A study on the effect of iron rust on archaeological wood applied on the archaeological gun No. 7 / 14 at the Museum of Applied Arts, Helwan University

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ABSTRACT

The topic of this research is based on studying the effect of iron rust on the natural properties of wood in a old gun at the Museum of Applied Arts in Helwan University. Iron pieces or parts were often used with different kinds of wood in old guns. They usually rust inside the wood causing a change in colour around the metal. In this research the effect resulting from the precipitation and interpenetration of the rust from the iron metal in the wood fibers is studied. The physiomechanical and chemical properties of wood which are correlated with those metals were the main points in this study, in addition to the deformation that takes place in the appearance of wood as a result of its spotting or blotting with the residue of the rust on the surface of wood. The identification of the damage, which occurs on wood as a result of these factors helped study the possibility minimizing the dual effect of wood and metals on each other in archaeological materials.

INTRODUCTION

This paper deals with an applied study on one of the antique objects belonging to the museum of the Faculty of Applied Art – Helwan University. The antique gun with a handgrip was made up of a spear of wood, a pipe and a blowup instrument made from gilded iron. The stages of treating and repairing of the gun were divided into three phases. The first stage, prior to repair and treatment, consisted of studying and documenting the condition of all parts of the object. The dimensions of all the parts were measured carefully and photographed. During this stage the gun was closely examined and samples were analyzed to identify the components of the metal parts. The condition and degree of damage were evaluated, and the materials used in previous restoration were documented. The second stage included the practical procedures or steps for repairing and maintaining the gun, which involved disassembly of the various parts and cleaning all of its components, strengthening, blocking and filling gaps and cracks, then isolating, reassembling and putting the pieces together correctly once again. The third stage, which is beyond the scope of this paper, included a proposal for either exhibiting or storing the gun after its repair and putting measures for maintenance and preventive conservation.

MATERIALS AND METHODS

1- For analysis and investigation infra-red spectroscopy (FTIR), atomic absorption analysis (Perkin Elmer ™ instruments and Unicam 939), X-ray diffraction (Philips, Diffractometer type: PW1840, Generator tension: 40KV, Wavelength Alpha1: 1.54056A°, Start angle: 4.025, End angle: 69.975, Maximum intensity: 67.24), light microscope and Scanning Electron Microscope with E.D.X (operator: EM unit Fac.Sc; All ISIS users: Demonstration Data SiLi detector and LV5400 model 2005) were used.

2- For treatment and restoration of the gun the following procedures were applied**:**

a - Dust layers from the initial parts of the gun (fig. 1- a,b,c) were removed internally and externally using mechanical cleaning techniques, especially different types of brushes, which were suitable for both wood and metal.

b – The state of the gun allowed easy handling and the metal parts that had been attached to previously added wood in old restoration (fig. 1- a,b,d) were separated from the gun.

c - Chemical cleaning and the removal of the remains of materials used in earlier repairs, was applied using distilled water and ethyl alcohol 95% with different mixture ratios 1:1, 2: 1, respectively. Ammonia solution (2%) was used to clean the dark strong dirt, as well as the use of heated distilled water to clean adhesive residue (glue as identified by FTIR) at the end of the wooden gun (fig. 2-a,b).

d - Cleaning of the remains of iron rust formed under the barrel, was applied by using a dilute solution of oxalic acid 1-2% in hot distilled water (William *et.al.* 1999), followed by washing off the parts cleaned with the acid with distilled water several times (fig. 2-c).

e - The metal parts that had been extracted and removed from the gun were cleaned using a solution of citric acid 3-5% by soaking and mechanical cleaning. This process was repeated several times until rust was removed. In the case of copper parts Rochelle salt solution was used in cleaning, followed by washing all the parts with distilled water and cycles of hot-cold for several times to prevent the future effect of solutions with the metal. Finally the parts were dried with ethyl alcohol.

f - The gilded iron barrel was cleaned chemically from the outside first using a solution of citric acid 5% to remove the weak layers of rust, and then soaking in EDTA solution (Ethylene Diamin Tetracetate - $Komplexon_3$) to clean the layers of black rust (Sobhy, 2006), and to increase the effect of the cleaning process and remove a layer of iron oxide magnetic black (magnetite), which has a scarce solubility, the powder of $Komplexon_3$ was added on the black portions. After every use of chemicals mechanical cleaning was applied to remove the products of corrosion that was dissolved so as to reach the desired effect of cleaning. This was then followed by washing with distilled water hot then cold, drying with ethyl alcohol, followed by isolation of all parts of the barrel inside and outside immediately after drying using two cross layers of Paraloid B72 dissolved in toluene 4% (fig. 2- d).

g - In addition to the isolation of all the copper parts of the gun as well as all the nails that had been dislodged from the gun, a solution of tannic acid 5% and followed by Paraloid B72 in toluene (4%) , was used, because the tannic acid inhibits acidic solutions (buffer) (Shaaban,2005).

h- In the last step all the parts were reinstalled using the screws that had been previously cleaned and isolated, then parts of the copper rings were put in place along the iron barrel to link between them and the parts of wood underneath(fig. 11).

RESULTS

Through examination and analysis of the different parts of the gun documentation of technique and materials used to make the gun was possible. The state of preservation was recorded prior to the repair and conservation stages. The following results were obtained:

A - Based on the shape and components, as well as by identifying the methods used, it is possible to presume that the gun dates back to the end of the eighteenth century AD.

B- By comparing the results obtained from analyzing the remains of an old adhesive used on many parts of the gun with several natural glues using FTIR it turned out that animal glue was used for adhesive purposes (fig. 3, 4).

C- Analysis of metal parts from the gun by Atomic Absorption showed that the three pieces of metal that connect the wooden part with iron barrel where made of a brass alloy, whereas the lock plate and barrel were made of iron (fig. 5, 6).

D- Samples taken from corrosion products from different parts of the gun were analyzed X-ray diffraction. it has been found an affected of wood gun and a private area of the bottom of the barrel and inside the nail holes by iron rust from iron metal parts around parts of timber as well as to the impact of air pollution in the atmosphere of the museum that increase the damage the piece (fig. 7, 8) .

E- Examination of two samples from both the wooden handle and the end of the gun using the optical microscope proved that Oak wood (*Quercus* spp.) was used (fig. 9).

F- To make sure the components of the layer gilding on the barrel metal of the gun, it has been analyzed a small sample from gilding material by X-ray fluorescence of the elemental analysis unit attached to scanning electron microscope (EDX), It has been shown of the outputs of the analysis that the substance of gilding is made up of gold , where it appeared on more than sub-level of sample and high rates, mixed with very small percentage (2.3%) of copper, in addition to the emergence of an iron the main component of the metal barrel of the gun (fig. 10).

REFERENCES

(1) Beutel, P., Heady, R., Young, D., Wood Preservation, the maintenance series, information sheet 5.1, NSW, Heritage office, endorsed by the heritage council of NSW technical advisory group, 1998, online edition (2004) 1-5.

(2) Blanchette , R. A., Deterioration of historic and archaeological woods from terrestrial sites, art, biology and conservation, Bio deterioration of works of art, University of Minnesota, the Metropolitan Museum of Art, New York, (2003) 341.

(3) Davis, R., Norton, J., "Corrosion of Metal in Contact With Wood", Queensland Forestry Research institute, timber 2, timber research and development advisory council (TRADAC), Fortitude Valley, QLD 4006, (1993) 1-3.

(4) Digest, B.R.E., Corrosion of metals by wood, Building research establishment, Digest, 301, (1985) (http://www.npl.co.uk/lmm/docs/corrosion-of-metals-by-wood.PDF-2004-10-04)

(5) Donny, L. Hamilton; "Methods of Conserving archaeological Material from under water sites" File 9: Metal conservation, preliminary steps, conservation files: ANTH 605, conservation of cultural Resources, Nautical archaeology program, Texas A&M University, 1999, World Wide Web, (2000) 1-2, (http://nowtarch.tamu.edu/class/ANTH605).

(6) Eaton, R.A, Hale, M.D.C., Wood decay, Pests and Protection, Chapman and Hall, 1st edition, London, (1993) 14-15.

(7) Elgood, R.; Firearms of the Islamic world in the Tareq Rajab Museum, Kuwait, I.B Touris Publishers, New York, London, (1995) 15.

(8) Mardikian , P. , and David .R. , "Conservation of a French pistol from the wreck of *"le cygne"* (1808)", Studies in Conservation , vol.41 , (1996) 162.

(9) Mohamed, W. A., "Study of treatment and conservation some archaeological jewellery", MA, Faculty of Archaeological, Cairo University, (1994 unpublished) 221.

(10) Sobhy, D. R., "Treatment and conservation of some Coptic archaeological iron objects, applied on some iron objects from Coptic museum, ", MA, Faculty of Archaeological, Cairo University, (2006 unpublished) 225.

(11) Unger, A., Schniewind, A.P., Unger, W., "Conservation of Wood Artifacts, A Hand Book", Springer- Verlag Berlin Heidelberg, Germany, (2001) 143.

(12) Williams, R.S, Knaebe, M., "Iron Stain on Wood", Forest Products Laboratory, USDA, Forest Service, U.S., Department of Agriculture, Madison, Wisconsin, (2002) 1-20, *www.fpl.fs.fed.us*.

(13) William, R.S; William, S.J; Feist, C. : "Water repellents and water-repellent preservatives for wood" , Forest products laboratory, United States, Department of Agriculture, FPL-GTR-104 , Madison , Wisconsin , (1999) 5.

(14) Zelinka, S.L; Rammer, D.R., "Review of Test Methods Used to Determine the corrosion Rate of Metals in Contact with Treated Wood", General technical Report, FPL- GTR- 156, Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin, (2005) 1-15.

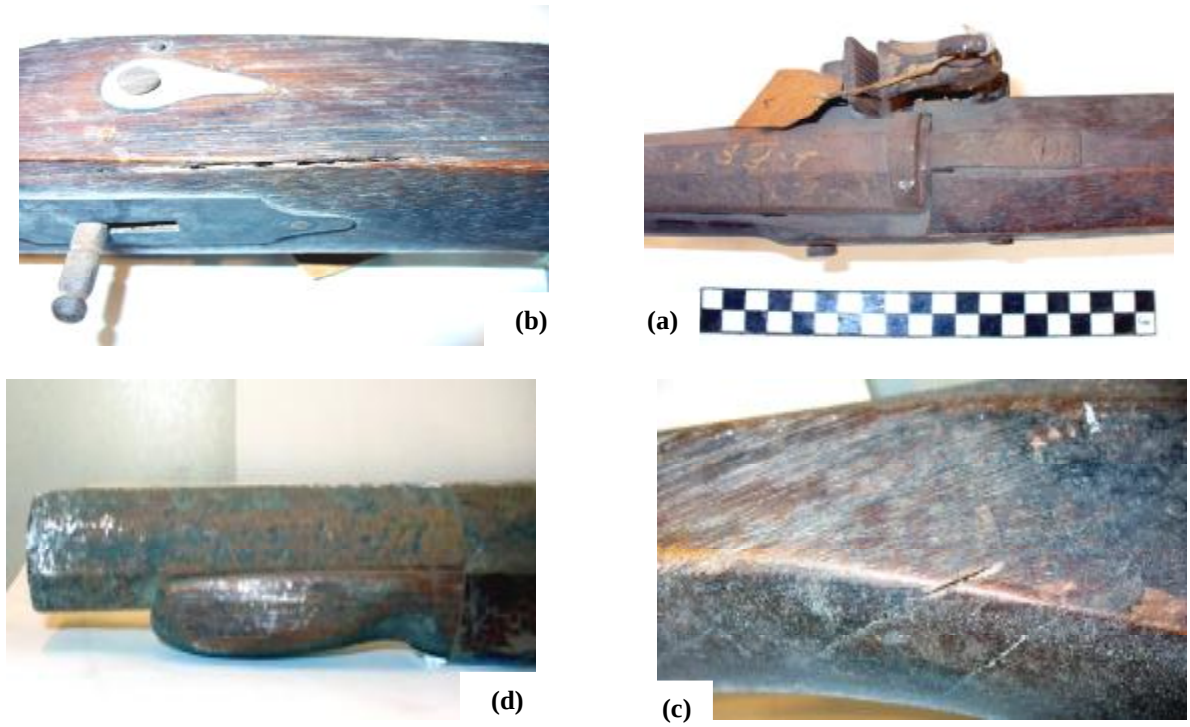

Fig.(1) shows the gun before treatment; a- shows the surface dust that distort the surface of the gun and blur the decoration, b- describes aspects of loss and separation in the gun wood next to trigger in the form of longitudinal crack, c- show damages in the form of cracks and separations in the wooden handle of the gun , d- show outputs of iron rust of red hematite and black magnetite which covers the entire body of iron barrel, especially at the open terminal end.

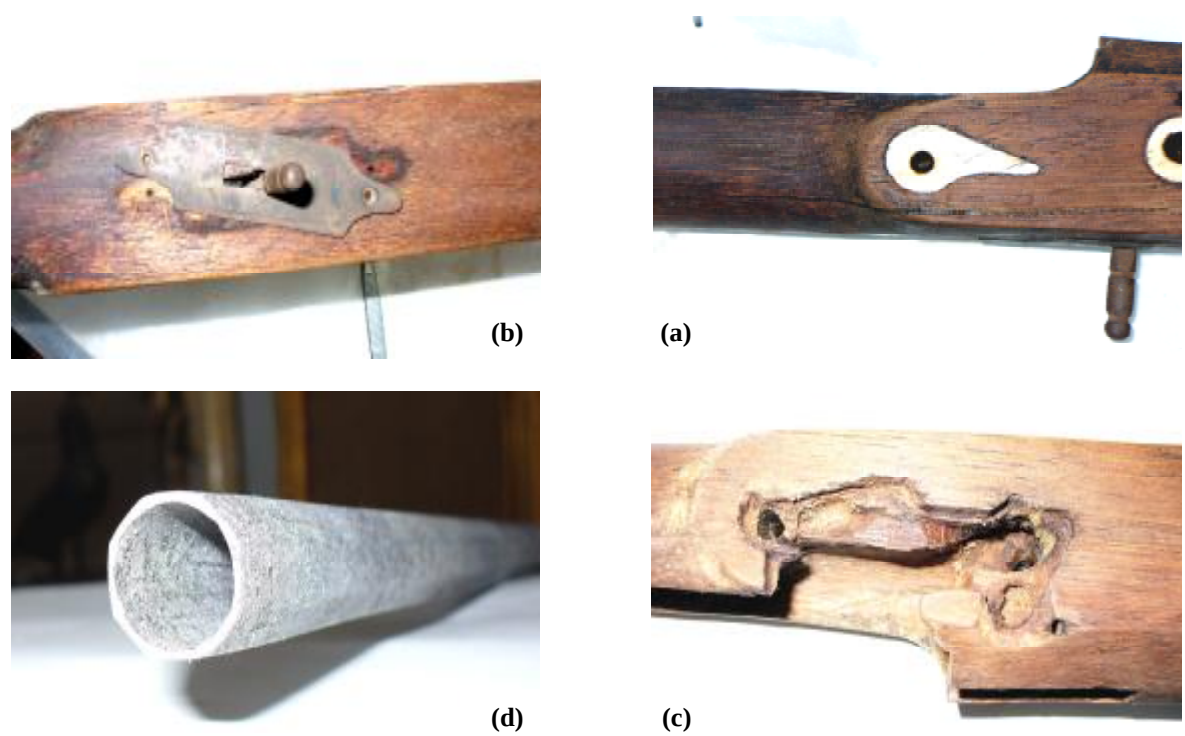

Fig.(2) shows the gun during and after treatment; a- Show part of the stages of localized initial chemical cleaning of the soot in wooden gun surface, b- Show decoder the 2 nails of metal ornament of the trigger to clean them and clean the wood parts underneath individually, c- Show part of the wood lock plate after cleaning the deposits of iron rust and adhesives residue, which was heavily spread out, d- Show iron barrel slot after cleaning.

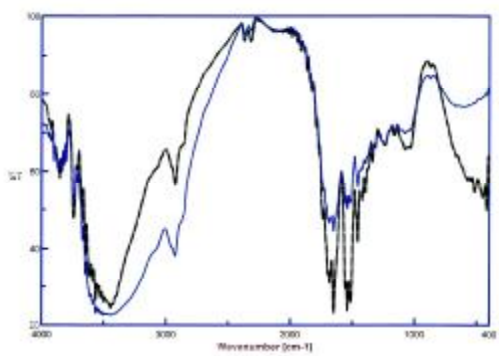

Fig.(3) shows that the sample taken from the wooden handle back and the other taken from the bottom of the iron barrel are of the same type of adhesive.

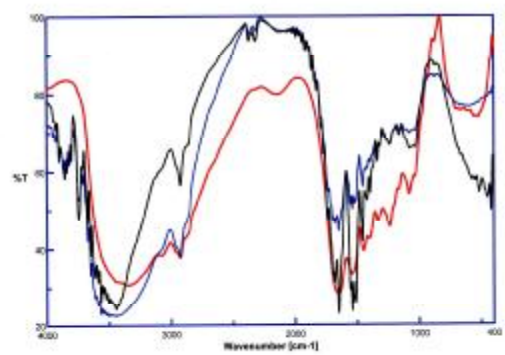

Fig. (4) shows that the spectra of sample analysis of archaeological adhesive by IR are similar to the sample spectrum of modern animal glue, which confirms that these samples of glue as well.

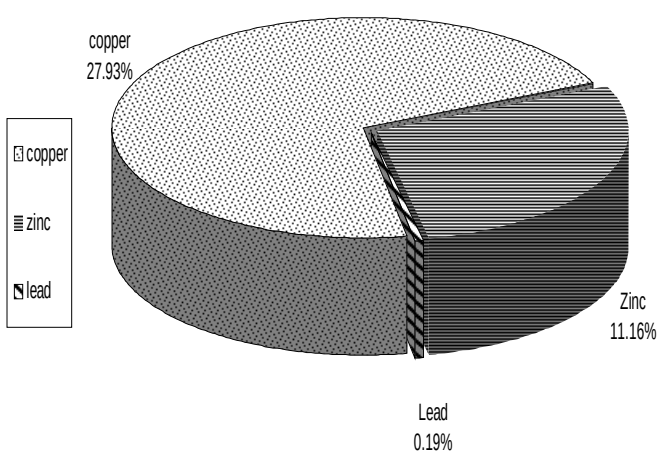

Fig. (5) shows the results of the analysis sample of metal East gun by atomic absorption, and it is clear that the sample of brass alloy.

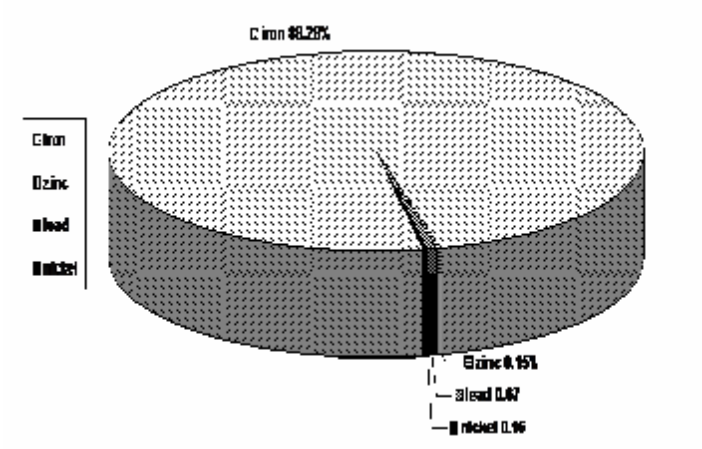

Fig. (6) shows the results of the analysis sample from the lock plate of the gun by atomic absorption, and it is clear that the sample of iron.

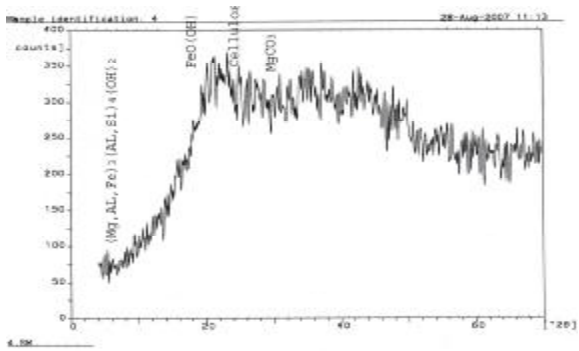

Fig. (7) shows the X-ray diffraction pattern for the sample of the material filling the bottom of barrel after the disassemble all the parts of wood ‹and shows the cellulose as a major component mixed with iron rust.

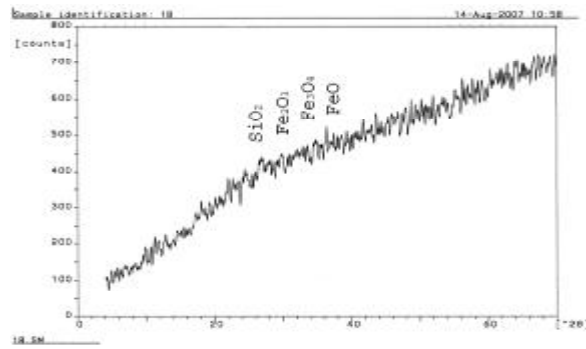

Fig.(8) shows the X-ray diffraction pattern of a sample of the lock plate and found to contain parts of the sample on the iron compounds with the remnants of dust and dust air.

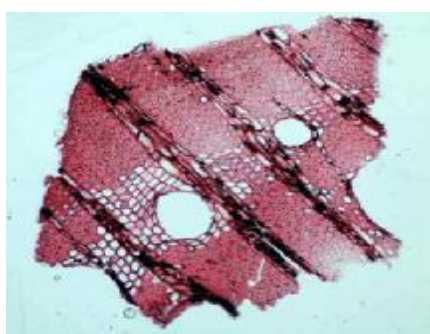

Fig. (9) shows cross section of Oak wood (*Quercus* spp.) on light microscope of sample taken from the gun (30x)

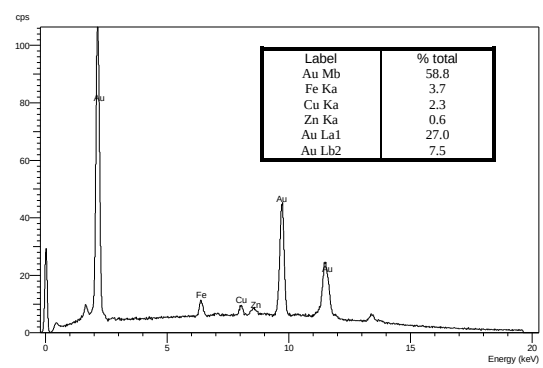

Fig. (10) shows the results of elemental analysis EDX of a sample of material gilding metal gun, it is clear from the gold with the appearance of some impurities

Fig. (11) Illustrates the gun after installation and assembling of the different parts, cleaned and isolated completed.