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Characterization Study of Sheath of Kalij Sword from Islamic Period

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Abstract

Sheath of sword is an important part and must be suiting its sword. Swords have a lot of shapes; kalij sword is the most famous kind. The sheath consists of variety materials, so sword sheath components has different reaction to deterioration factors. This sheath in the store of Islamic art museum suffer from rust of metal parts, separation of the lower metal part, missing part of dry leather, cracks at the wooden support and microbial infection. The sheath has examined by Digital Microscope (Usb microscope) and microbial investigation. It had analysis by Attenuated Total Reflectance with Infra-Red Radiation spectroscopy (ATR-FTIR), X-Ray fluorescence (XRF), Scanning Electron Microscope with EDX unit (SEM-EDX) and X-Ray Diffraction (XRD). Results illustrated that is the sheath from Othman period. Examination with usb microscope showed that the leather is snake leather. Microbial investigation cleared *Microbacterium imperial* for metal, *Bacillus jeotgali, Microbacterium imperial, Micrococcus lutus* and *Kocuria turfanensis* as a bacteria in addition *Arthroderma curreyi* and *Chaetomium funicola* as fungi for leather, *Aspergillus fumigatus*, *Aspergillus ustus* and *Chaetomium tetrasporum* for wood. Analysis by AT-IR result showed that the adhesive is animal glue. Analysis with XRF and EDX showed the metal part is alloy from Brass and iron adds to it. XRD showed that the rust consists of Limonite, Magnetite, Iron Sulfide, Paratacamite, Copper Sulfide, Zinc Sulfate, Calcite and Silica.

Keywords: Sheath; USB Microscope; Microbial Investigation; ATR-IR; XRF; SEM; EDX; XRD

Introduction

All old civilizations know metal weapon science Bronze Age, the most important kind is sword [1] which had made from Bronze then from iron [2]. weapon in ancient society have essential role in development to save gains and wealth [3]. weapons divided two classes Offensive like sword and defensive like shield [4,5]. Sword consist of a blade, hilt for catch and sheath (scabbard).The sheathes made from several materials to save sword and contain suspending loops for hanging on the horse or on the warrior. In the beginning scabbard (sheath) was made from bronze and iron [6] then from wood decorative with Lacquer painting, [7] sometimes wood is covered with leather, [8] silk and metal. The sheath matches its sword in shape.

The Islamic swords divided two types straight and curved. That curved sword became exist in the 15th century AH 9th AD, between them little curved kind was appeared [9,10]. Sword has a lot of names depend on its shape, the curved on called kalij in Turkish and Saber in Arabic language. The Ottoman Empire in Turkey adopted that Mongolian origins sword (kalij) and modified to be distinguished Othman era since 1800 AD; have single edge blade and its end section is double edge [11,12,13].

The research aim to Characterization Study the sheath, which in Islamic art museum store with number 39229/2 (Figure 1). Characterization is a significant part of documentation. Documentation is important for describe everything in the object by written, photo and drawing, its keep data [14]. (Archaeological work and documentation together in every step, beginning from excavation and 3D documentation for place and objects [15,16] during restoration process until finished. Documentation include Characterization (investigation and analysis for the object) that often not available because of limited devices in museums [17] and depend on if there are minor parts falling from the objects. Every object is unique in its material and surrounding condition, so there are different investigation and analysis use to each object according the condition and what we need to know.

The sheath structure is inner support from two pieces of wood together with two parts of metal in the front and end; the middle part covered with leather and has two suspending loops. There is in one of sheath side curved metal strip decorative with gold as so as the two metal parts. The front metal part have symbol in one side a star and on the other side star with crescent in gold.

Straight distance between both ends of the sheath is 85.5 cm and maximum width 4.5 cm.

Study the symbols of the crescent and star, found that symbols refer to the Ottoman Empire [18]. The star in the Othman Empire had eight points (Figure 2), after collapse and became Turkish republic, the star became have five points only [19,20].

Previous studies for swords are without sheath (for metallic blades) [21,22,23,24]. The only sheath mentioned before from wood only. The research study for complex structure material sheath, so i used Usb microscope to document deterioration and recognize leather kind, microbial investigation for determine existing bacteria and fungi, also ATR-FTIR for recognize adhesive material on wood under separated metal part. X-Ray fluorescence XRF and Scanning electron microscope (SEM) with EDX unit to know elements in the object. X-Ray Diffraction (XRD) for establish compounds in the metal parts.

Materials and Methods

Materials

The sheath in my study consists of a lot of material (wood, leather and metal), each one have different physical and chemical properties, so have different affected by deterioration factors. Those different materials beside each other cause extra deterioration phenomena.

The famous factors of deterioration are Oscillation humidity & Temperature, light (U.V&IR), biological influences and pollutants in surrounding air, each archeological material affected different as it indoor or outdoor [25]. Those factors cause weakness of leather, [26] deformation and loss mechanical properties especially density for wood, [27] corrosion and rust for metal which cause change in composition and its color [28].

The sheath describe; wood is the basic support of the sheath in the same length 85.5 cm (Figure 3-A). The metal in the front 17 cm and separated metal part 13 cm length (Figure 3-C), the distance between two suspending loops 11 cm and wide for each one 3 cm. the wood under separated part have dirt and unknown adhesive (Figure 3-E). The leather has dust on it and suffers from dry and loses parts beside metal parts and inner line of gathering wood parts (Figure 3-b, d). Metal parts have rust and change color. The rust under the gold decoration made it fell off (Figure 3-A, C, d). He was caught while smuggling, Case No. 2829 of 1995, Cairo Airport. Then it was placed in the storage of the Museum of Islamic Art.

Methods

Digital Microscope

USB Microscope 5-500 X magnify.

Microbial Investigation

I take Swabs from wood, leather and metal. Swabs were cultured on plates of cellulose, protein, Dox and nutrient agar media. Microorganisms' identification carried out at Laboratory of Microbiology, Grand Egyptian museum, Ministry of Antiquities with optical microscope.

Attenuated Total Reflectance with Infra-Red Radiation spectroscopy (ATR-FTIR)

It is a technique for fast and non-destructive method to obtain IR spectra to identify organic material [29]. The device use is Platinum-ATR, BRUKER, 2014, (with library software), In Islamic Art Museum.

X-Ray fluorescence (XRF)

I used portable X-Ray Fluorescence (pXRF), Niton, Model XLt 592 GKV, Series 8138 with software version 4.2E, (USA), in National Research Centre.

Scanning Electron Microscope with EDX unit. (SEM-EDX)

The devise is QUANTA 3D 200i, FEI (SE Detector R580), in Grand Egyptian museum, Ministry of Antiquities.

X-Ray Diffraction (XRD)

The equipment model X'Pert PRO with Secondary Monochromator, Cu-radiation (λ=1.542Å) at 45 K.V., 35 M.A. and scanning speed 0.04/sec. with ICDD files. The Ministry of Petroleum, Central Laboratories Sector.

Results

According to historical study of swords the sheath belongs to Othman empire; in the period between appear this kind 1800 and 1922 A.D. the collapse of Othman empire.

Digital Microscope

The picture was taken by USB Digital Microscope showed dryness of leather, cracks and missing parts, crack in wood under leather (Figure 4), it also cleared the kind of leather is snake leather (Figure 5) By compared with references [30,31,32,33].

The pictures were taken for metal show dirt like crust in the end of front metal part, suspending loops and edge of separated metal part. (Figure 6) The pictures taken for gilded part of metal show the metal was scratched before gilded by gold paper not gold solution. (Figure 7) USB Microscope declared dryness and cracks in adhesive on wood under separated metal part, (Figure 8).

Microbial Investigation

The isolations microorganisms were identifying by Optical Microscope after cultured and grow on four media mentioned before, the results showed *Microbacterium imperial* for metal, *Bacillus jeotgali, Microbacterium imperial, Micrococcus lutus and Kocuria turfanensis* as a bacteria in addition *Arthroderma curreyi* and *Chaetomium funicola* as fungi for leather, *Aspergillus fumigatus, Aspergillus ustus* and *Chaetomium tetrasporum* for wood and *Microbacterium imperial* for surrounding air (Table 1), classified as Bactria and fungi in (Figures 9, 10).

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Figure 1: Show the sheath of kalij sword from Islamic art museum store with number 39229/2, (a) The front side (b) back side.

Figure 2: Show the sheath symbols the crescent and 8 point star.

Figure 3: Show the sheath deterioration phenomena, (a) dirt's on the sheath, (b) writing sheath number on it and rust, (c) separated metal part, (d) rust and lose gelded parts on suspending loops. Missing parts and rust on leather (beside decorative metal strip), (e) dirt and adhesive on wood under separated metal part.

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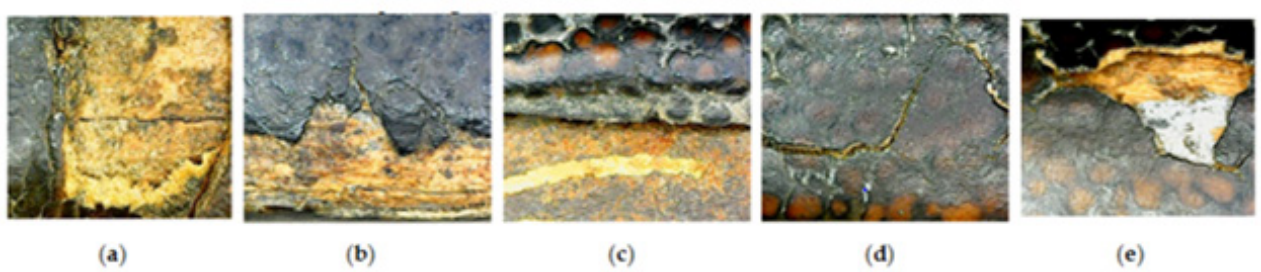

Figure 4: Showed the sheath leather deterioration phenomena (a) Leather missing parts beside the front metal part, (b) dried leather untill britthe and fall in inner line of gathering wood, (c) missing part of leather beside metal decorative strip, (d) cracks in leather in distance between two suspending loops, (e) missing part of leather beside one of suspending loop.

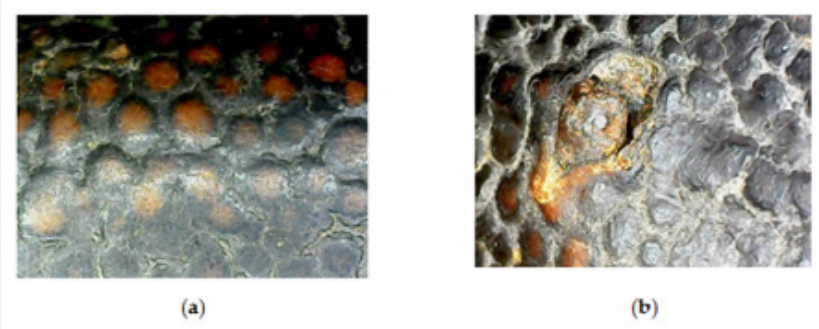

Figure 5: Show the kind of sheath leather is snake leather, (a) from one side of the sheath (b) from another side.

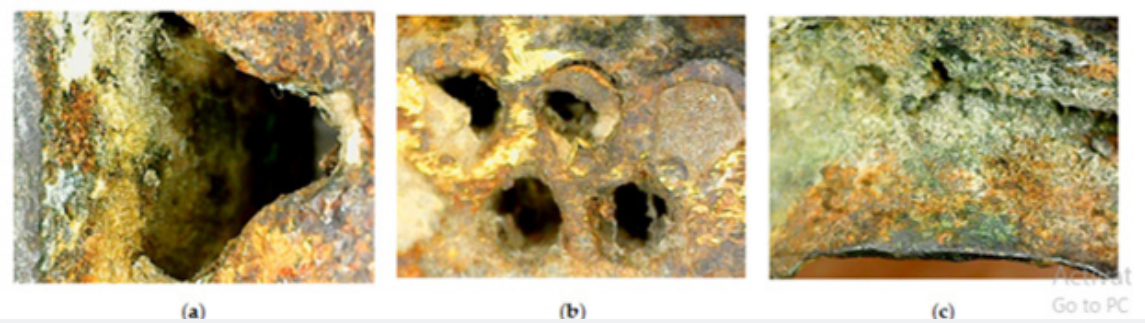

Figure 6: Show the rust in metal parts (a) from front metal part; (b) suspending loops, (c) edge of separated metal part.

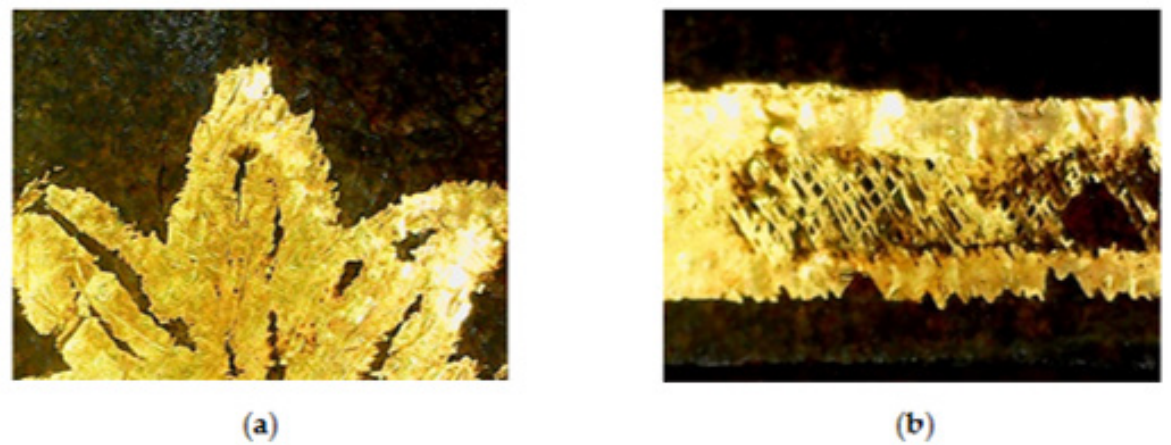

Figure 7: Show parts of gold on metal (a) Part of gilded star of front metal part; (b) Gilded line In metal separated part.

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Figure 8: Show adhesive on wood under separated metal part.

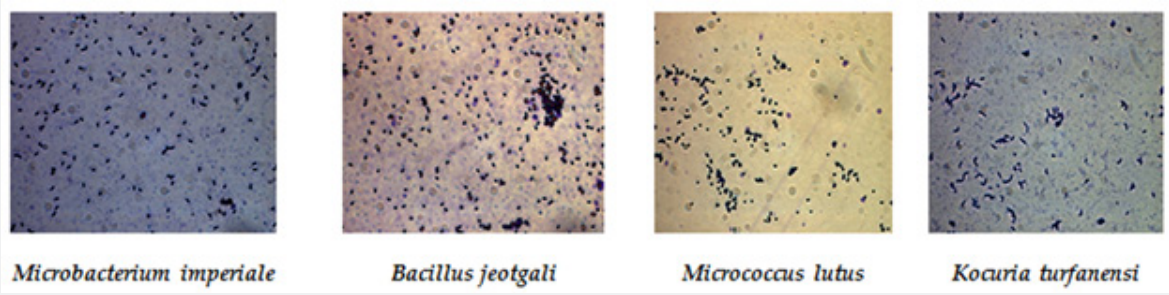

Figure 9: Bacteria isolated from mummy with optical microscope at (1000x).

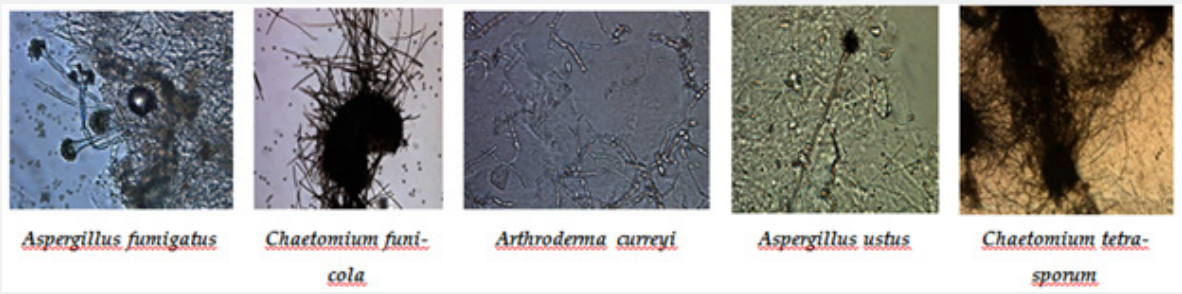

Figure 10: Fungi isolated of sheath with optical microscope at (400X).

(ATR-FTIR) results:

As non-destructive method to obtain IR spectra, it was analyzed the adhesive on wood under separated metal part by compared with library in device, the result is animal glue. (Figure 11) The leather of sheath had analyzed also (Figure 12).

X-Ray fluorescence (XRF)

The rusts were analyzed as in (Figures 13, 14, 15) and showed the presence of iron, copper and zinc metals in a large percentage, in addition to the presence of some impurities Pb and Au. Gold is high percentage in Figure 15 due to the sample place.

(SEM-EDX) analysis

This analysis give very magnify with high resolution picture so could see dirt on leather (Figure 16-b) and damage in wood cells on back of adhesive crust fall (Figure 16-d). Analysis is determined O and C in all patterns which indicate to exist of oxides and carbonate. The results appear Fe, Cu, Zn, Ca, Cl, Si, and S elements in different percent plus impurities of Na, Al and Mg elements Figures (17-22). The Chloride element is active and cause rusts.

X-Ray Diffraction (XRD)

For small samples I put rust of the front metal part, suspending loops and separated metal part together. The rust from metal parts were analyzed, the results appeared compounds of Magnetite, Iron Sulfide, Copper Sulfide, Calcite, Silica, Zinc Sulfate and Paratacamite as in (Table 2), Figure 21.

Discussion

The evidences of the sheath curved shape and decorative with crescent and eight point star return it to Othman period, [18] exactly from 1800 the time of beginning this kind appears [12]

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to1922 AD the collapse of Othman empire. The sheath made basic support from one piece of wood then divide it in half lengthwise. The shape of a sword is carved into the wood each half. The two half piece of wood together by glue and covered with leather and metal parts [5,8].

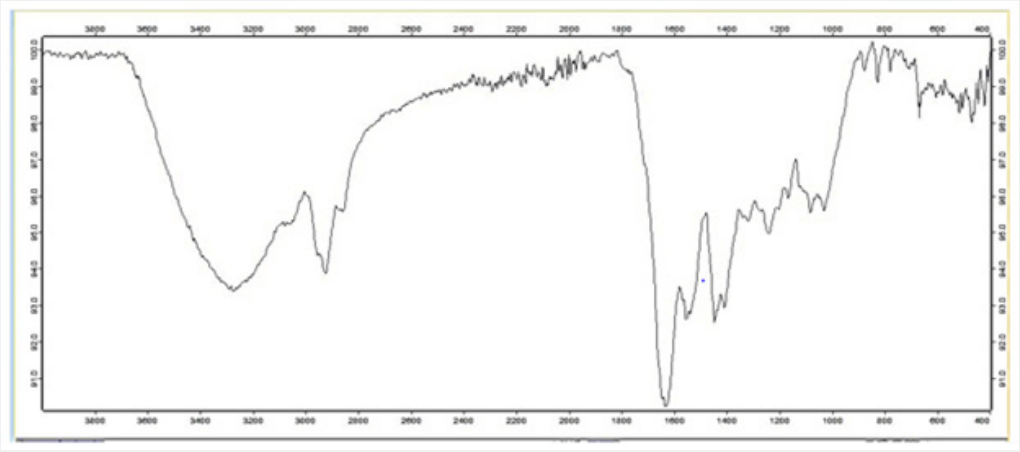


Figure 11: ATR-FTIR analysis for adhesive on wood under separated metal part of the sheath.

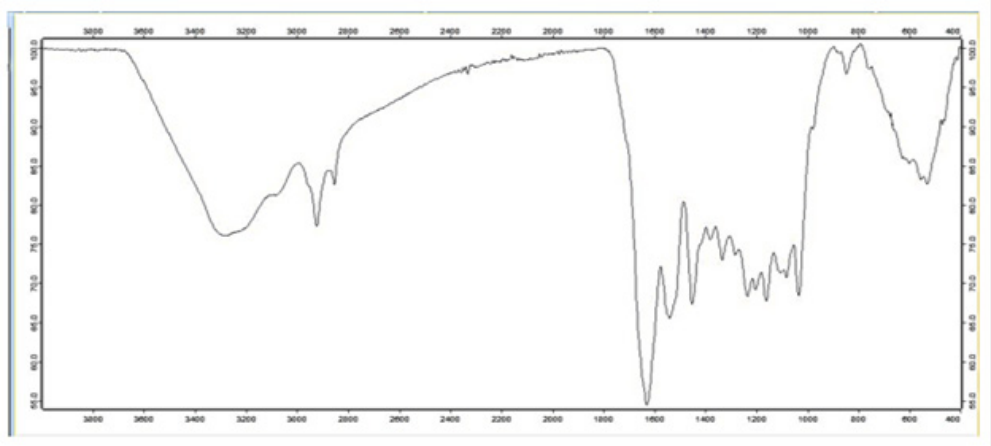
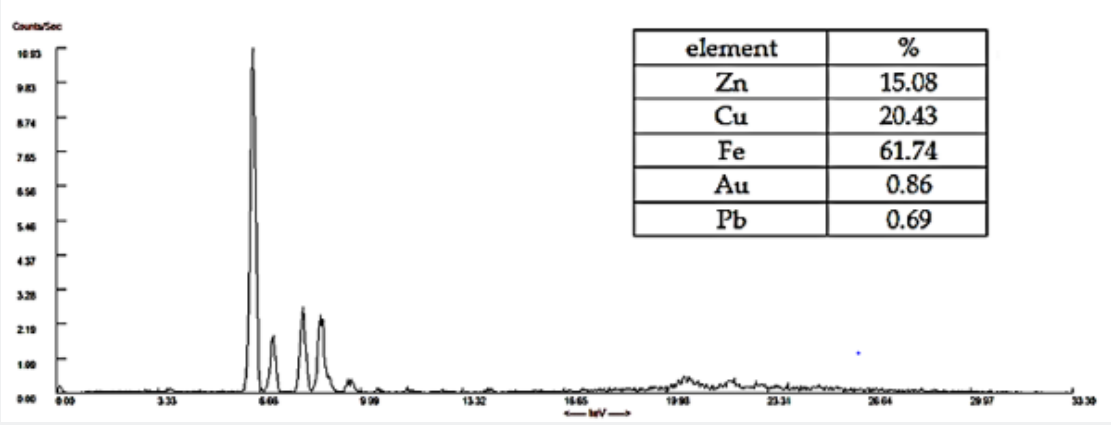


Figure 12: The ATR-FTIR spectra for leather of the sheath.



element	%
Zn	15.08
Cu	20.43
Fe	61.74
Au	0.86
Pb	0.69

Figure 13: Pattern of XRF for rust on external surface of front metal part of the sheath.

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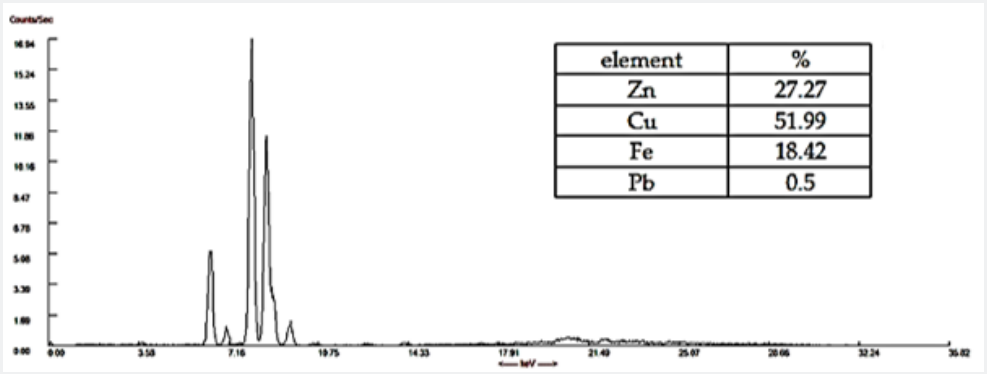
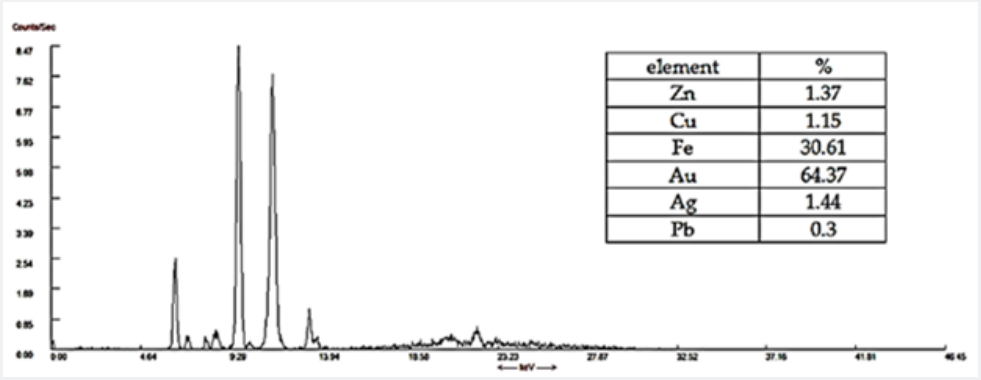


element	%
Zn	27.27
Cu	51.99
Fe	18.42
Pb	0.5

Figure 14: Pattern of XRF for Greenish rust on the edg of separated metal part.



element	%
Zn	1.37
Cu	1.15
Fe	30.61
Au	64.37
Ag	1.44
Pb	0.3

Figure 15: Pattern of XRF for rust from metal strip decorative with gold.

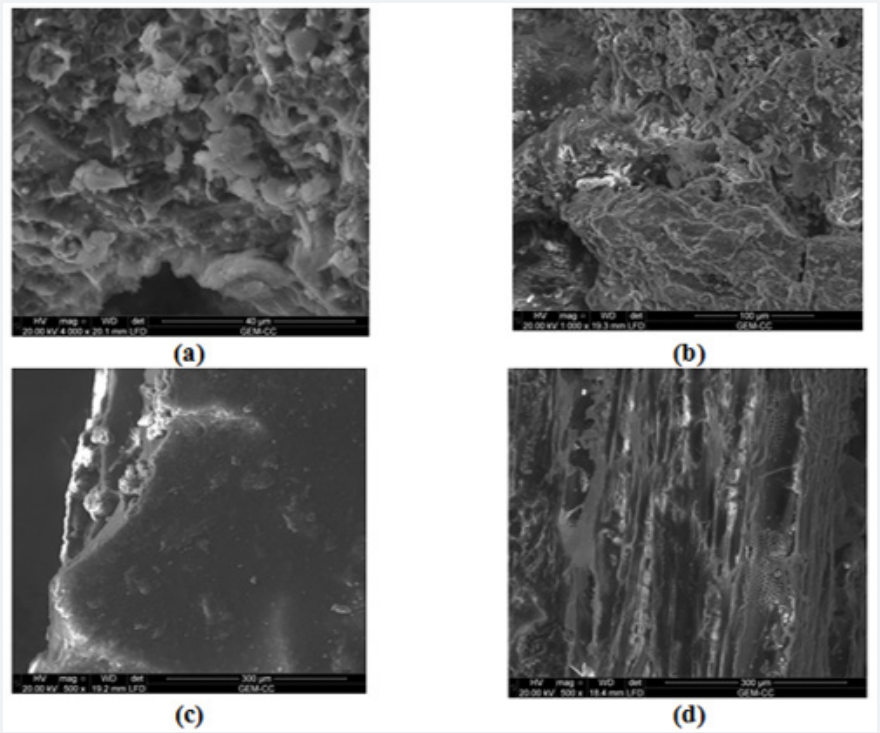


Figure 16: Picture by SEM (a) rust from metal parts 4000X, (b) small dry fall leather of the sheath 1000X(c) a fall crust of adhesive on wood under separated metal part 500X, (d) wood stick on a fall crust of adhesive 500X.

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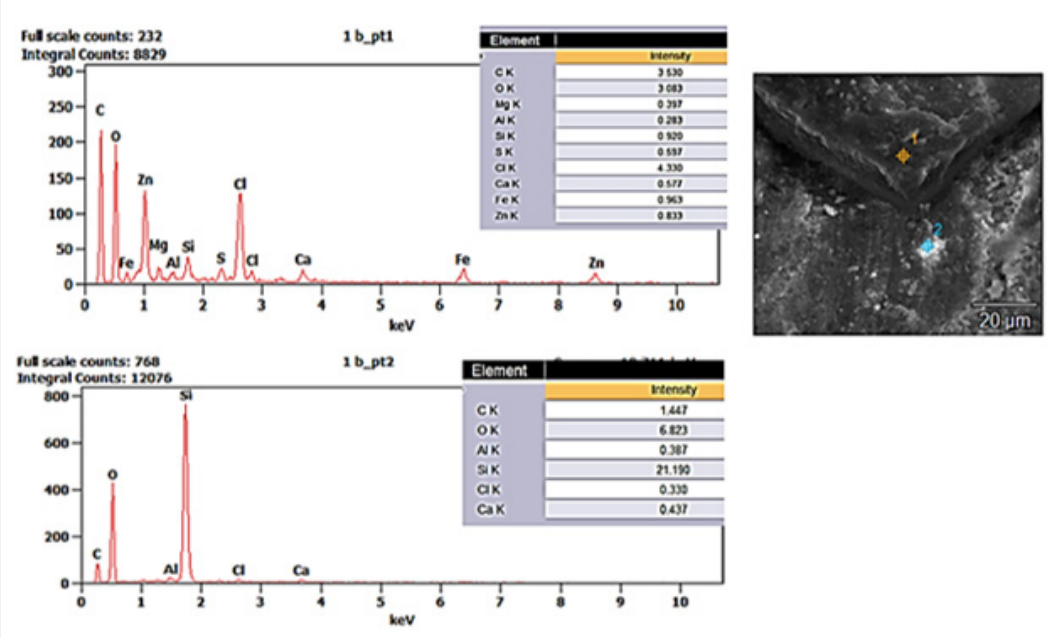

Figure 17: SEM micrographs and EDX analysis for rust from front metal part of the sheath.

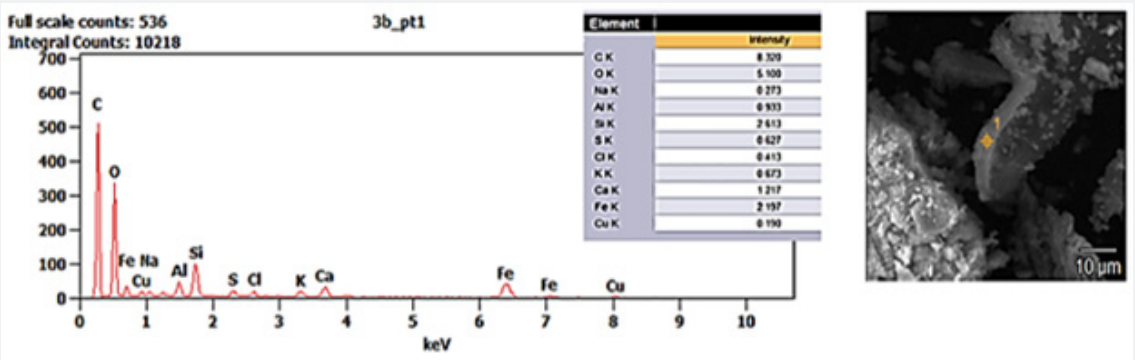

Figure 18: SEM micrographs and EDX analysis for rust from separated metal part of the sheath.

Digital USB Microscope pictures showed dryness, cracks and missing parts of leather beside metal parts due to different expansion and contraction between metal and leather [25]. Snake leather is too sensitive and thin, so rust of metal made leather dried fast and easy to fall when meat the expansion and contraction of wooden support under it. The missing part of leather on curved edge of the sheath due to old use. The crack in leather between two suspending loops is because of tensile strength and dry of leather. The wooden support is thin in the end under metal separated part Figure 3-e, with light color Figure 4 and have homogeneous structural Figure 16-d that indicate to Beech wood [34,35].

The pictures with USB Microscope appear technique of gilded part on metal, it was happened by scratched surface and Press on gold paper to stick, that is clear in print of cloth press with it (Figure 7). the metal part in the end of the sheath may take off for two reasons; lose the adhesive its properties by dryness and Friction between that part with sword hand. The ATR-FTIR spectra of glue resemble to spectra of leather and that is logical, because of animal glue made from animals' leathers and bone [36].

By analyses result of XRF pattern found Fe, Cu and Zn elements. Those results lead to say that metal consist of alloy from Brass alloy and add iron to it. . In the bronze age rarely alloy is pure, the old manufacturer add iron to gain stronger alloy and resistant to corrosion [37]. Ancient times zinc was an additive on metals since 16th century. Zinc add to Copper to produce Brass alloy, to prevent rust exist [38]. Because of the metal is alloyed of Brass and iron was added, so manufacturer use casting molds way for metal parts in the sheath [39].

Analysis with SEM-EDX shows elements in major presence C, O, Zn, Cl, Si, minor elements Fe, Cu, Ca, Al, traces of Mg, Na, as in Table 3. By analyses XRD pattern of rust product, Table 2, Figure

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23 and compare SEM-EDX it is clear that the sheath was exposing to humidity which cause rust products. It is clear Limonite and magnetite caused by high humidity [22]. Limonite ($FeO(OH)\cdot_nH_2O$) is amorphous [40,41], so did not appear in XRD pattern put under USB-Microscope it is obvious Figure 6. The humidity cause Paratacamite $Cu_2(OH)_3Cl$. Chlorine ion could exist by sea especially exist of Na element or use salt and chlorine solution [42,43] for cleaning and disinfectant the sheath and its sword after use.

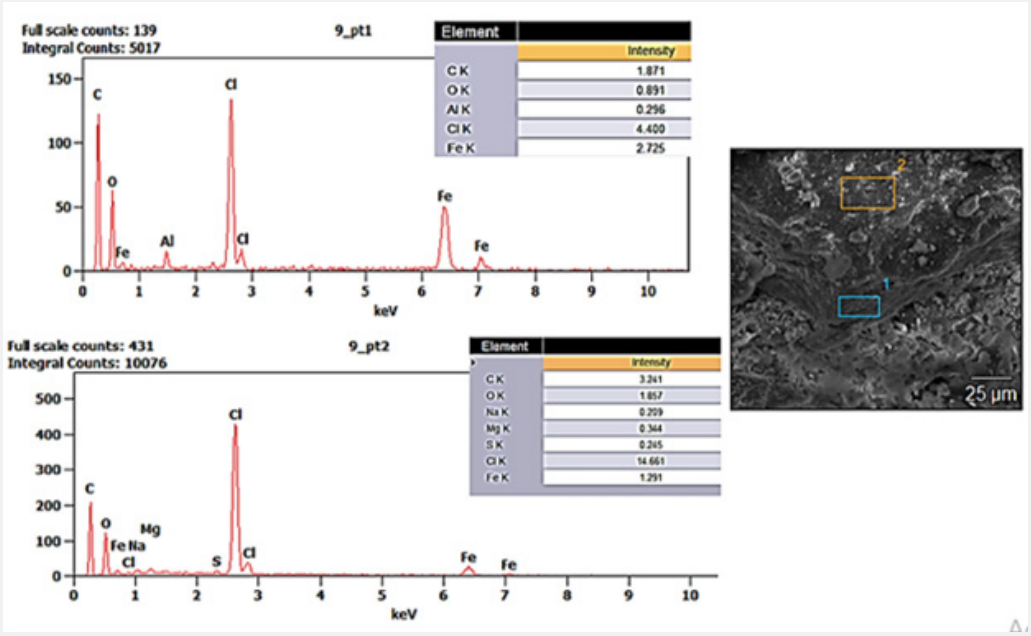

Figure 19: SEM micrographs and EDX analysis for leather (external side) of the sheath.

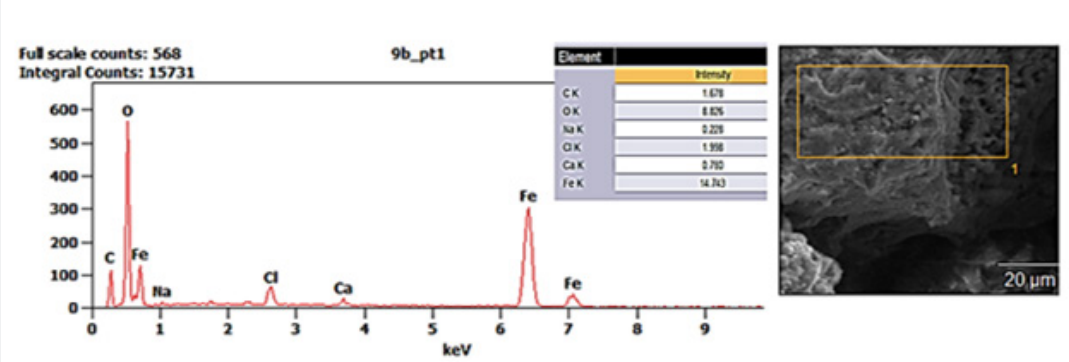

Figure 20: SEM micrographs and EDX analysis for leather (inner side- sample back) of the sheath.

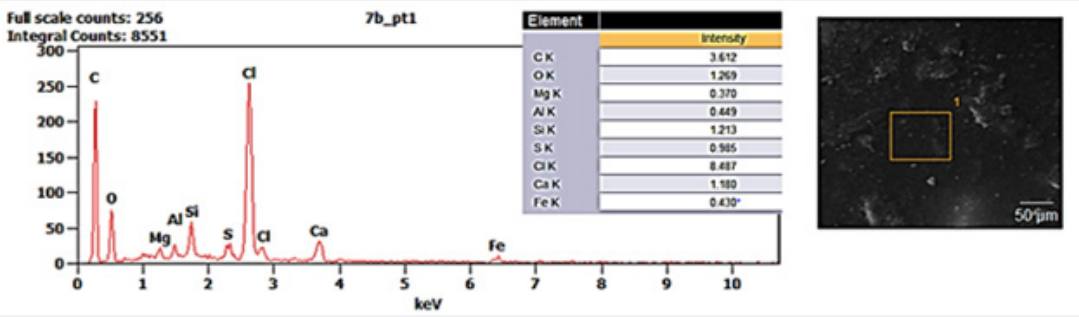

Figure 21: SEM micrographs and EDX analysis for adhesive on wood under separated metal part of the sheath.

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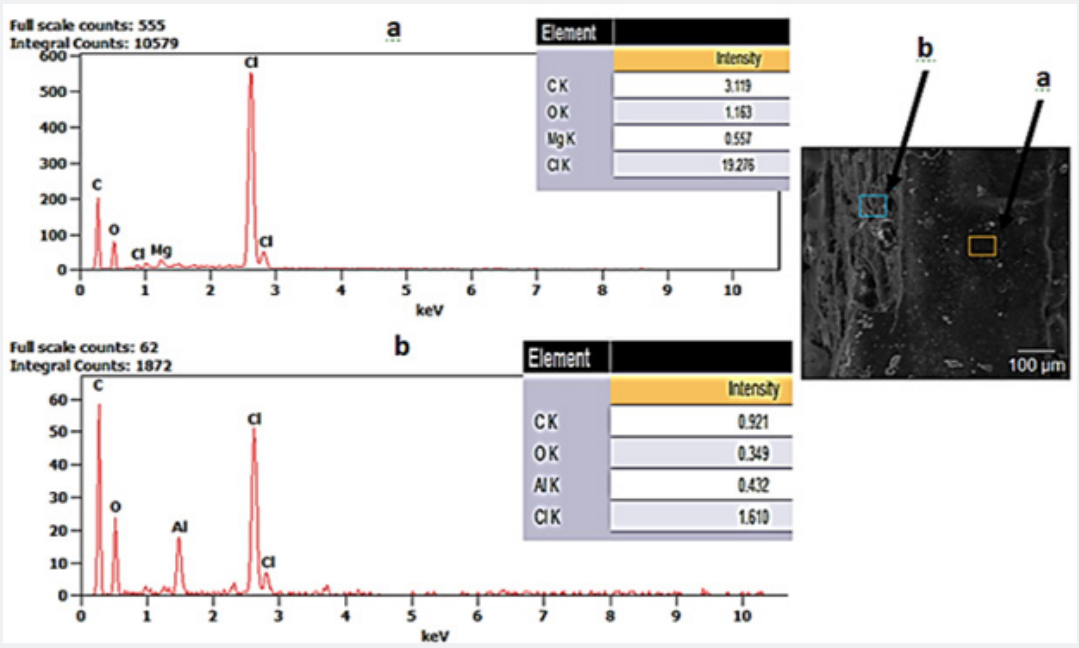

Figure 22: SEM micrographs and EDX analysis for crust of adhesive stacked wood on it (a) adhesive side (b) wood side.

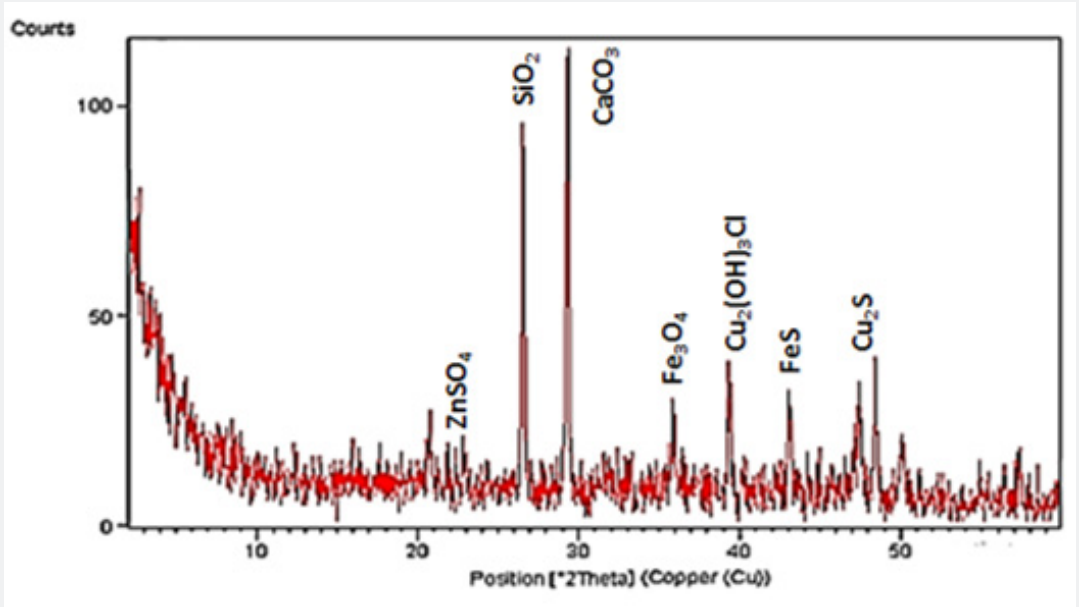

Figure 23: XRD pattern for rust product in the metal parts of the sheath.

Al and S elements refer use of Alum $Al(SO_4)_2.12H_2O$ which is preservative material [44] it could be used for cleaning the sheath and its sword after war. Alum was used in Ancient time as a tanning for leather [8], it could be used for tanning snake leather of the sheath. Alum used also to conservation wood in the beginning 1900's. [45,46] so it could be used for this reason before entering the store of Islamic Art Museum. That interpretation exist of Al element in all structure of the sheath and made it logic exist of S element which cause rust of iron in Iron Sulfide FeS, Zinc in Brass alloy Zinc Sulfate $ZnSO_4$ and copper as Copper Sulfide Cu_2S. It is known that iron rusts fast than copper so it is clear Fe in most samples in Table 3, but Cu not [47]. Mg element is impurities in Alum, Calcite $CaCO_3$ and Silica SiO_2 are dirts from ancient use of the sheath and its sword.

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There are deterioration circle among the sheath component, wood and leather attract humidity that make metal rusted. The rust of metal cause dryness of leather and fall parts especially beside metal parts, wood and adhesive also affected by rust become weak and had cracks and lose the adhesive its properties caused separated end metal part. Therefore Toxicity of rust compounds the only microbe exists on metal is *Microbacterium imperial* which actually exists in surrounding air Table 1.

Table 1: Isolated microorganisms grow on different media (Nutrient, Dox,s, Protein and cellulose agar).

Swab cite	Media			
	Nutrient agar	Dox,s agar	Protein agar	cellulose agar
metal	*-ve*	*Microbacterium imperial*	*-ve*	*-ve*
leather	*Bacillus jeotgali*		*Arthroderma curreyi*	*-ve*
	Micrococcus lutus	*-ve*	*Chaetomium funicola*	
	Kocuria turfanensis			
	Microbacterium imperial			
wood	*-ve*	Aspergillus fumigatus	-ve	*Aspergillus fumigatus*
				Aspergillus ustus
				Chaetomium tetrasporum
Surrounding Air	*Microbacterium imperial*	*-ve*	*-ve*	*-ve*

Table 2: Compounds of rust on metal parts of the sheath and its chemical formula.

Name of the Compound	Chemical Formula
Calcite	$CaCO_3$
Silica	SiO_2
Paratacamite	$Cu_2(OH)_3Cl$
Copper Sulfide	Cu_2S
Iron Sulfide	FeS
Magnetite	Fe_3O_4
Zinc Sulfate	$ZnSO_4$

Table 3: Elements for the sheath component by SEM-EDX analysis.

Cite	Elements			Notic
	Major	Minor	Traces	
Metal (front part)	C, O, Zn, Cl	Fe, Si, Ca, S	Mg, Al	Figure 17 (pt-1), it is look as Oxides, Sulfide, carbonate
	Si, O	C	Al, Cl, Ca	Figure 17 (pt-2) bright spot it is quartz (sand)
Metal (front part)	C, O, Si	Fe, Cu, Ca, Al	S, Cl	Figure 18, it is look as Oxides, Sulfide, carbonate and chlorides
Leather (external side)	C, O, Cl	Fe, Al	---	Figure 19 (pt-1)
	C, O, Cl	Fe, S	Na, Mg	Figure 19 (pt-2)
Leather (inner side- sample back)	O, Fe, C	Cl	Ca, Na	Fig. 20, it is clear that rust of iron oxide and chloride penetrate to inner side of leather
Adhesive	C, O, Cl	Si, Ca, S, Al	Fe, Mg	Figure 21
	C, O, Cl	Mg	----	Figure 22 – (a)
Wood	C, O, Al, Cl	----	----	Figure 22- (b)

Conclusion

The sheath I studied return to late period of Othman empire 1800-1922 A.D. It is have complex structure of three different materials (wood, leather and metal). The sheath techniques is, made basic support from wood then covered with leather and fixed metal parts in front and end with decorative support metal strip and suspending loops. The different material of the sheath

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causes a lot of deterioration. Leather and wood organic materials so they hygroscopic attract humidity that make metal rusted. The rust causes dryness and fall parts of leather. Rust affected on wood make it fragile easy to attack with bacteria and fungi. By studying leather it is snake leather. Microbial examination appear *Microbacterium imperial, Bacillus jeotgali, Micrococcus lutus, Kocuria turfanensi as bectria and Aspergillus fumigatus, Chaetomium funicola, Arthroderma curreyi, Aspergillus ustus, Chaetomium tetrasporum as fungi*.

Analysis with ATR-IR showed that the adhesive used is animal glue. The analysis with XRF, SEM-EDX and XRD proved that the metal is alloy from Brass and iron was added. The rusts products and its color are Limonite (Yellow to brown(, magnetite and Iron Sulfide (black) for iron, Paratacamite (light green) and Copper Sulfide (black) for copper, Zinc Sulfate, Calcite and Silica (white).

References

1. Molloy B and Horn C (2020) Weapons, Warriors and Warfare in Bronze Age Europe. pp: 117-141.
2. Mark JJ (2017) Weapons in Ancient Egypt.
3. Feugère M (2002) Weapons of the Romans. Tempus, HAL Id: halshs-00007319.
4. Asimopouls P A contribution to study about the defensive and the offensive weapons of ancient Greeks. Hellenic Military Academy, Greece, pp: 9-26.
5. Hassn HM (2009) A Study on Unpublished Object Reserved In: Arthur M. Sackler Museum, Harvard University Art Museums. Journal of the General Union of Arab Archaeologists 10(1): 466-496.
6. Czarnecka K (2017) New (Old) Type of Sword Scabbard From The Early Roman Period. Chjsh, Journal Študijné zvesti 61: 59-74
7. Park J, Cho H and Lee J (2018) Organic Material Analysis of a Lacquered Wooden Sheath of Long Sword with Ring Pommel Excavated in Imdang Ancient Tomb. Journal of Conservation Science 34(5): 369-377.
8. Harjula J (2005) Sheaths, Scabbards and Grip Coverings The Use of Leather For Portable Personal Objects In The 14th - 16th Century Turku. Gummerus Kirjapaino Oy, Saarijärvi, p: 30-58.
9. El-Zamly YE (2021) Manufacturing of swords and its Use in Mamluk State Era. Al-Aqsa University Journal of Humanities 25(1): 292-223.
10. Zaky AR (1961) Introduction to the Study of Islamic Arms and Armours.
11. Algohaini MM (2022) An artistic study of an Ottoman sword in the Military Museum (Ingolstadt, munich, Germany unpublished before) Journal of Archaeological Research And Studies 10: 1-14.
12. Wadsworth J (2015) Archeometallurgy related to swords. Materials and Characterization Journal 99: 1-7.
13. Alexander D (2001) Swords and Sabers during the early Islamic period. Gladius XXI, pp. 193-220.
14. Huvila I, Skȍld O and Bȍrjesson L (2021) Documenting information making in archaeological field reports. Journal of Documentation. Emerald Publishing Limited 77(5): 1107-1127.
15. Valente R, Brumana R, Oreni D, Banfi F, Barazzetti L, et al. (2017) Object-Oriented Approach For 3d Archaeological Documentation, The International Archives of the Photogrammetry. Remote Sensing and Spatial Information Sciences XLII-2/W5: 707-712.
16. Campana S, Remondino F (2007) Fast and Detailed Digital Documentation of Archaeological Excavations and Heritage Artifacts. Layers of Perception – CAA pp: 36-42.
17. Moore M (2001) Conservation Documentation and the Implications of Digitisation. Journal of conservation and museum studies 7: 6-10.
18. Kaya P (1997) Search For the Origin of the Crescent and Star Motif in the Turkish Flag.
19. Smith W (2024) flag of Turkey, Britannica.
20. Yapp ME and Shaw SJ (2024) Ottoman Empire -historical empire. Eurasia and Africa, Britannica.
21. Grazzia F, Brunettib A, Scherilloc A, Minojad ME, Salisd G, et al. (2018) Non-destructive compositional and microstructural characterization of Sardinian Bronze Age swords through Neutron Diffraction. Materials Characterization Journal 144: 387-392.
22. Salem Y, Oudbashi O and Eid D (2019) Characterization of the microstructural features and the rust layers of an archaeological iron sword in the Egyptian Museum in Cairo (380–500 A.D.), Heritage Science 7: 19.
23. Doračić D, Hošek J, Brauns M and Čakširan IM (2022) Technical Examination and Conservation of the Early Medieval Sword from Bojna-Brekinjova Kosa. In book "Secrets Oof Iron - From Raw Material to an Iron Object", Zbornik Instituta Za Arheologiju Serta Instituti Archaeologici Knjiga. pp: 195-206.
24. Udrescu OV, Plaiasu AG, Barbulescu CA, Catalin Ducu M, Moga SG, et al. (2022) Analysis of Archaeological Sword Materials from Buridava Site. Journal of Science and Arts 22(2): 483-496.
25. Hejazi B, Frick J and Garrecht H (2020) Deterioration Factors of Delicate Materials. Otto-Graf-Journal 19: 71-90.
26. Abdel-Karim MH (2019) The use of Re-Tainning Materials for the Treatment of Vegetable Tanned Leather: Article Review. Bulletin of the Faculty of Arts 53(2): 61-84.
27. Tornari V, Basset T, Andrianakis M and Kosma K (2019) Impact of Relative Humidity on Wood Sample: A Climate Chamber Experimental Simulation Monitored by Digital Holographic Speckle Pattern Interferometry. Journal of Imaging 5(65).
28. Rimmer M, Thickett D, Watkinson D and Ganiaris H (2013) Guidelines for the Storage and Display of Archaeological Metalwork, Cardiff University, Technical Report.
29. Kazarian SG, Chan KLA (2006) Applications of ATR-FTIR spectroscopic imaging to biomedical samples. Biochimica et Biophysica Acta 1758(7): 858-867.
30. Duffy C (2013) Here's looking at you kid: Under the microscope with leather. British library.
31. Gray BS (2012) Guide to the Identification of the Shed Skins of the Snakes of Canada. USA pp: 50-62.
32. Gray BS (2015) Shed Snake Skins Identification: A Guide to Snake Skins Found in Penssylvaina. PARS, pp: 6-21.
33. Tsai TS and Mao JJ (2017) Species Identification of Shed Snake Skins in Taiwan and Adjacent Islands. Zoological Studies Journal.
34. Ali M (2020) Weathering of Outdoor Beech Wood and Methods of Conservation. Conservation Science in Cultural Heritage 20(1): 167-180.
35. Al-musawi H, Huber C, Ungerer B, Jakob M, Pramreiter M, et al. (2024) The Effect of Rays on the Mechanical Behaviour of Beech and Birch at Different Moisture and Temperature Conditions Perpendicular to the Grain. Forests, 15: 584.

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36. Schellmann NC (2007) Animal glues: a review of their key properties relevant to conservation. Studies in Conservation 52(8): 55-66.

37. Craddock PT and Meeks ND (1987) Iron in Ancient Copper. Archaeometry journal 29(2): 187-204.

38. Biswas AK (2006) Brass and Zinc Metallurgy in the Ancient & medieval world: India's Primacy and the Technology Transfer to the west. Indian Journal of history 41(2): 159-174.

39. Niece S, Ward R, Hook D, and Craddock P (1990) Brass in the Medieval Islamic World.

40. Neff D, Reguer S, Bellot-Gurlet L, Dillmann P, Bertholon R (2004) Structural characterization of corrosion products on archaeological iron: an integrated analytical approach to establish corrosion forms. Journal of Raman Spectroscopy 35(8-9): 739-745.

41. Britannica (2009) limonite mineral.

42. Wisniak J (2002) The History of Chlorine – From Discovery to Commodity. Indian Journal of Chemical Technology 9: 450-463.

43. Britannica (2025) chlorine.

44. Affinity Chemical (2020) Aluminum Sulfate Composition and Uses.

45. Häggström C and Sandström T (2013) Alum-treated archaeological wood Characterization and re-conservation. Swedish National Heritage Board, p: 6.

46. Łucejko JJ, McQueen C MA, Sahlstedt M, Modugno F, Colombini MP, et al. (2021) Comparative chemical investigations of alum treated archaeological wood from various museum collections. Heritage Science 9: 69.

47. Samina M, Karim A and Venkatachalam A (2011) Corrosion Study of Iron and Copper Metals and Brass Alloy in Different Medium. E-Journal of Chemistry 8(S1): 344-348.

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