The Conservation of an Ottoman Egyptian Percussion Muzzleloader

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Introduction

This study discusses the analysis and conservation of an Ottoman muzzleloader from the museum of the Faculty of Applied Arts, Helwan University (fig 1). It is a composite material which includes a wooden handle/stock embellished with silver pierced openwork fixed to the wood with silver nails and an incised silver butt-plate decorated with niello. The barrel is fluted and decorated with gilded floral patterns, a Quranic verse and a date 1271A.H. During cleaning the original Ottoman Egyptian silver hallmarks were recovered including an official standard for the purity of silver 80% and a monogram signature (tughra) of the reigning ruler. Non destructive analyses of metal parts were performed using a portable X-ray Fluorescence while the silver and iron corrosion products were analyzed using X-ray diffraction. Further analyses of the silver was made possible by analyzing a detached silver nail using environmental ESEM+ EDS. FTIR was used to verify the presence of adhesives used for the application of gilding onto the steel barrel. The conservation was performed without disassembling the muzzleloader using minimum possible intervention due to the composite nature of the firearm.

Fig (1) Ottoman Percussion muzzleloader at the Museum of the Faculty of Applied arts, Helwan University

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History

Muzzleloaders are firearms into which the projectile and propellant charges are loaded from the muzzle of the gun. In percussion ignition a small impact-sensitive charge (Mercury(II) fulminate, $Hg(CNO)_2$) is held in a cup-like container (the "cap") fig (2b.2). The cap is placed on a nipple screwed into the barrel of the gun. When the hammer falls, the flame from the explosion ignites the charge in the barrel and propels the projectile. This firing mechanism introduced in 1805 by the Reverend John Forsyth of Aberdeen Shire was a great step in advancement from the use of flintlock ignition system which produced flint-on-steel sparks to ignite a pan of priming powder and thereby fire the gun's main powder charge. It enabled the muzzleloader to be fired in any weather, therefore, a weapon of precision and reliability[1]. Percussion Muzzleloaders had however, a short period of widespread and were replaced by the late 1860's with breech-loading metallic shells.

Fig (2a,b) a)details of percussion firing mechanism, b)1-hammer 2-percussion"cap"after Ripley, G.and Dana, C.,[2]

[1] Strachan,H., European Armies and the Conduct of War (London, 1983), pp. 111-13.
[2] Ripley G., And Dana, C., The New American Cyclopædia: A Popular Dictionary of General Knowledge, Appleton,1870)

In Ottoman Egypt, students were sent to study Western gun making techniques. A small ordnance mission went to France in 1825, and individuals studied there, and in England, well into the 1830s. Finally, arsenals were established in Cairo and Alexandria to produce copies of English and French weapons. These represent Africa's first military-industrial complex, and by the 1820s, it had begun producing a considerable array of armaments[3]. Cairo and its suburbs, along with Alexandria and al-Rashid, obtained the most significant military factories.

Private gun makers designed ornate pistols and rifles, which often featured significant amounts of artistic inlay. Egyptian-made pistols, carbines, and long-guns featured significant quantities of brass, silver, bone, or ivory -inlay.

Such expensive pistols functioned as weapons of war and were status symbols. Additionally, with strict gun-control laws, owning weapons was considered a badge of office by the Turks, Circassians, and Albanians who comprised Egypt's ruling elite. Yusef Hekekyan, a keen observer of the period, often referred to these men as the "pistol gentry[4]."

Description

The firearm consists of a fluted cast iron? smooth bored barrel [5] decorated with gilded Ottoman floral patterns (Acanthus , palm leaves ,etc…and a Quranic verse (Al-Anfal “17”) in a primitive soft cursive script reading:

[3] Dunne, J., An Introduction to the history of Modern Education in Egypt, London, Luzac &co.1938, p.172-174.

[4] Dunne, J., Egypt's Nineteenth century Armaments Industry" in " Girding for battle, The arms trade in a global perspective,1815-1940, 2003. p.4,5.

[5] Bastable, M., From Breechloaders to Monster Guns: Sir William Armstrong and the Invention of Modern Artillery, 1854-1880, Technology and Culture, Vol. 33, No. 2 (Apr., 1992), pp. 213-247

"وما رميت اذ رميت و لكن الله رما"

"when thou threwest (take aim), it was not thy act, but Allah's"

Fig (3) Fluted smooth bored barrel with Quranic inscriptions

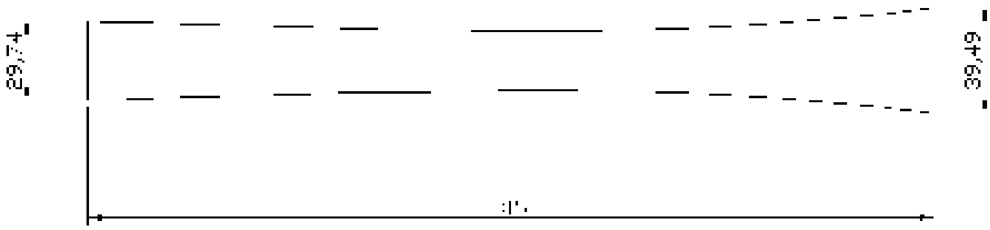


Fig (4) Dimensions of the fluted barrel

The steel barrel is fluted at both sides, its dimensions were 31.5cm long with diameters Ø2.97 cm and Ø3.94 cm (fig 4). A date Year 1271 A.H. ~ 1854 A.D (fig 5) is gilded on the breech of the firearm.

Fig (5) Year 1271 A.H. ~ 1854 A.D

The wooden handle/stock is decorated with silver pierced openwork fixed to the wood with silver nails, while the butt and lock plates are engraved with incised patterns filled with niello. The silver was stamped with Ottoman Egyptian Silver Hallmarks (Egyptian fineness marks in Arabic) in the official standard for the purity of silver (80% silver) (fig 6) and a monogram signature (tughra) of the reigning ruler.

Fig (6) Ottoman Egyptian Silver Hallmarks (Egyptian fineness marks in Arabic) in the official standard for the purity of silver (80% silver)

The government of the Ottoman sultans controlled the distribution of precious metals by testing the purity of the gold and silver used to fashion precious objects and strike coins. An official stamp (*sah*) guaranteeing the purity accompanied by the monogram signature (*tughra*) of the reigning sultan was stamped on all precious metalwork. The marking was done by a special assay office in the Ottoman mint. The stylized *tughra-stamps* of the Ottoman Sultans as well as the hallmarks of the silversmiths and the monograms of the cities allow us to date rather precisely the enormous quantities of precious metal objects which have survived from the Ottoman period[6].

The firearm is dated to 1271A.H. ~1854 A.D., which would coincide with the reign of Sultan Abdulmejid the First (Abdü'l-Mecīd-i evvel) (1823 –1861A.D.), who reigned from 1839 to 1861A.D. A tughra was found stamped on the silver butt -plate concealed beneath the thick layer of silver tarnish. After

[6] Kürkman,G., Ottoman Siver Marks, Matusalem, Istanbul, 1996, p.

consultation with a tughra specialist, Dr. Ercan Mensiz[7] stated that not all of the tughra parts were illegible therefore he could not confirm that it belonged to Sultan Abdulmejid the First and suggested that it could also be a tughra-like signatures (panche-claw) used by viziers and other officials (fig7).

Fig (7a,b,c) a- Official tughra of Sultan Abdulmejid the First , b- tughra on the muzzleloader, c- different parts of the tughra

Other gilded symbols were found on the lock plate resembling a simplified form of Ottoman Coat of arms or military emblem, and a military unit symbol[8], in addition to an unidentified stamp on the gilded barrel. The upper design possibly resembles the Ottoman star and crescent, while the inscriptions below is a "Sah" sign, which is an official Ottoman stamp guaranteeing the purity of silver and gold work (fig8).

7 "Ercan Mensiz a tughra specialist" personal communication.

٨ عبد المنصف سالم حسن نجم " شعار العثمانيين على العمائر و الفنون فى القرنين الثانى عشر و الثالث عشر الهجريي (١٨-١٩) و حتى إلغاء السلطنة العثمانية "دراسة أثرية فنية" مجلة كلية الآثار – العدد العاشر ٢٠٠٤

Fig (8a,b,c,d,,e,f) a,b- Ottoman Coat of arms or military emblem, and a military unit symbol, c,d- Stamp on the gilded barrel, e-Ottoman Star and crescent, f- "Sah" sign an official Ottoman stamp guaranteeing the purity of silver and gold

Condition Assessment

The silver openwork and cast-plates were covered with a disfiguring dull black tarnish hiding silver hallmarks and niello, in addition, some parts of the pierced silver openwork and nails were missing. The wooden handle was scratched and some micro-cracks were visible due to fluctuations in temp and RH in the uncontrolled museum environment. The muzzle, percussion hammer and lock-plate were covered with iron corrosion products. Some of the gilding layer overlaying the muzzle was missing and the underlying scratches (chequered lines) were visible. The original trigger guard had been replaced with an unfitting crude metal sheet at a later date.

Fig (9a,b,c) a-tarnished silver openwork showing missing areas and nails and evident scratches in the wood, b-corroded hammer and lock-late, c, replaced trigger guard with the original carved recess in wood

Materials and methods

A non-destructive technique was used to analyze the metallic components of the firearm using portable X-ray Fluorescence (XRF) NITON/XLt 8138 (USA). The software version 4.2 E was used to determine the alloy composition in different areas. Further analyses of the silver was made possible by analyzing a detached silver nail using environmental ESEM+ EDS, Philips - Environmental Scanning Electron Microscope, Model XL.30 Philips. It was examined without any coating at low vacuum (0.8torr.) Backscattered Electron images of the cross-sections at 25 kv. Acceleration voltage with back scattered detector (BSE) was at 5 mm eucentic working distance and a spot size 7.0 JEOL JSM S400LV-EDX link ISIS-OXFORD, using high vacuum. After examination and analyses the nail was replaced to its original position in the sliver openwork.

The mineral composition of the corrosion products was determined using (XRD) Philips PW 3710/31 diffractometer with Cu-target tube and Ni filter at 40 kV and 30 mA, operated by Philips' APD diffraction software. Results are identified using ASTM (American Society for Testing and Materials) card database for mineral identification. Fourier Transform Infrared Spectroscopy (FTIR) JASCO FT-IR - 460 plus spectrometer; for the identification of the presence of an adhesive used for the application of gilding onto the steel barrel and identification of corrosion products.

Results and Discussion

Three different spots of the silver butt plate and openwork were analyzed using portable XRF showing a slight variation in the composition and a slight discrepancy from the Silver Hallmarks in the official standard for the purity of silver (80% silver).The analysis displayed a silver copper alloy (87% Ag-10% Cu).

Table (1) Results of the XRF analysis of the silver butt and openwork

	Ag	Cu	Fe	Sn	Au	Pb	Sb	Zn
Ag1	86.48	10.82	1.63	0.09	0.2	0.51	0.00	0.00
Ag2	87.22	9.94	0.25	1.00	0.2	0.57	0.5	0.00
Ag3	87.80	9.77	0.35	0.76	0.2	0.50	0.44	0.06

Due to the fine thickness of the gold leaf (>20 µm) and the penetration of XRF (20-100µm), the analysis revealed the underlying elements displaying a high concentration of Fe. These results were used to assist in identifying the gilding technique used. For gilding iron several techniques have been used including:

- direct application where gold leaf is mechanically burnished onto a scratched surface to increase the adhesion of gold
- direct application using an adhesive[9]
- fire-gilding with gold amalgam

[9] Selwyn,L., Metals and Corrosion, a Handbook for the Conservation Professional, Canadian Conservation Institute, 2004,p.76-77

- close-plating technique (the use of soft solders as tin and lead to enhance the adhesion of gold to the metal substrate)
- the use of silver to provide a better surface for gilding [10].
The absence of tin, lead or silver underneath the gilding excluded the use of soft solder or silver as an intermediate layer leaving behind the use of either gold amalgam or an adhesive (table2).

Table (2) Results of the XRF analysis of the gold leaf

	Fe	Au	Cu	Sn	Pb	Ag	Sb	Zn
Au	62.84	35.17	1.15	0.00	0.1	0.5	0.00	0.04

Analyses of both the iron hammer and barrel were performed, however due to limitations in the XRF technique the carbon content could not be quantified.

Table (3) Results of the XRF analysis of the hammer

	Fe	Mn	Ni	Pb	Sb	In	Cd
Fe1	98.79	0.56	0.10	0.10	0.00	0.01	0.01

Table (4) Results of the XRF analysis of the barrel

	Fe	Mn	Pb	Zn	Cu	Co	Pt
Fe2	97.22	0.13	1.82	0.08	0.12	0.31	0.1

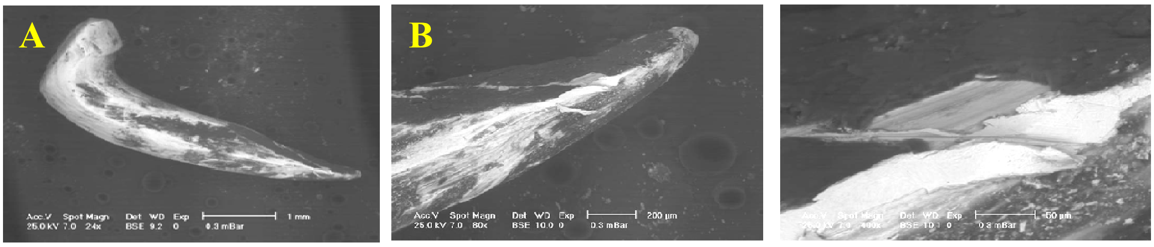
[10] Weisser, T.D., Gilded Metals, History, technology and Conservation, archival, 2001, p.256.

The XRF analysis of the barrel was not conclusive regarding the percentage of carbon, to determine whether it was cast or wrought iron. In the first half of the 19th century, there were two ways to construct a gun: it could be cast in one piece or forged by shrinking layers of wrought iron around an inner core that itself was either cast or forged. Both approaches were followed in the 1850s. Various cooling techniques were tested to strengthen the cast-iron guns. The guns were hollow cast and cooled from inside out by running water through the bore while keeping the exterior walls hot with fire. The metal close to the bore solidified first and was then squeezed by the outer portions as they cooled and contracted. Guns manufactured in this way had greater endurance than guns bored from solid castings that had cooled from the outside inward[11].

Elemental analysis of a silver nail used to fix the silver openwork onto the wooden handle was performed using Energy Dispersive Spectroscopy (EDS) which identified the presence of a baser alloy of silver 60% and copper 37% (fig9,a), in addition to chlorine and sulfur (fig 9,b). The presence of chlorine and sulfur suggests the formation of silver chloride (AgCl) and silver sulfide (Ag_2S) compounds as corrosion products on silver. While silver chloride is initially white, when exposed to light it experiences a photoreduction process and disassociates into chlorine molecules and silver atoms[12]. The resulting metallic silver can have a gray-black appearance. Silver sulfide also has a black appearance which coincides with the black tarnish covering the silver details. In addition to evident thickness of silver tarnish layer, the silver nail demonstrated wear, abrasion of the surface and some cracks, while being examined by ESEM.

[11] Bastable, M., From Breechloaders to Monster Guns: Sir William Armstrong and the Invention of Modern Artillery, 1854-1880, Technology and Culture, Vol. 33, No. 2 (Apr., 1992), pp. 213-247

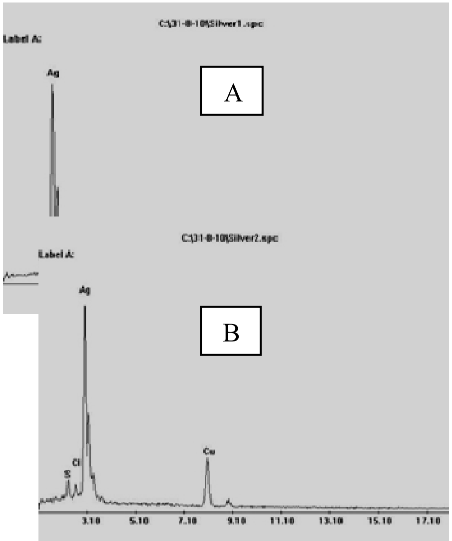
[12] Craig Hillman, Joelle Arnold, Seth Binfield, Jeremy Seppi, Silver and Sulfur: Case Studies, Physics, and Possible Solutions



Fig(10) ESEM of the silver nail showing wear, abrasion, silver tarnish and areas A and B analyzed by EDX

Table (5) EDX analysis of areas A and B

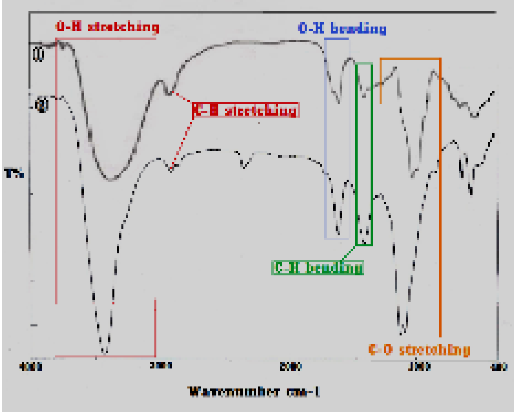
Element	Point A At%	Point B At%
Cl K	2.07	3.16
Ag L	60.68	53.63
Cu K	37.25	35.99
S K	00.00	7.33
Total	100.00	100.00



Fig(11a,b) EDX analysis of point (a) and (b)on the silver nail

To determine whether adhesives were used to attach the gold onto the iron, a sample of the gilding on the steel barrel was analyzed using FTIR. The obtained spectra were compared to standard spectra of Gum Arabic and found to be identical[13]. This confirmed that the gilding technique used was the application of an adhesive over a scraped surface to ensure good bonding between the gold and iron.

[13]Derrick, M.R.; Stulik, D. and Landry, J.M.(1999): Infrared spectroscopy in conservation science, The Getty Conservation Institute, U.S.A



[Result of Peak Picking]

No.	Position	Intensity	No.	Position	Intensity	No.	Position	Intensity
1	3430.74	83.2598	2	2920.66	93.7528	3	2356.52	94.0065
4	1631.48	90.1737	5	1428.99	89.6525	6	1158.04	84.4027
7	1119.48	84.5833	8	675.828	83.4390	9	605.039	92.4241
10	425.227	96.5696						

Fig (12) FTIR spectra showing comparison between sample and Gum Arabic

Table (6) FTIR spectra and functional groups

Wavenumber cm^{-1}		Functional GROUP
Gum Arabic (Standard)*	**Sample**	
3600-3200	**3430.74**	**OH stretching band (broad band due to intermolecular hydrogen bonding)**
٢٨٠٠ -٣٠٠٠	**2920.66**	**C-H stretching band of aliphatic group**
~ 1600	**1631.48**	**OH bending band**
1480 -1300	**1428.99**	**CH bending band**
1300 -900	**1158.04 1119.48**	**C-O stretching band**
800-600	**765 605**	**C-H bending**
---	**425**	**May be sigma Fe_2O_3 but is very weak**

<u>Identification of corrosion products</u>

Goethite, iron oxyhydroxide, α –FeO(OH) and Hematite , iron (III)oxide , α -Fe_2O_3 were identified as the corrosion products on the barrel and hammer. The tarnish on silver was identified as Acanthite, silver sulphide, α–Ag_2S which is a stable phase.

Cleaning and Conservation

When a firearm is received by a conservator/museum, it must be checked immediately to ascertain that is not loaded. The load-checking procedure for muzzle-loading firearms is to insert a cleaning rod without a brush down the barrel as far as it will go towards the breech. The rod is then marked at the end of the muzzle with a piece of tape, removed and aligned with the muzzle. If the distance from the end of the rod to nipple base- in percussion-cap firing mechanisms- is more than 1cm there is probably an obstruction in the barrel, most likely a projectile and powder.

Another important issue when conserving an ancient firearm is whether it is possible to disassemble it and work on the different parts individually or regard it as a composite material and choose the most appropriate materials and methods.

As the condition of wood was questionable due the uncontrolled environment in the poorly sealed showcases and the risk of wear, it was decided not to disassemble the muzzleloader. The firearm was left intact with the exception of two straight –slot screws that partially covered the silver plates because it was difficult to clean around them.

Silver

Tarnish removal from silver objects is usually referred to as "silver polishing," although the term “silver cleaning” would be a more accurate description of the intent of the operation. The purpose of silver polishing is to produce a smooth and highly reflective surface, while, in silver cleaning, surface deposits are removed and the underlying silver surface, which may or may not be reflective, is revealed. Therefore, an ideal cleaning system for silver is one that will remove the tarnish layer without altering the underlying silver surface. Such a system minimizes both the removal of silver and the alteration of the existing scratch pattern[14]. Tarnish can be removed from silver chemically, electrochemically, or mechanically.

Chemical cleaning, however, can instigate the removal of niello, cause pitting and yellow discoloration while electrochemical reduction can cause a dull matte finish and pitting of the silver. In mechanical processes, abrasive polishes are generally used. Commercial polishes could contain ammonia which lead to the dissolution of copper-the baser metal in the silver alloy- and a tarnish inhibitor that slows the tarnishing rate of silver for a short time, latter-on however the objects start to tarnish rapidly and unevenly[15]. Moreover, commercial polishes are somewhat abrasive and, while they remove silver and tarnish from the surface of an object, they leave behind a pattern of fine scratches and a white powdery precipitate that is difficult to remove. The extent of this scratching can be tested by using the polish on unscratched Plexiglas. The depth and pattern of scratching that result on the Plexiglas will be similar to what would appear on the silver surface[16].

Different polishing pastes were prepared and tested on Plexiglas. Precipitated calcium carbonate, white/natural spirit and denatured alcohol showed the best results.

The silver was first cleaned with a non-ionic detergent in distilled water, rinsed with swabs dampened with distilled water then dried with ethyl alcohol to remove any particles or residues that will interfere with the tarnish removal process.

An effective polish was made by freshly mixing a small amount of precipitated calcium carbonate (overnight polishes dry out and tend

14 Wharton, G., Maish, S.L., Ginell ,W.S., A Comparative Study of Silver Cleaning Abrasives , Journal of the American Institute for Conservation, The American Institute for Conservation of Historic & Artistic Works Vol. 29, No. 1 (Spring, 1990), pp. 13-31

15 Wharton,G., Maish, S., Ginell, W., A Comparative Study of Silver Cleaning Abrasives, Journal of the American Institute for Conservation, Vol. 29, No. 1 (Spring, 1990), pp. 13-31

16 Selwyn, L., Silver care and tarnish removal, Canadian conservation Institute Notes, CCI 9/7, 1993.

to leave deep scratches) mixed with white/natural spirit and denatured alcohol. This was applied using cotton swabs. Although cotton swabs tend to leave lint, especially around the silver nails it proved to be effective on the delicate a'jour-like silver.

Iron

The uneven areas of surface rust were removed mechanically from the barrel and lock-plate using natural bristle and glass bristle brushes and a lint-free cloth with mineral spirits to soften the accretions and wipe off the resulting rust. The barrel interior was cleaned using a brush of the proper caliber followed by mineral spirits.

Gold

The surface of gold was cleaned with non-ionic detergent in distilled water, applied carefully on swabs to remove encrusted dirt (Non-ionic detergents yield no link between it and metal surface so it can be easily rinsed or washed off.

Wood

The areas of the wooden stock not covered with silver were cleaned using a mild detergent in distilled water applied with cotton swabs, then rinsed with swabs dampened with distilled water then dried and cleaned again with mineral spirits.

Coating

The formation of tarnish inside display cases can be minimized by using desiccated silica gel to keep the relative humidity (RH) low, and activated charcoal or a suitable commercial product to remove tarnishing gases. Lacquering or waxing is not recommended for silver because of the difficulties in obtaining an even coating. If the coating has not been applied well, it may be uneven or have streaks and small holes. If this is the case, the end result of any retarnishing may be worse than if no coating had been applied at all. However, in an open display where a coating is deemed to be necessary, microcrystalline wax or lacquers such as the cellulose nitrate[17] are suitable. Silver cellulose nitrate was used to coat silver and microcrystalline wax for iron. The coating was applied using a natural bristle brush.

Fig (13) Details of the muzzleloader before and after cleaning and conservation

Conclusion

In the course of the documentation, analysis and conservation of the Ottoman Egyptian percussion muzzleloader several marks high significance were exposed including a monogram tughra of Sultan Abdelmajid the First, several Ottoman Egyptian Silver Hallmarks in the official standard for the purity of silver (80% silver and gilded symbols on the lock plate resembling a simplified form of Ottoman

[17] Luxford, N., Thickett,D., Preventing silver tarnish – lifetime determination of cellulose nitrate lacquer, Metal 07, vol.5 Protection of metal artefacts, 2007, p.88-93

Coat of arms or military emblem, and a military unit symbol[18], in addition to a stamp on the gilded barrel. The upper design resembles the Ottoman star and crescent while the inscriptions below is a “Sah” sign, an official Ottoman stamp guaranteeing the purity of silver and gold work. The analysis of the silver showed a slight variation in the composition and a slight discrepancy from the Silver Hallmarks (80% silver) showing a silver copper alloy (87% Ag-10% Cu). [19]. Due to the fine thickness of the gold leaf (>20 µm) and the penetration of XRF (20-100µm), the analysis revealed the underlying elements displaying a high concentration of Fe. These results together with FTIR analysis were used to confirm the use of an adhesive in the application of the gold leaf excluding the use of soft solder or silver as an intermediate layer. Goethite, iron oxyhydroxide, α –FeO(OH) and Hematite , iron (III)oxide , α - Fe2O3 were identified on the barrel and hammer, while the silver tarnish was identified as Acanthine, silver sulphide, α–Ag_2S which is a stable phase.

For the cleaning and conservation of composite objects without disassembly, care must be taken that the materials used are safe for both the organic and inorganic components. Different polishing pastes for cleaning silver were prepared and tested on Plexiglas. Precipitated calcium carbonate, white/natural spirit and denatured alcohol showed the best results and were applied using cotton swabs. The rust on the barrel and lock plate were cleaned mechanically, followed by mineral spirits. The surface of wood and gold were cleaned using a non-ionic detergent to remove surface grime. Silver was coated with cellulose nitrate, while the iron was coated with microcrystalline wax to protect from further corrosion in the uncontrolled museum environment.

[١٨] عبد المنصف سالم حسن نجم " شعار العثمانيين على العمائر و الفنون فى القرنين الثانى عشر و الثالث عشر الهجريي (١٨–١٩) و حتى إلغاء السلطنة العثمانية "دراسة أثرية فنية" مجلة كلية الآثار – العدد العاشر ٢٠٠٤

[19] Weisser, T.D., Gilded Metals, History, technology and Conservation, archival, 2001, p.256.