer brackets, frame lines that form the brackets and the calligraphy itself. Even though gold is used faintly in the small flower bouquets and frame lines/sides, it is used more brightly in bigger flowers within the bouquets. The pattern aestheticized as such allows depth through the entirety of the piece and forms an effective perspective; rendering the artwork both readable and viewable.

6 It is the type of writing in which the composition is drawn symmetrically. These often ½ symmetrical compositions are called "mirrored writing" or "kalem-i müsenna". Müsenna can be seen in all kinds of stacking writings, especially in Celi.

7 Asiye Okumuş, *Türk Süsleme Sanatlarında Barok ve Rokoko* (İstanbul: İlke Kitap, 2016), 147.

8 Ornament made in shaded style with water gold.

9 Okumuş, *Türk Süsleme Sanatlarında Barok ve Rokoko*, 169.

2. Hattat Hayrettin Bey

There is not much information about calligrapher Hayrettin Bey. It is known that he was a student of the famous calligrapher Çarşambalı Hacı Arif Bey (El-Hac Mehmed Arif Bey) (1310/1892)

Arif Bey, named after where he lived, Çarşamba district in İstanbul, the calligrapher learned about Sülüs, Nesih and Tuğra from Mustafa Rakım's apprentice Haşim Efendi and Nes-Talik from Kıbrisizade İsmail Hakkı Efendi and Ali Haydar Bey[10]. Also known as simply Çarşambalı amongst other calligraphers, Arif Bey mostly occupied himself with Celi Sülüs and since he was a friend of Sami Efendi, they exchanged each other's duties throughout this piece. They made many beautiful stacking compositions in Celi Sülüs writing. Additionally, Çarşambalı was very skilled in Müsenna writing. His plaques written in gold (Zerendud) are also displayed in Selimiye and Rum Mehmed Paşa mosques in Üsküdar. He appended his signature as Arif or as Mehmed Arif **(F. 3).**

Training the calligrapher Hayreddin Bey**,** whose background regarding Sülüs is unknown, Arif Bey was an artist whose skills were equivalent to the great master of Celi Sülüs Sami Efendi[11].

F. 3: Ketebe (sign) Çarşambalı Arif Efendi, müsenna celi sülüs (Alpaslan, Osmanlı Hat Sanatı Tarihi, 168)

10 Okumuş, *Türk Süsleme Sanatlarında Barok ve Rokoko*, 169.

11 Alparslan, *Osmanlı Hat Sanatı Tarihi*, 168.

3. The Current Condition of the Artwork

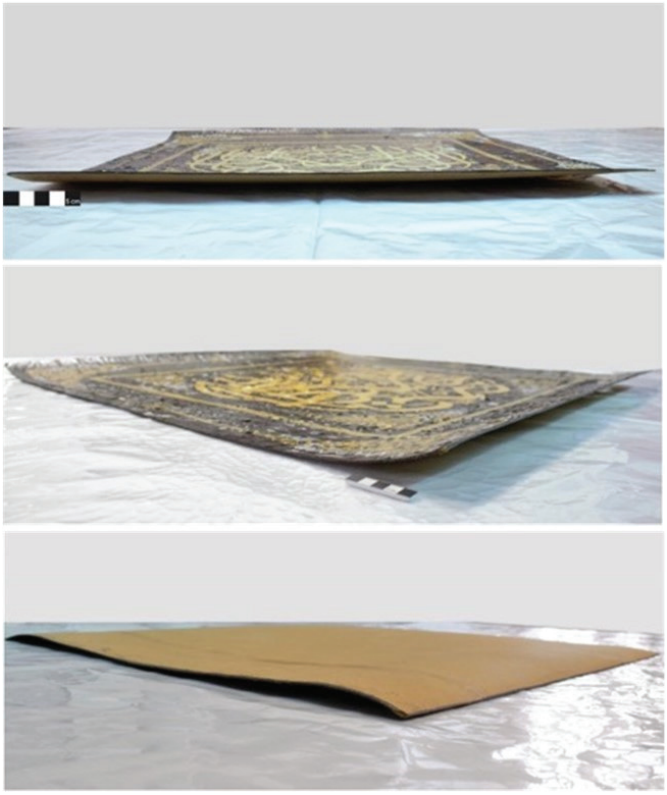
3.1.The Current Condition of the Calligraphy

The 78 x 79 cm Zerendud plaque is fixed on an 83 x 80 cm cardboard with double-sided tape, which is framed in a 100 x 98 cm gold leaf frame with bright flat glass. It has been determined that the artwork has been previously conserved and restored. The artwork, which came to our laboratory with its frame, was severely damaged. Muraqqa was used as carrier for the 78 x 79 cm artwork. Over a black background, gold paint was used for the calligraphy and motifs; along with white paint for the decorations in certain areas **(F. 4)**.

F. 4: Framed and Unframed condition of the Calligraphy (Gülder Emre, 2019)

Deformations of 3-4 cm on the top and bottom part and about 1 cm on the left and right sides were observed due to high relative humidity and poor storage conditions. The edges of painting have curved upwards; forming an upward slope **(F. 5)**. In other words, the artwork is concave towards the middle and raised towards the sides. This further aggravates the overall condition of the piece. Additionally, the drawing is shorter than the frame. It is fixed with double-sided tape on a white cardboard; thought to have been added in previous restorations and was painted black haphazardly.

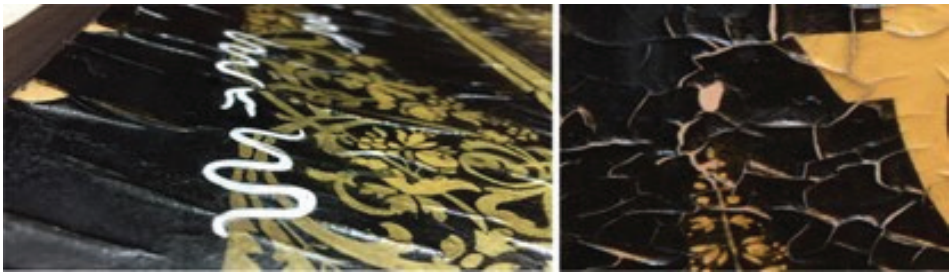
The varnish, which is presumed to have been applied by spraying, was not distributed homogeneously due to the uneven texture of the surface, resulting in the appearance of glare. The artwork has lost its flexibility and become fragile, probably due to deterioration caused by internal and external factors, such as varnishing of the calligraphy, displaying/storing in conditions of varying relative humidity and temperature, or complete evaporation of the solvent in the natural/artificial varnish coating **(F. 6)**.



F. 5: Deformation in the calligraphy (Gülder Emre, 2019)

F. 6: The rough structure of Varnish (Gülder Emre, 2019)

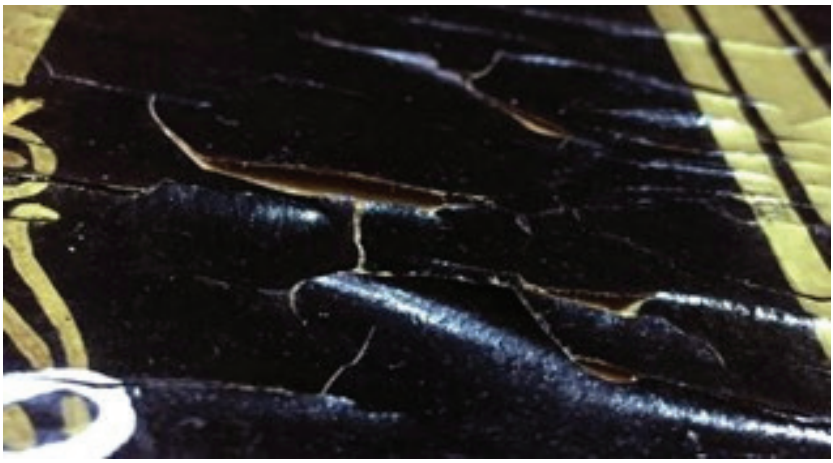
There is also paint stripping in certain regions. The stripping is caused by fluctuations in the relative humidity and temperature, as well as the application of incorrect painting techniques during the making of the layers. The layers or binding agents have weakened and become fragile over time, improper restoration applications, tension and/or deformations caused by mechanical factors also caused stripping of the paint **(F. 7).**



F. 7: The layers of paint loss (Gülder Emre, 2019)

In addition to the micro and macro fractures caused by aging, cupping can be seen on the surface. Cupping is the delamination of paint where the paint layer, in some cases along with the surface, curls away adjacent to the cracks; forming a concave center with raised edges, like a cup or crater. Due to delamination, the refraction quality of the paint is altered; causing severe changes in the appearance of the calligraphy. The paint layer is also fairly sensitive **(F. 8, F. 9)**.

F. 8: Cupping seen in the paint layer (Gülder Emre, 2019)



F. 9: Blistering of the paint layer (Gülder Emre, 2019)

The pressure of atmospheric conditions on the paint layer is also extremely important. Different humid conditions may occur on the back and front sides of the artwork during display/storage. Moisture migration between the back and front happens through the cracks that become permeable. When the binder and lining layer softens due to moisture, the stiff layers of paint cause shrinkage in the canvas; forming tent-like shapes. Over time, the paint layer peels off the surface. It increases the surface tension of the varnish layer over the artwork and because of the moisture, blistering occurs in the varnish.

Another detection made is the artwork has gone through previous processes of conservation and restoration. During a previous restoration, the artwork was fixed on high-acid cardboard with double-sided tape to support its back when framed. The tape lost its viscidity over time; which caused the artwork to separate from the cardboard. Sides of the white cardboard on which the piece was restored, were painted haphazardly with black paint **(F. 10)**.

F. 10: The calligraphy is pasted on cardboard (Gülder Emre, 2019)

3.2. The Current Condition of the Frame

The Glass of the 100 x 98 cm. frame is 2 mm thick standard glass. The frame has a pattern of intertwined flower motifs and is 8 cm thick **(F. 11)**.

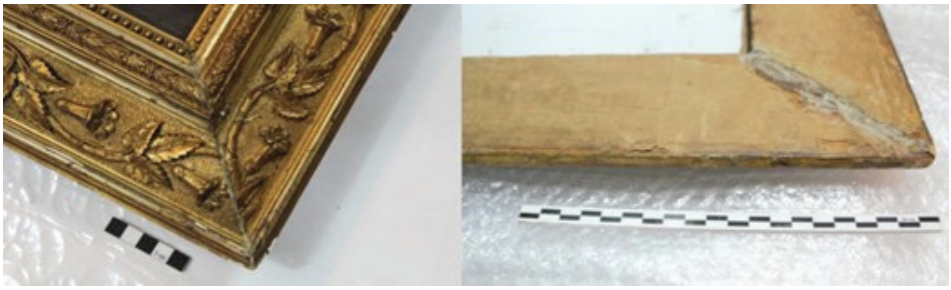
F. 11: General condition of the frame (Gülder Emre, 2019)

There is an ample amount of superficial dirt on the frame. Some fragments are lost from the inner and outer parts of the top right corner and there are microfractures on the surface, as well as macro ones in some areas, which can also be seen **(F. 12, F. 13)**.

F. 12: Surface dirt and cracking areas of the frame (Gülder Emre, 2019)

F. 13: Details from the cracking areas of the frame (Gülder Emre, 2019)

Corrosion was also observed on the nails used to increase the mechanical strength of the connections. As can be seen, when looking at the glue marks on the corners, it was determined that the artwork has been previously restored and the corners of the frame have been joined using PVA **(F. 14)**. Additionally, it is seen that the artwork does not fit the frame fully. It is measured to be around 4 cm shorter than the frame.



F. 14: Places pasted with PVA (Gülder Emre, 2019)

4. Methods

4.1. Documentation

Being one of the essential stages of the conservation and restoration process, documentation is utilized when determining the current state of the artwork. Examinations made using visible, raking, UV and IR light provide data about the making process, severity of the damages and so forth; to be used when determining which conservation and/or restoration methods should be followed. Furthermore, SEM/EDX pigment analysis is made to determine the properties of the paint used in the making and restoration processes. SEM provides information related to surface texture, microfractures, degradations on the surface, varnish and pores in the surface. Along with SEM, EDX can be used for the elemental analysis of the pigment. [12]

Examination Using Visible Light (VIS): Detected deteriorations, the technique used by the calligrapher in his signature, etc. Micro and macro photographs were taken and recorded with a 6.1 megapixel Nikon D200 camera, 18 x 70 mm lens, ISO 100 setting, 500w flash and Hasel photo umbrella. The photographs were then saved in JPEG format. After visual analysis, the deteriorations were classified according to their types and each type of deterioration was assigned a symbol. Later, the symbols were photoshopped over the picture of the artwork using CS4 software and a legend for the symbols was added **(F. 15)**.

12 M. Lynn Henson and Tammy A. Jergovich "Scanning Electron Microscopy and Eneryg Dispersive X-Ray Spectrometry (SEM/EDX) for The Forensic Examination of Paints and Coating", *Forensic Examination of Glass and Paint: Analysis and Interpretation* (2005), 244.

F. 15: Processing of deterioration legends (Gülder Emre, 2019)

Additionally, natural light and artificial light similar to natural light (LED, incandescent light, etc) were used. The light must illuminate the piece homogeneously, with a90° angle and should not form any shadows. Hence, the details on the surface, the colours and deformed areas in the piece were examined **(F. 16, F. 17)**.

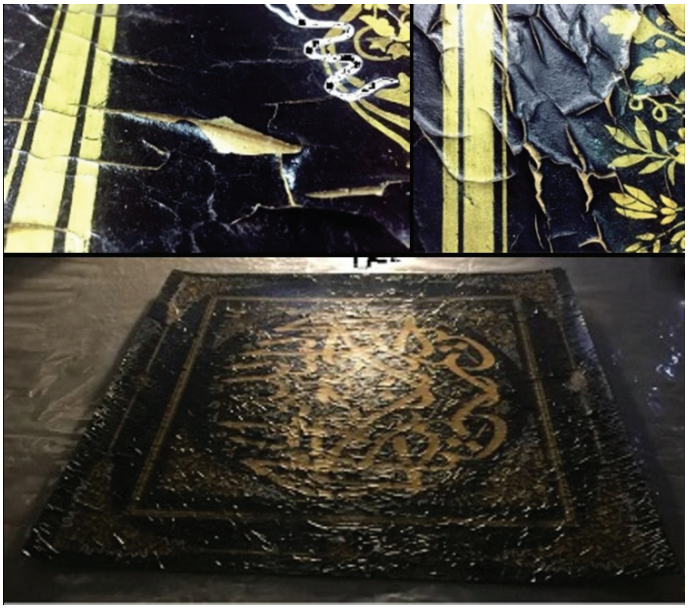
F. 16: General view in the visible light (VIS) (Gülder Emre, 2019)

F. 17: Details in visible light (VIS)- Cracks and blisters parts of the paint layer (Gülder Emre, 2019)

Examination Using Raking Light (RAK): Using this method; fractures, flaking and blistering as well as deformations can be seen in greater detail. Visual data provided by this method is more precise. Light coming from left and right form shadows; showing the surface texture more clearly and pronounced.

The artwork is examined by illuminating from left and right, at 45° and smaller angles, using artificial light. Examining the shadows formed, the damages stated above and deformations were observed in greater clarity and documented **(F. 18, F. 19)**.

F. 18: General views raking light (RAK) (Gülder Emre, 2019)



F. 19: Details in raking light (RAK)- Cracks and blisters parts of the paint layer (Gülder Emre, 2019)

Examination Using Ultraviolet Fluorescence (UVF): The painting was shot using a Fujifilm camera with a 12.3 megapixel Nikon AF-100 lens that has a UV and IR sensitivity of between 380-1000 nm. Two Philips TL 40W fluorescent lamps were used as UV light sources. UV filters for photography were also used. Exposure

time was adjusted between 8 and 30 seconds depending on the distance between the fluorescent lamp and the painting. The time interval was determined very cautiously to protect damage from the UV light. The pictures taken were saved in JPEG format.

UV fluorescent helps identify materials on the artwork like the pigment, paint and varnish[13]. This allows retouched areas, additions as well as certain pigments and different varnish types to be spotted and examined. The varnish over the painting was observed in greater detail when UV light was used instead of visible light. Additionally, retouched areas were visible due to the areas becoming darker under UV light **(F. 20)**.

F. 20: Varnish appearance in ultraviolet (UV) light (Gülder Emre, 2019)

Examination Using Infrared Fluorescence (IRF): The painting was shot in a dark environment using a Fujifilm camera with a 12.3 megapixel Nikon AF-100 lens that has a UV and IR sensitivity of between 380-1000 nm. Two Philips 250W infrared lamps were used as IR light sources. IR filters for photography were also used. Exposure time was adjusted between 8 and 40 seconds depending on the distance between the fluorescent lamps and the painting. The time interval was determined very cautiously to protect damage from the IR light. The pictures taken were saved in JPEG format.

In infrared photography, the shots have a limited spectral range of 700-900 nm. and the light has 2-5 nm. permeability through the paint layer. Deeper layers of paint can be reached only if more advanced recording equipment is used, such as IR sensitive

13 Betül Engin, "Yağlıboya Tablolarda Kopya ve Sahtecilik Bilimsel Analizlerle Özgünlük Tespitinin Araştırılması ve Uygulama Örneği" (MA thesis, Istanbul University, 2022), 114.

video cameras. This method is used for learning about the stages of the preliminary draft, validating the authenticity of the piece, detecting unreadable or hidden signatures, writings, etc[14]. IR light examination did not reveal data related to the techniques used in the making process **(F. 21).**

F. 21: Examination of the calligraphy with infrared (IR) light (Gülder Emre, 2019)

Examination Using Light Microscope: It is an optical analysis method used for determining the colour, form and thickness of the pigments, originality of the paint layer, the artist's painting technique (brush strokes), whether he used a special surface or not[15], etc. Issues and stratigraphy of the artwork (invisible cracks, swellings, peeling, etc.), thin layers, deformations, retouches and degradations in the varnish coat can easily be examined. The artwork was examined using a Leica M80 Binocular microscope and the blisterings, cracks, peeling and rough texture of the varnish coat were seen in more detail **(F. 22)**.

14 Engin, "Yağlıboya Tablolarda Kopya ve Sahtecilik Bilimsel Analizlerle Özgünlük Tespitinin Araştırılması ve Uygulama Örneği" 111.

15 Engin, "Yağlıboya Tablolarda Kopya ve Sahtecilik Bilimsel Analizlerle Özgünlük Tespitinin Araştırılması ve Uygulama Örneği" 114.

F. 22: Examination of the calligraphy with the light microscope (Gülder Emre, 2019)

5. Analysis

5.1. SEM-EDX Analysis Results

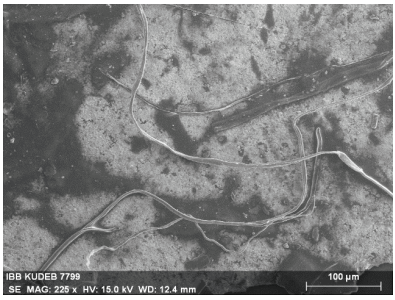
The Carl Zeiss branded Scanning Electron Microscopy (SEM) device is the EVO LS 10 model that was used. Bruker brand Quantax 200 model Energy Dispersive X-ray Spectroscopy (EDX) device with extended pressure (EP) mode is used together with the SEM device. EDX is used together with the SEM analysis to act as a combined instrumental analysis method. Small-sized samples are used for the analysis **(F. 23)**.

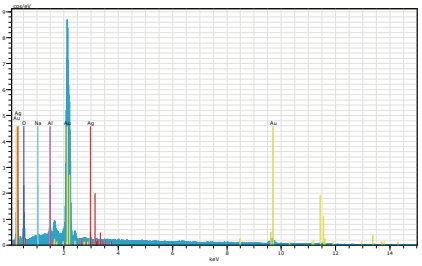
F. 23: Samples taken for Sem-EDX analysis (Gülder Emre, 2019)

The results of the samples taken are as follows:

Sample Number 1 (Inner Painted Frame)

As seen in F. 23, gold (Au, 95.92%), silver (Ag, 0.62%) and aluminum (Al) elements are detected. The sample is made of nearly pure gold. (**F. 24).**





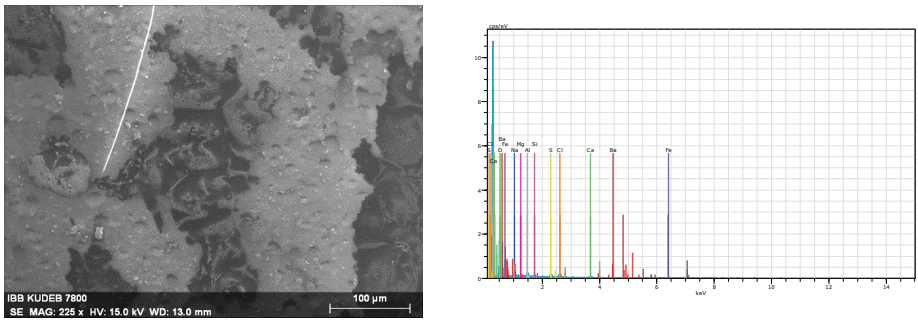
F. 24: SEM image and **s**pectrum of pigment sample 1 (KUDEB, 2022)

Sample Number 2 (Black)

As seen in F. 23, barium oxide (BaO, 3.30%), calcium oxide (CaO, 9.13%), aluminum oxide (Al_2O_3, 14.68%), silicon dioxide (SiO_2, 9.06%), sodium oxide (Na_2O, 20.03%), sulphur dioxide (SO_2, 19.64%) and iron oxide (FeO, 9.49%) as well as Magnesium (Mg) were detected.

In the sample; barium white, black iron oxide, a small amount of ultramarine blue and again, plaster and clay coming from the lining layer were found. Large amounts of organic matter were also detected. However, due to the lack of devices that can identify organic material, like FTIR, the data couldn't be supported. The varnish coat

can also be seen in greater detail in the SEM images than in the ones where visible light was used (**F. 25)**.

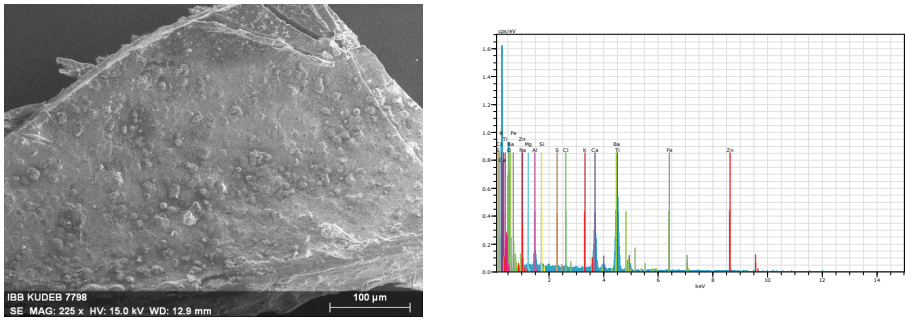


F. 25: SEM image and **s**pectrum of pigment sample 2 (KUDEB, 2019)

Sample Number 3 (White)

As seen in F. 23, due to the pigment colour being white, titanium oxide (TiO2, 52.88%), zinc oxide (ZnO, 0.48%), barium oxide (BaO, 23.43%), calcium oxide (CaO, 14.75%), aluminum oxide (Al_2O_3, 4.33%), silicon dioxide (SiO_2 , 1.12%), sodium oxide (Na_2O, 0.73%), sulphur dioxide (SO_2, 0.93%), iron oxide (FeO, 0.27%) were detected; along with magnesium (Mg) and potassium (K) elements.

In the sample; titanium white, lithopone and iron oxide paint as well as plaster and clay coming from the lining layer were found. Detection of these paints indicates that this area had gone through restoration and had been retouched previously. Furthermore, the varnish coat can be seen in greater detail in the SEM images than in the ones where visible light was used **(F. 26)**.

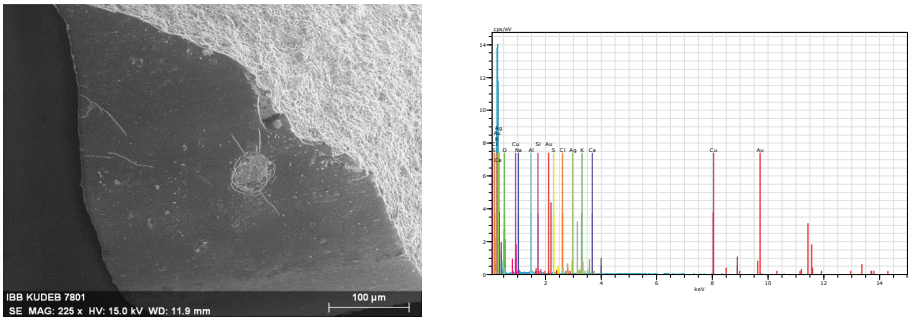


F. 26: SEM image and **s**pectrum of pigment sample 3 (KUDEB, 2019)

Sample Number 4 (Outer Painted Frame)

As seen in F. 23, calcium oxide (CaO, 1.18%), aluminum oxide (Al_2O_3, 21.84%), silicon dioxide (SiO_2, 29.10%), sodium oxide (Na_2O, 0.91%), lead oxide (PbO, 0.27%) were detected. Silver (Ag, 44.94%), copper (Cu, 0.27%) and magnesium (Mg) elements were also found.

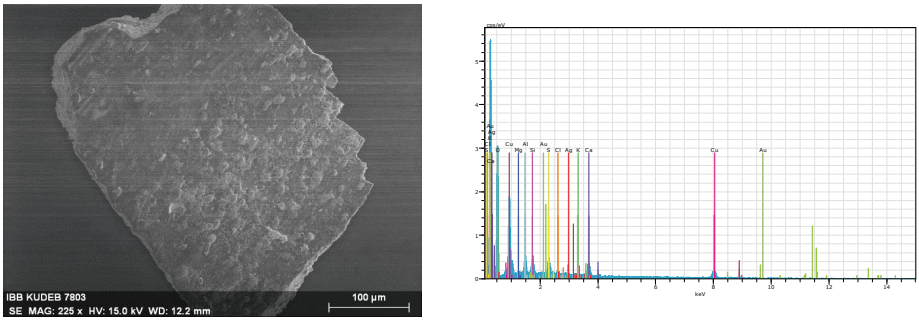
In the sample; silver, malachite, red lead and clay coming from the inlay were detected. Malachite is thought to appear due to the oxidation of the silver (**F. 27)**.



F. 27: SEM image and **s**pectrum of pigment sample 4 (KUDEB, 2019)

Sample Number 5 (Solid Leaf Frame)

As seen in F. 23, calcium oxide (CaO, 12.27%), aluminum oxide (Al_2O_3, 10.63%), silicon dioxide (SiO_2, 13.04%), sulphur dioxide (SO_2, 15%) and potassium oxide (K_2O, 1.34%) were detected. Copper (Cu, 41.77%), silver (Ag, 0.79%) and magnesium (Mg) elements were also found (**F. 28**). Since the rate of copper in the sample is high while the rates of gold and silver are very low, use of gilding paint is verified.



F. 28: SEM image and **s**pectrum of pigment sample 5 (KUDEB, 2019)

6. Results

6. 1. Conservation and Restoration Methods

After all stages of documentation are completed, the painting is removed from the frame and conservation-restoration process is planned; considering the painting's current condition, making minimal adjustments and taking conservation ethics into account when necessary. The applications are done in the following order:

a) Documentation

b) Diagnosis

c) Conservation and Restoration Process

· Consolidation

· Surface Cleaning

· Filling

· Retouch

· Varnishing

· Maintenance, display, storage

6. 2. Conservation-Restoration Treatments Made to the Calligraphy

Following the completion of all stages of documentation regarding the current state of the artwork, the calligraphy was removed from the frame for conservation and restoration. After the detection of degradations in the carrier and the surface caused by poor storage, display and environmental conditions such as humidity, heat and light; a small section of the painting was subjected to a moisture/water test, which revealed that the paint was water-based. This simple but effective test is useful for determining which material(s) should be used.

The 3-4 cm upward curve of the left and right sides which pull the carrier caused a slope to be formed on the surface. This caused micro and macro fractures to occur through the paint layer on the surface **(F. 29)**. If not interfered with on time, the slope would get gradually steeper and would cause the painting to break into pieces. Therefore, the first thing to do should be to flattened it. In this case, however, pre-reinforcing the peeled concave parts of the paint layer is considered but it is given up later on; due to the paint being water- based. Another issue is the surface of the painting being varnished. The varnish makes the paint more fragile due to the surface

tension it creates. The old and poorly applied varnish must be removed first. This would reduce the surface tension over the paint layer and stretch the painting; relieving physical stress. If it is pressed without removing the varnish, stress in the corrugated areas may increase and the painting may fall apart. The number of fractures throughout the paint layer can also increase and existing fractures may get deeper. Therefore the varnish should most certainly be removed prior to pressing; to prevent damages from occurring.

F. 29: Removing the varnish layer from the surface (Gülder Emre, 2019)

The method of removing dirt and varnish from the surface of the artwork must be suitable for the water-based property of the paint. The surface cleaning was done using a 2:1 mixture of ethyl alcohol white spirit and bamboo sticks wrapped in cotton. The cotton wrappings were frequently changed. The varnish and dirt were carefully removed, without damaging the paint layer. Since the paint layer had not been reinforced previously, the cleaning was done meticulously and very finely; using a magnifying glass when necessary. The purpose of this treatment is only to reduce surface tension and to make the painting more flexible. The artwork was left to rest for three days after the cleaning.

After cleaning the paint layer that was hardened by the varnish, the artwork is made ready for pressing. Firstly, flaked or potentially flaked areas were reinforced beforehand. Again here, since the paint is water-based, the pH-neutral adhesive Evacon-R was used[16]. The adhesive is applied to the swollen, flaked and cracked areas using a

16 Karin Scheper, "Een Onderzoek naar Evacon-R, Gedrag en Toepassingen Van een Witte lijm," *CR: Interdisciplinair Vakblad voor Conservering en Restauratie* 6 (1) (2005), 32.

sable watercolor brush No. 1 and then glued with a restoration iron using Melinex as a separating layer.

Following the pre-reinforcement, the artwork was once again left to rest for three days for the adhesive to dry. Later, the back of the artwork was lightly steamed to increase flexibilityand flattened by pressing with weights **(F. 30)**.

F. 30: Pressing the Calligraphy (Gülder Emre, 2019)

In order to prevent the recurrence of the deformations on the carrier, to keep the artwork flat and to increase its durability; 1 cm. thick, recyclable, acid-free white honeycomb cardboard, suitable for supporting the artwork, was glued using Plextol B 500[17] adhesive and pressed again between two layers of melinex **(F. 31)**. The artwork was pressed for fifteen days to ensure that it adhered well and flattened; it was checked every two days. After the confirmation of the aforementioned conditions, the artwork was removed from the press.

F. 31: Consolidation process of the support (Gülder Emre, 2019)

Since the previous restorations were very durable, the patches were not removed from the surface in accordance with the minimal adjustment policy. The pre-reinforcement procedure was continued after the pressing stage as well. The flaking,

17 Plextol B500 is generally used as an adhesive in lining and consolidation processes. It is an aqueous dispersion of copolymers based on butyl acrylate and methyl acrylate. See Stefanie De Winter "Conservation Problems with Paintings Containing Fluorescent Layers of Paint", *CeROArt* [Online], EGG 1, 2010, DOI: https://doi.org/10.4000/ceroart.1659

cracks and peeling seen in the paint layer were treated using Evacon-R and No. 1 sable brush again. The paint layer was fixed to the carrier by applying a heat-sensitive adhesive using restoration iron and melinex. The adhesive residues were removed using white spirite **(F. 32)**.

F. 32: Adhesion stages of the cupping layer (Gülder Emre, 2019)

All cracks are put through the same treatment. Cracks caused by ageing, unsuitable display and storage conditions or the use of poor-quality materials cannot be repaired. They can only be alleviated by the reinforcement process during the restoration. Therefore, each fracture is treated carefully and with precision **(F.33)**.

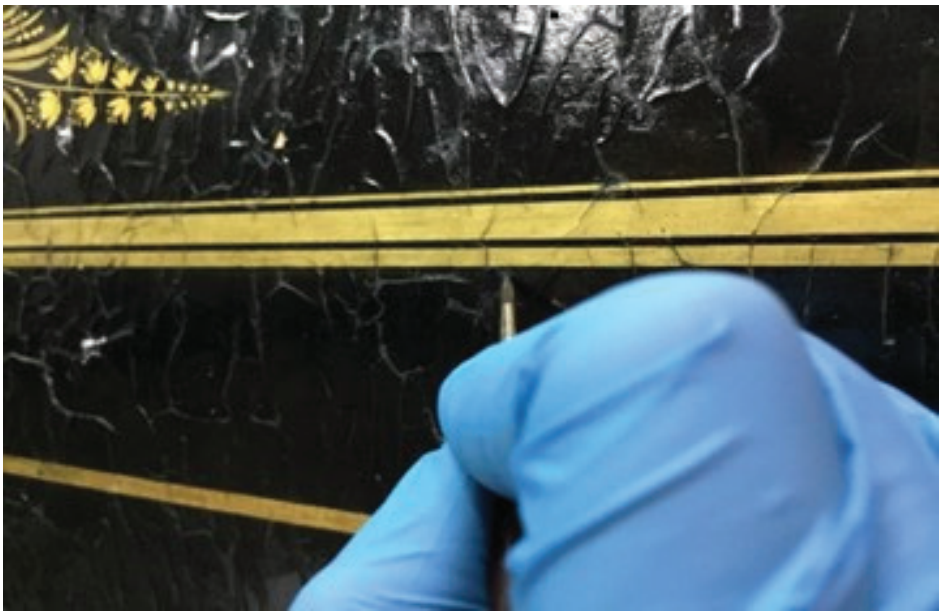
F. 33: Adhesion stages of the cupping layer (Gülder Emre, 2019)

After the reinforcement stage, a detailed surface cleaning process was initiated. The surface was cleaned by the microemulsion method, using bamboo sticks wrapped in small amounts of cotton. The rested work is varnished with a retouching varnish thinned with 50% white spirit to prepare it for the filling stage. After one day of drying, the filling stage was started. Fine paper powder is mixed with methyl cellulose and Evacon-R in a 1:1 ratio. To form a paste. It was then applied as a thin coat on the exfoliated areas. After the fillings dry, they are corrected to blend in with the painted surface **(F. 34)**.

F. 34: Filling stage (Gülder Emre, 2019)

In the retouching stage, the recyclable Kremer Paraloid B-72 retouching paint was used. The gold areas were completed with crushed gold and worn out afterwards. After an additional two days of rest, a coat of varnish was applied using Kremer-branded Regalrez 1094 [18]varnish to protect against damage caused by atmospheric conditions and physical impacts **(F. 35)**

18 It has been used as a painting varnish in conservation since 1991 see Mustafa Kemal Dallık, "Yağlı Boya Tabloların Koruma-Onarımında Vernik Uygulaması: Regalrez 1094, Keton (Ms2a) ve Dammar Reçine Verniklerinin Karşılaştırılması" (MA thesis, Istanbul University, 2022), 101. Its chemical structure is 100% hydrogenated, low molecular weight, hydrocarbon resin, in other words, hydrogenated hydrocarbon (HC) resin (100% hydrogenated oligomers of styrene and alpha-methyl styrene) Michael O'Malley, "Review of Samples from the 1994 CCI Workshop "Varnishes: Authenticity and Permanence" after 15 Years of Natural Ageing," *Journal of the Canadian Association for Conservation* 35 (2010), 3-8. It can be supplied ready-made as a solution, or it can be purchased as a resin and turned into liquid varnish. Samet Wendy, *Painting Conservation Catalogue, vol. 1: Varnishes and Surface Coatings* (Washington D.C: American Instiute for Conservation of Historic and Artistic Works, 1998), 109-110.



F. 35: Retouching stage (Gülder Emre, 2019)

6. 3. Conservation Treatments Made to the Frame

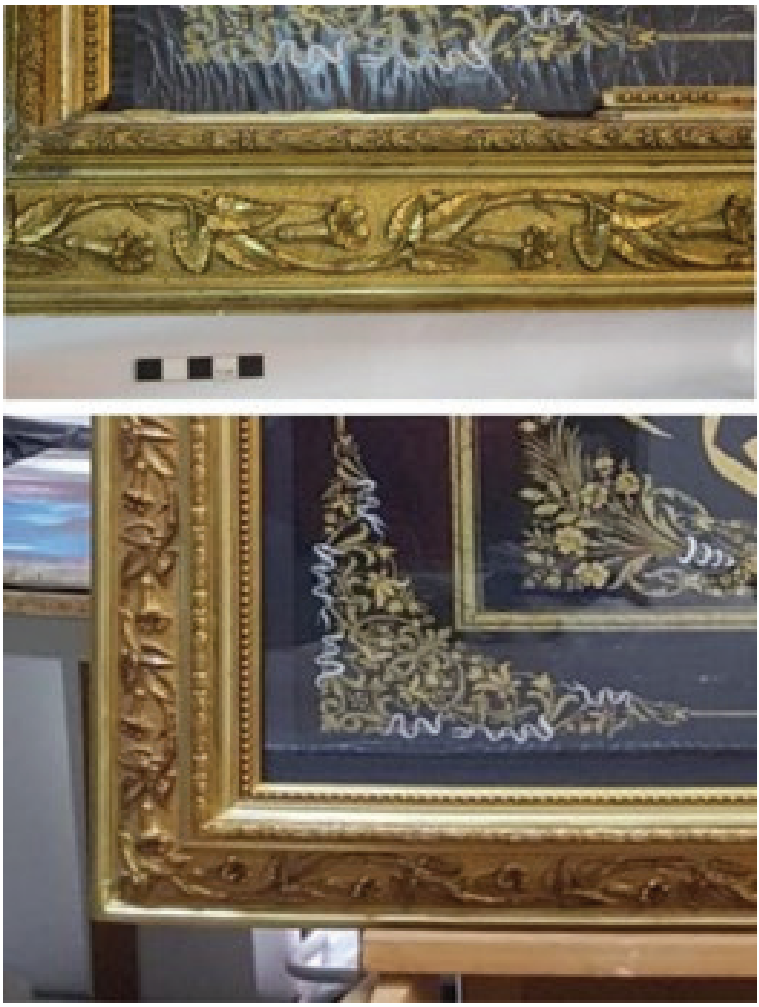
The fairly dirty surface of the frame was firstly cleaned with synthetic saliva[19]. Especially the layers of dirt between the motifs on the frame were removed very carefully. The frame was then left to dry **(F. 36).** Then, the process of completing the deteriorated motifs was started. First of all, it was checked whether the motifs continue or not. The remaining intact parts of the frame were molded to be used to complete the broken patterns in the motifs. A paste made using bologna plaster and rabbit skin glue was poured into the mold and left to dry. The dried paste was then removed from the mold, firmly sanded to get rid of any height or thickness difference from the rest of the frame, and then fixed the broken areas. The paste was applied to the broken-down parts that do not have motifs and corrected by sanding **(F. 37)**. 5% Paraloid B72 in acetone was applied to exposed areas to strengthen the wood and prevent it from absorbing moisture. Then the gypsum-glue paste mentioned above was applied again.

19 Synthetic Saliva is an aqueous solution consisting of a protein, mucin, and the chelating agents sodium and triammonium citrate that reproduce the detergent and emulsifying properties of natural saliva. It is very effective in cleaning light dirty surfaces or materials such as gold leaf. “Saliva”, accessed December 25, 2023, https://www.insituconservation.com/en/products/reagents/synthetic_saliva

F. 36: Cleaning stage of the frame (Gülder Emre, 2019)

F. 37: Completion process (Gülder Emre, 2019)

After the reinforcement and completion of the broken parts, the frame was put through retouch and dirt removal processes again. The type of paint to use was decided by SEM-EDX analysis. Different hues (carats) of crushed gold paint were used in the restored areas of the frame **(F. 38)**.



F. 38: Before and after restoration of the frame (Gülder Emre, 2019)

After the restoration of both the calligraphy and frame was completed, framing the calligraphy process was started. As mentioned before, the calligraphy is almost 5 cm shorter than the frame. The frame is also slightly curved. First, using a lath with the frame is considered but it is given up later on to prevent an unfit appearance; due to the sides of the frame not being straight. The artwork was framed within a thin, acid-free framing matte; which has a slightly lighter colour than the calligraphy. Afterwards, the calligraphy was fixed to the stable frame and wrapped in Tyvek[20] fabric **(F. 39)**.

20 Tyvek fabric is frequently preferred after conservation. It is a 100% synthetic material and is produced from high- density, spun-bonded polyethene fibers. It is used in conservation due to its lightness, durability and breathability, as well as its resistance to water moisture, abrasion, and microorganism entry. ("Tyvek", accessed December 25, 2023, https://www.dupont.com.tr/tyvek/what-is-tyvek.html)

F. 39: Before and after restoration of Calligraphy (Gülder Emre, 2019)

Conclusion

In this study, the conservation of a 19th- century calligraphy and its frame was carried out. 'Basmala' is written on the celi sülüs calligraphy plate signed by Calligrapher Hayrettin, drawn in gold on a black background. There is very little information about the life of the calligrapher Hayrettin Bey. It is known that he was a student of the famous calligrapher Çarşambalı Mehmet Arif Bey (1828-1893). Baroque period influences are seen in the calligraphy, and the Rococo style is at the forefront in floral motifs.

Firstly, documentation studies were carried out on the previous restoration and badly damaged the calligraphy. In the documentation stage, the artwork was examined with visible (VIS), raking (RAK), UV (ultraviolet) and IR (infrared) lights, respectively, and information was obtained about the state of deterioration and the construction stages of the artwork. Light microscopy was also used in these examinations. The previous restoration of the calligraphy plate, which was also detected with visible light (VIS), became more evident with ultraviolet light. With the data obtained, deterioration and damages were identified and processed on the photographs of the calligraphy and the frame with the help of appropriate legends and Photoshop programs. In addition, pigment analysis was performed with SEM-EDX. Especially in the conservation stage, which is a very important stage, it was determined whether gold was used in the frame and on the calligraphy.

A total of 5 samples, 3 from the calligraphy and 2 from the frame were taken and SEM-EDX analyses were performed. The samples were taken carefully, especially from the spilt parts, without damaging the artwork. According to the SEM-EDX results, gold close to pure was detected in the sample (1) taken from the calligraphy. In sample (2), barium white, black iron oxide, ultramarine blue, gypsum and clay from the lining layer and a lot of organic material were detected. In sample (3), tita-

nium white, lithopone and iron oxide paint, gypsum and clay from the lining layer were found. Sample (4) taken from the frame yielded silver, malachite, red lead and clay from the ground. In sample (5) taken from the frame, a large amount of copper, a small amount of silver, gypsum and clay were observed. When all the results are evaluated, it is understood that the Basmala part of the calligraphy was made with gold leaf close to pure, and the white paint used in the decorations was a mixture of titanium oxide and lithopone. A very thin primer layer of clay and plaster was found on the primer. The frame has a primer of plaster and clay. The frame was leafed with silver on the thin corrugated part of the frame. Malachite is thought to be the result of corrosion of the copper in silver due to its impurity. Other parts of the frame are painted with gilding.

SEM-EDX analyses also revealed a large amount of organic material. These results indicate the presence of other pigments. SEM-EDX alone is not sufficient here. These pigments can be detected with different analysis techniques.

In the light of the information obtained in the documentation, the conservation process was started. The calligraphy was consolidated surface cleaned, filled, retouched and varnished respectively.

In the previous restoration treatment, as a result of applying the varnish on the calligraphy thickly and haphazardly with spray, the surface tension of the calligraphy is too high and cracks and lifts have occurred. This varnish needs to be taken first. Micro-emulsion method was used to remove the varnish from the surface. Then, the blistered areas on the calligraphy surface were adhered with Evacon-R. Evacon-R is a very suitable adhesive for paper conservation, especially on thick and layered surfaces. The adhesive was activated with a hot restoration iron over Melinex. The outwardly concave calligraphy was pressed, but the deformation did not improve. The calligraphy, which had a very weakened backing and a lot of deformation, was supported with acid-free honeycomb cardboard to both strengthen it and remove the deformation. Concave bending and weakening of the ground was strengthened and deformation was eliminated. In the filling process, the pulp was mixed with methyl cellulose and Evacon-R at a ratio of 1:1 and turned into a paste and intervened where necessary. Kremer Paraloid B 72 restoration paint was used on the areas to be retouched. The issue of applying varnish to the calligraphy has been discussed a lot, but since the surface is very damaged, Regalrez 1094, which has been used very frequently recently on painted and gold surfaces, has been applied as a very thin layer for protection.

The calligraphy is made on cardboard, it is hygroscopic, meaning it is reactive to water. It responds to fluctuations in relative humidity. Displaying the artwork works best in a climate that is not too dry or too humid, which could lead to physical deteri-

oration and mold growth. The RH cycle can cause significant damage. High humidity (above 75% relative humidity) and inadequate air circulation encourage mold growth. Locally high temperatures (such as in hot display cases or storage near a radiator) can cause the artwork to dry out. The ideal climatic conditions for artwork are a stable relative humidity between 45% and 55% and a constant human comfort temperature between 18°C and 22°C.

It is necessary to avoid storing or displaying under daylight with spotlights or artificial lights. These conditions can cause discoloration, drying, and photochemical degradation. Light fades or darkens the color of some paints and increases the deterioration of materials. Since damage caused by light is cumulative and irreversible, it is necessary to limit the duration of exposure as much as possible. Calligraphy should be displayed or stored at a maximum light level of 150 lux and ultraviolet light content of less than 75 µW/lm. If the work is preferred to be stored, it can be protected on baked steel rail systems painted with acid-free paints.

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