

Physicochemical factors effect on the archaeological leather in museums

تأثير العوامل الفيزيوكيميائية على الجلد الأثري بالمتاحف

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Abstract:

The combination of physicochemical factors represented by humidity, heat, light, pollutant gases, and solid particles surrounding museums made the antique leather material more susceptible to damage by losing its mechanical and physical properties, thus becoming subject to other factors, and this is what is observed in the collection of leather artefacts preserved in national museums. Leather suffers from physiological manifestations that threaten its safety and sustainability, and therefore it is necessary to take proper measures to prevent and stop damage. The aim of this research is to shed light on the physical and chemical damage that affect the archaeological leather in museums, and this is to raise awareness museum curators to the necessity of preserving these cultural properties, which are testimonies of our deep past and part of our cultural identity.

Key words: Archaeological leather, museum, physicochemical factors, damage, physiological manifestations.

الملخص

إن اجتماع العوامل الفيزيوكيميائية المتمثلة في الرطوبة، والحرارة، والضوء، والملوثات الغازية، والجزيئات الصلبة المحيطة بالمتحف، جعل مادة الجلد الأثري أكثر عرضة للتلف بفقدان خصائصها الميكانيكية والفيزيائية، فأصبحت بذلك سريعة التأثير بعوامل أخرى، وهذا ما يلاحظ على مجموعة القطع الجلدية المحفوظة بالمتاحف الوطنية، حيث تعاني من مظاهر فيزيولوجية تهدد سلامتها وديمومتها، وبالتالي من الضروري اتخاذ الإجراءات السليمة للوقاية من الضرر وإيقاف التلف، والهدف من هذا البحث هو تسليط الضوء على التلف الفيزيائي والكيميائي الذي يؤثر على الجلد الأثري بالمتاحف، وهذا لتحسيس مسؤولي المتحف بضرورة الحفاظ على هذا الإرث، الذي يعد حقيقة من حقائق ماضيينا العميق وجزء من هويتنا الثقافية.

الكلمات المفتاحية: الجلد الأثري، المتحف، العوامل الفيزيوكيميائية، التلف، المظاهر الفيزيولوجية.

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1- Introduction:

The issue of archaeological leather is of great importance as it has been present in human life since ancient times, whether in its covering. It is considered his second skin and accompanies his body and protects it from external factors, in addition to his movements, military equipment, and others. These multi-purpose uses are born of a number of properties that the leather has, such as containment, binding, plasticity and decoration...etc. This is what allowed it to be a revealer of the history of ancient societies, and enables the study of ethnic groups preserved in the museum.

leather, like other organic materials, is susceptible to damage due to the influences surrounding it, whether it is stored or displayed in museums. This results in various physiological manifestations that confirm the presence of serious injuries that threaten its safety. It is an unstable animal material that is exposed to changes in the environment that make the conditions for its preservation very difficult. This is what we will try to shed light on through this research, the problem of which revolves around damage to archaeological leather. In this context, the problem was presented as follows:

**What are the physical and chemical factors affecting archaeological leather?
What are the physiological manifestations of damage resulting from it?**

The aim of this research is to introduce the material of archaeological leather, focus on the physicochemical factors affecting it, and demonstrate the manifestations of damage. This is to harness the capabilities and find the necessary preventive solutions to reduce damage to leather in museums.

2. Definition of leather:

Leather is a natural product resulting from a group of processes known as tanning, which aims to transform animal skin into a non-rotting material that is resistant to the effects of water and has a physical property that gives the option of use.¹ It is a living material characterized by the softness and tenderness of the grain leather thanks to the care of the tanner.²

¹ Collectif, Encyclopaedia universalis, Vol: 5, Paris, Novembre1969, p.210.

² Dossier bibliographique, Procédés de découpe automatique, CTC, Lyon, France, 1948, p.7.

3.History and industry of leather:

The leather industry is one of the oldest activities practised by humans during the prehistoric period as they moved from using simple leather to using fur and leather clothing in the modern era.³ The first observations were discovered in the 19th century AD dating back to the Paleolithic era, when a cultural group was found that faced a difficult climate. They used a type of leather clothing that required rubbing and softening and traces of use were found on stone tools such as scrapers.⁴

4. The effect of physicochemical factors on archaeological leather in museums:

The physical and chemical factors can be summed up in the poor climatic conditions surrounding the archaeological leather, including changes in temperature and humidity, light and ultraviolet (UV) rays, and interaction with ambient pollutants including gases and solid particles (dust and dirt).⁵ This vulnerability to these factors is due to the fact that the leather is hygroscopic as it contains a certain amount of Water and the fact that its physical properties are related to the amount of ocean water that is why it is exposed to this type of damage.⁶

4.1. Humidity effect:

The effect of humidity is related to temperature so that the absolute amount of water vapor is not harmful but rather the relative humidity.⁷ As the air temperature increases, the amount of moisture it contains decreases and vice versa. When the air is cold to a certain temperature, the relative humidity increases until it exceeds the temperature so that The water begins to condense into fine droplets. This moisture

³ Amokrane (S.), Artisanat de l'Ahaggar, Art et identité, Capedes, Septembre 2005, p.72.

⁴ Audoin-Rouzeau (F.), Beyries (S.), "Le travail du cuir de la Préhistoire à nos jours", Actes des rencontres, 18-20 octobre 2001, Antibes, 2001-2002, p.194.

⁵ Fogle (S.), Leather, Central research laboratory for art and science, Holland, 1985, pp.31-33.

⁶ Cauliez (N.), Les facteurs de dégradation des documents d'archives, Département de la conservation Archives nationales, Stage technique international d'archives, France, 2011, pp.2-3.

⁷ Caillaud (D.), Annesi-Maesano (I.) et autres, Contamination fongique en milieux intérieurs, Diagnostic, Effets sur la santé respiratoires, Conduite à tenir, Conseil supérieurs d'hygiène public de France, Septembre 2006, p.19.

affects the chemical and physical properties of the organic matter and encourages biological spoilage.⁸

4.1.1.Effect on leather:

The leather should not be exposed to rapid changes in relative humidity, nor to very high or very low levels. In a dry environment with a low humidity of less than 30%, the leather loses its natural moisture and breaks down.⁹ The reason is due to the drying and breaking down of the collagen structures, which also happens to the glue added to the leather. This contributes to reducing its mechanical resistance, i.e. hardening as it requires humidity approaching 50% to maintain its ductility.

As for an environment with high humidity, i.e. more than 65%, and a temperature between 22 and 50°C, this encourages the development of microorganisms that feed on collagen and substances added to the leather causing it to rot.¹⁰ Rapid moisture changes cause the leather fibers to swell after absorbing moisture and then shrink once they are released. Thus, weaken the leather mechanically. After its layers separate, it appears in a change in size and a loss of plasticity and softness.¹¹

As for leather pieces subjected to recent restoration, they are affected by fluctuations in relative humidity slowly, gradually cracking and warping.¹²

However, if the leather comes together with other elements, whether glued or mucus, it reacts slowly or quickly to the relative humidity. It can bend or tear after the stitching separates and blackening appears on the surface of the leather resulting from the tanning reaction after the advanced hardening of the material.¹³

⁸ Flieder (F.), Duchein (M.), *Livre et documents d'archives, Sauvegarde et conservation, Cahier techniques, Musée et monuments 6, Protection du patrimoine culturel*, Paris, 1983, p.28.

⁹ Institut canadien de conservation, "Le soin des cuirs de tannage végétal et minéral", Note de l'ICC, N°8/2, Ottawa, Canada, 1992, p.2.

¹⁰ Cauliez (N.), *Op.Cit*, p.4.

¹¹ Flieder (F.), Duchein (M.), *Op.Cit*, p.28.

¹² Cauliez (N.), *Op.Cit*, p.4.

¹³ Institut canadien de conservation, *Op.Cit*, p.2.

4.2.Heat effect:

The various sources of heat are the heating and lighting equipment and the heat emitted by visitors in the museum, as well as the external natural heat. The effect of heat on the pieces is not the same and it does not interact in the same way with all materials. Organic materials contain different properties of expansion depending on the temperature. If the latter too low makes the leather material sensitive with cracks appearing on its surface,¹⁴ while too high temperature causes chemical damage that appears in the accelerated acid decomposition of the collagen molecules, which are divided into very small molecular chains. In a humid and hot climate, the leather pieces are exposed to their color, so they dry out, break down and lose their mechanical resistance.¹⁵

4.3.Light effect:

Solar light is electromagnetic waves with an extension between 290 and 2400 nm, and the naked eye only sees the extension of waves containing between 400 and 750 nm, which are visible radiation that contains all the colors of the rainbow from violet to red and radiation of high or low wave extension is invisible. Ultraviolet rays have a long wavelength of 400 nm, which is very energetic and has a photochemical effect that damages materials. Outside of a long wavelength of 700 nm, the radiation is thermal, which are infrared rays.¹⁶

The high energy of light causes chemical reactions along the visible, infrared and UV wavelengths, promoting chemical oxidative decomposition of the leather.¹⁷

UV rays are the most harmful to the leather because their very short wavelength emits high activity energy causing photochemical damage and the rays are between 300 and 400 nm.

Visible light between 400 and 760 nm and infrared rays above 760 nm cause less damage than UV rays.

Both UV and infrared rays create very high temperature or very low relative humidity and these conditions cause dryness of the leather.¹⁸

¹⁴ Gob (A.), Drouguet (N.), *La muséologie, Histoire, Développements, Enjeux actuels*, 3ème tirage, 21 Rue du Montparnasse, Paris, 2004, p.139.

¹⁵ Flieder (F.), Duchein (M.), *Op.Cit*, p.29.

¹⁶ Cauliez (N.), *Op.Cit*, p.6.

¹⁷ Adcock (P. E.), *IFLA Principes de conservation*, Trad: Varlamoff (M-T.), Kremp (V.), *International préservation issues*, N:3, Royaume-Uni, France, 1986, p.32.

All types of radiation are harmful as a result of their large energy which represents wave movement colliding with pieces of leather. Part of this energy is absorbed to decompose some molecules, especially organic compounds. They change chemically and become sensitive ; Their color fades and their resistance to bending, tearing, and pulling decrease.¹⁹

4.4 Environmental Pollution:

The problem of damage to leather antiques resulting from environmental pollution is not new. With the development of industry and the increase in automobile traffic, pollution phenomena have become very important during the last twenty years. The majority of pollutants result from the combustion of coal, fuel oil, and home heating.

Air is composed of a mixture of gases and solid particles, which are very thinly distributed depending on location and seasons and this composition can vary greatly.

4.4.1.Gas:

It consists of the combustion of petroleum materials which release a large number of vaporized chemical compounds such as acids and oxidants. Among the harmful acids there are sulfurous compounds there are : nitrogenous compounds and salts.²⁰

4.4.1.1.Sulfur dioxide (SO₂):

It is an acidic gas dissolved in water, produced during the combustion of coal, petroleum, and iron sulfur (FeS₂).²¹ This gas combines with solid and liquid particles spread in the air and becomes an important compound for the distribution of microscopic particles. All organic compounds, including leather, are sensitive to the effect of sulfur dioxide as it decomposes their acids and breaks them down.²² As for metals attached to the leather, microscopic droplets of sulfuric acid form on their surfaces, which accelerate their corrosion.²³

¹⁸ Conseil canadien des archives, Manuel de conservation des documents d'archives, Chapitre 3, Environnement, Ottawa, Canada, 2003, pp.21-22.

¹⁹ Kathpalia (Y.P.), Conservation et restauration des documents d'archives, UNESCO, Paris, 1973, pp.74-77.

²⁰ Flieder (F.), Duchein (M.), Op.Cit, p.30.

²¹ Pascoe (M.W.), La pollution de l'environnement et ses effets sur les documents d'archives: Une étude Ramp, Unesco, Paris, Septembre 1988, p.9.

²² Flieder (F.), Duchein (M.), Op.Cit, p.30.

²³ Tomsin (P.), « Les patrimoines mobiliers scientifique et technique : spécificités de leur restauration, De leur conservation et de leur valorisation », CeROArt [Online], N°1, 2007, p.9. URL : <http://journals.openedition.org/ceroart/370> ; DOI : <https://doi.org/10.4000/ceroart.370>.

When sulfur compounds combine with dust and impurities, they cause physical and chemical damage to the leather in the presence of moisture and air.²⁴

4.4.1.2. Hydrogen sulfide (H₂S):

It is a gas characterized by the characteristics of a weak acid resulting from the damage of proteins containing sulfur. Its weak acidity does not significantly damage organic materials, but it affects the metals associated with them and contributes to their corrosion.

4.4.1.3. Nitric oxide (NO) and nitrogen dioxide (NO₂):

Nitrogen oxides are gases formed when the air holds high temperatures under the influence of lightning and flames and are produced by the combustion of gasoline engines, furnaces and boilers that operate with coal, wood, gas and diesel.²⁵

When nitrogen mixes with air humidity, it turns into acids that attack and damage pieces of leather and ozone is formed, which affects organic materials and results from the combination of light and nitrogen oxide.²⁶

The combination of nitrogen with oxygen produces various oxidants at high temperatures, including: nitrogen oxide (NO) and nitrogen dioxide (NO₂), which contribute to the abrasion of organic materials, including leather.²⁷

4.4.1.4. Ozone (O₃):

It is an unstable composition of oxygen. It is produced under the influence of discharges, electric sparks and ultraviolet light rays and because ozone decomposes slowly and forms a strong oxidizing agent, it can affect many organic materials and cause cracks in the leather when its amount increases.²⁸

²⁴ Kathpalia (Y.P.), Op.Cit, p.83.

²⁵ Pascoe (M.W.), Op.Cit, pp.9-10.

²⁶ Adcock (P. E.), Op.Cit, p.31.

²⁷ Flieder (F.), Duchein (M.), Op.Cit, p.30.

²⁸ Pascoe (M.W.), Op.Cit, p.9.

4.4.2.Salts:

Salts are found in industrial areas and in a large proportion in marine areas. Winds work to distribute fine particles of sea spray and salts as they are hygroscopic and contribute to the abrasion of organic materials, including leather.²⁹

4.4.3.solid particles:

They are represented by soot, dirt and dust that contribute to mechanical damage by rubbing and dirtying the leather pieces on which they are located. Dust and dirt absorb gaseous pollutants and become a nest for harmful chemical reactions.

4.4.3.1. Dust:

It is a compound mixture of textile fibers, industrial steam and fats applied by the tips of the hands, inorganic substances such as flint crystals, sodium salts transmitted through spray or parts of the skin³⁰ and other very fine mineral and organic particles such as iron oxidants, aluminum sulphate, magnesia carbonate, and a large amount of... Carbon and Asphalt. The diameter of these particles varies and they result from industrial activity and urban agglomerations. These fine particles that form dust are intertwined with each other and are always acidic and hygroscopic and accelerate the reaction.³¹

When dust mixes with water vapor, it encourages the proliferation of mold as a result of it containing fungal spores which increases the corrosion of salts, the decomposition of water and the rise of acids.³²

A speck of dust attracts moisture as it is necessary for the formation of gaseous pollutants in the surroundings and has a chemical effect on materials. Dust and impurities are microscopic particles that maintain a higher than normal level of humidity on the surface and therefore, it is necessary to maintain the cleanliness of the rooms in the museum.³³

²⁹ Flieder (F.), Duchein (M.), Op.Cit, p.30.

³⁰ Adcock (P. E.), Op.Cit, p.31.

³¹ Flieder (F.), Duchein (M.), Op.Cit, p.30.

³² Adcock (P. E.), Op.Cit, p.31.

³³ Kathpalia (Y.P.), Op.Cit, p.84.

4.4.4.Chemical damage mechanism:

The presence of water in the form of steam, acidity and gases all contribute to the breakdown of leather collagen by cutting along the chain of large molecules which leads to the weakening of the substance. Manifestations of decomposition are observed on the leather by damage to its structure, loss of its mechanical resistance and increased permeability. It is very sensitive to the effects of oxidizing substances present in the oxygen of the air.³⁴ Chemical damage increases when leather pieces are connected to metal parts.

4.4.4.1.Metal and leather combination:

When the relative humidity increases, gaseous pollutants, especially sulfur anhydride, cause acid accumulation and a chemical attack on leather pieces and the metal elements associated with them.³⁵

Among the existing links, there are earrings, nails, buttons...etc. As for the materials used, they are copper and its alloys (brass) and bronze, all of which interact with the fatty materials present in the leather and thus form green and blue waxy corrosive materials called “ Turquoise, which is a copper salt, and there is silver that causes this type of corrosion if it contains a small amount of copper. As for iron and its alloys, as well as white iron, it corrodes upon collision with leather because it is acidic which weakens the latter and breaks.³⁶

³⁴ Cauliez (N.), Op.Cit, p.8.

³⁵ Fogle (S.), Op.Cit, p.39.

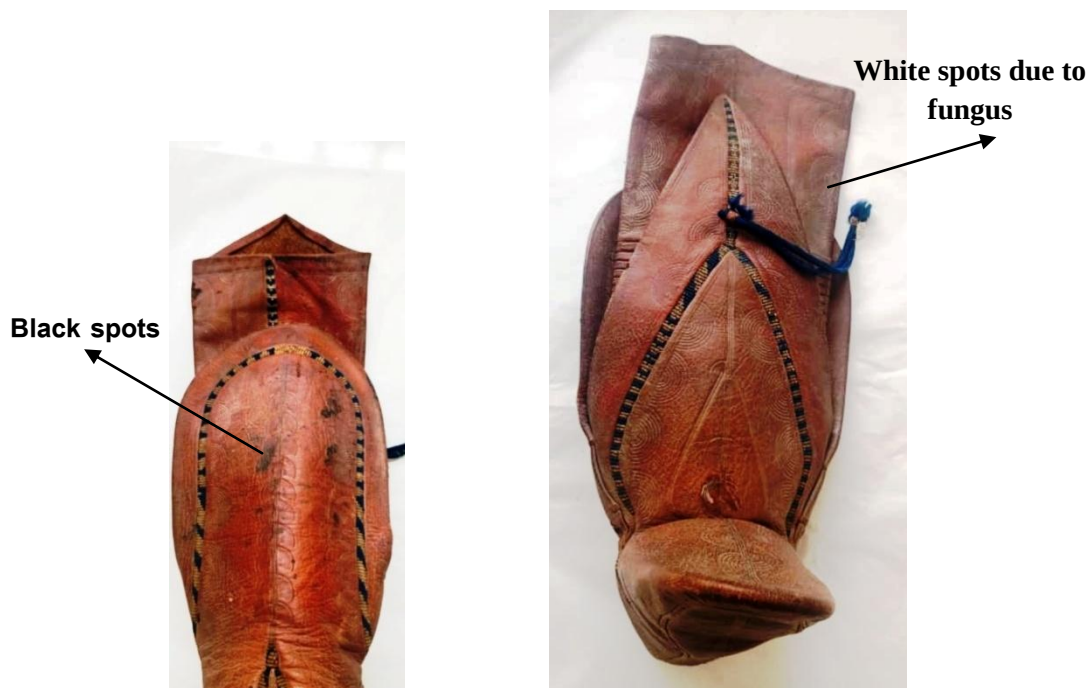
³⁶ Institut canadien de conservation, Op.Cit, p.3.



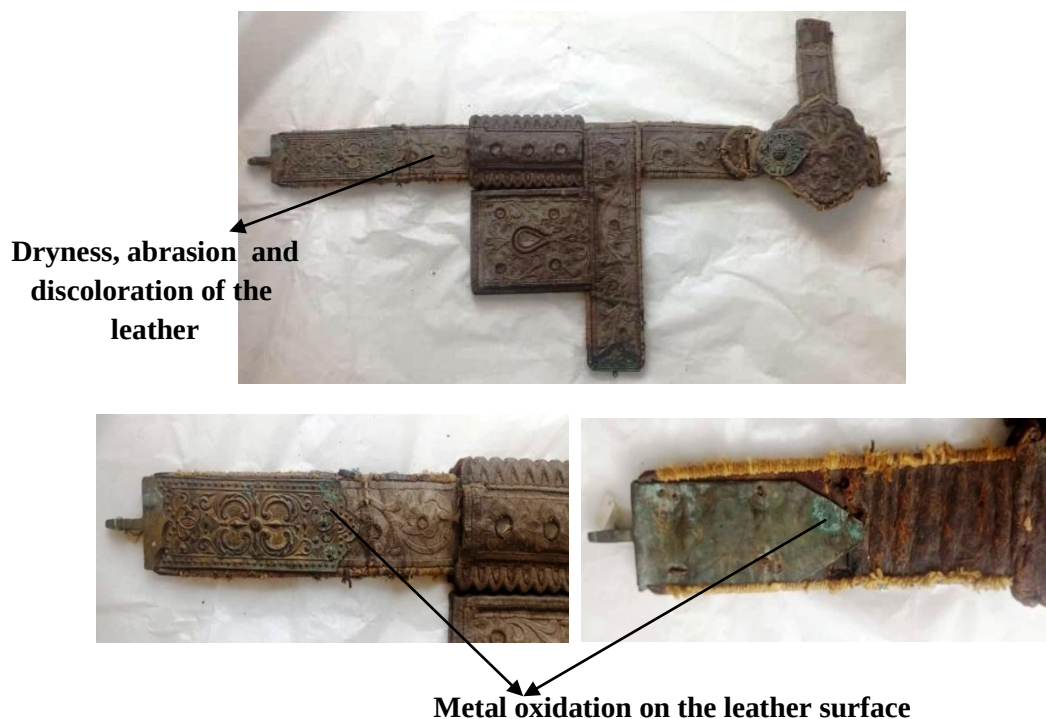
Pic 1. Dryness, abrasion, tear and discoloration of the leather piece
Source: National Museum of Antiquities and Islamic Arts



Pic 2. Dryness, discoloration and abrasion of the leather surface and oxidation of the metal, changing its color to green.



Pic 3. Presence of fungal spots and black spots resulting from the tanning reaction on the surface of the leather



Pic 4. Dryness, abrasion and discoloration of the leather with oxidation of the metal on its surface.

5. Conclusion:

The primary duty of museums for preserving movable heritage is to protect archaeological collections and ensure their safety and permanence so that they remain for emerging generations because they are part of the cultural identity. However, what is observed on some leather pieces in national museums of prominent signs of damage shows their exposure to the complex environmental system represented by problems of humidity and heat, light, dust, gaseous pollutants, dirt and other influences. This study of the physicochemical factors allowed us to reveal one of the conditions that the leather in the museum suffers from, which is the absence of a good policy for preservation, storage and display. It is manifested in the lack of inspection, monitoring, and periodic cleaning. The combination of all these factors contributed to accelerating the possibility of injury to the pieces. Therefore, it is necessary to reconsider these shortcomings and defects and try to improve the condition of leather preservation in museums by providing the needs and requirements required by the leather pieces to ensure their stability and this is by respecting special laws. For example, the humidity should be between 45 And 60% and every increase or decrease affects it. As for the temperature, it was set between 15 and 22 °C, and every decrease or exceeding more than 25 °C leads to its damage. Thus, the problem of mold is eliminated due to the increase in humidity and the pieces are hardened with the blades of decorative colors to increase temperatures rips and seam separation to temperature and humidity changes.

Leather pieces stored inside drawers or cabinets must be organized by providing adequate ventilation and covered with cotton cloth bags, polyethylene bags or silk papers without acid and alkaline storage to protect them from dust and dirt.

- Ensure the cleanliness of the warehouse and exhibition halls by using a vacuum cleaner on the drawers, cabinets, facades and floors. As for the pieces, they are cleaned away from the warehouse or exhibition halls using a soft brush, then using a vacuum cleaner.

- Organizing inspections inside the exhibition halls and the warehouse to detect damage from duct leakage and condensation. For example : the accumulation of dust and dirt and monitoring the thermometer and humidification...etc.

Raising awareness of the need for museum research officials to pay attention to new scientific studies and research and to the findings of developed countries in the field of damage and preservation of archaeological materials, especially sensitive organic materials such as leather and also in good methods of display and storage in museums and this is to achieve a correct application of preventive preservation, all for the benefit of the cultural and civilizational heritage which carries human identity. So, our goal is to preserve it in every way.

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