The Deterioration of Domestic Wooden Surfaces of Historical Buildings in Upper Egypt

Domestic woods grown in ancient Egypt were used for many purposes such as structural elements in historical and archaeological buildings in Upper Egypt in particular. In this area, wooden artifacts are subjected to various deterioration factors such as moisture, temperature and solar radiation that have considerable deterioration of the outer surface of the wood structure elements. It is important to identify and understand the reasons of the deterioration process for the future conservation purposes and to determine the appropriate treatments. In this study, two different examination techniques were used, scanning electron microscopy (SEM) and fourian transform infrared spectroscopy (FTIR), to examine some deteriorated samples from historical and archaeological buildings, which showed various degrees of deterioration of the wood surface and the changes on the main chemical compounds of wood.

Keywords: Domestic wood- Deterioration- Tamarisk- Acacia- FTIR.

1- Introduction

Wood is one of the most important materials used by ancient humans through different ages and even now, where there are many uses for it. Wood was used for many purposes, including artificial and constructional (Traore; et al, 2018), as well as being used as a source of fuel and energy.

Through the different ages in Egypt, wood was one of the most important raw materials used by the ancient Egyptians. They resorted to import many types of wood to meet their artistic and constructional requirements. This type of wood is called the imported wood which has the appropriate length and timber straightness, as they were used along with the domestic wood.

The domestic types of wood are those which have been grown in Egypt. They had been used in many purposes such as movable and stable works, in addition to their use as important and varied structural elements in historical and archaeological buildings, whether they were those dating back to the Pharaonic, Christian and Islamic times.

Domestic woods have many qualities that helped to diversify their use, such as strength, durability and abundance; however their length has not been suitable for many works, especially wooden ceilings.

Types of Domestic wood which were common in Egypt during the different ages:

1-1. Tamarisk wood:

Tamarix sp

Family: *Tamaricaceae*

This type of wood is one of the most common types of domestic wood in Egypt since ancient times. It is one of the rings to semi-ring porous, Hardwoods. It belongs to the Gymnosperms plants (Kandil; et al, 1994), it is a small tree, fast growing, drought resistant (Waly, N, 1999), characterized by hardness, strength and with a light wood color. This tree grows in the desert areas, on the sides of the agricultural roads and along the streams (Nazir, W, 1970).

Tamarisk was used for many purposes such as; funerary furniture (El Hadidi, N; Hamed, S, 2013), shipbuilding, chariots, agricultural machinery and as a source of fuel also used it was used in the implementation of many structural elements throughout the ages.

1-2. Acacia wood:

Acacia sp

Family: *Leguminosae*

Acacia wood was one of the hardwoods used extensively in ancient Egyptian civilization. It comes from a medium size fast-growing thorn tree. Its wood is strong and resistant to decomposition and used for many purposes such as statues, furniture and other structural elements inside archaeological buildings (Nazir, W, 1970), (Kandil; et al, 1994).

1-3. Uses of Domestic wood in archaeological buildings:

There are many uses of Domestic wood in archaeological buildings, the most important ones are as follow:

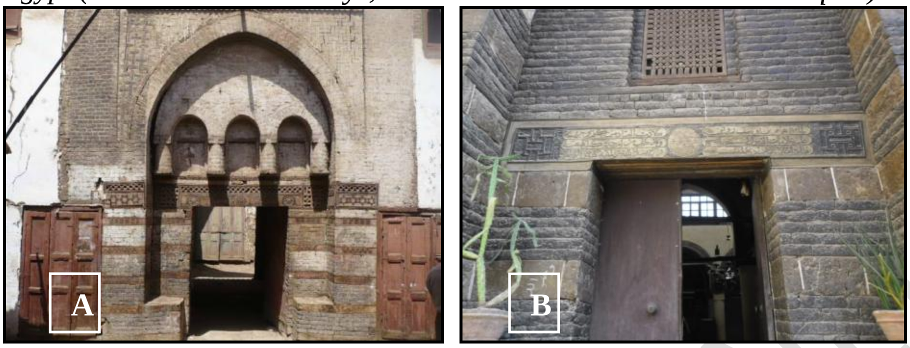
1-3-1- Wooden lintels:

Wooden lintels are the woods that are placed at the top of the entrance door for the archaeological and historical buildings, especially the Christian and Islamic periods, where the red bricks and adobe bricks were used for construction purposes in those periods, and these materials cannot withstand large stone blocks as was done in the Pharaonic temples.

Wood was used for this purpose for many reasons, including lightweight, availability, durability, ease of formation and ornamentation.

These wooden lintels have two main functions within the archaeological buildings, as they function as architectural elements to carry the load of completing the building to many floors (Ali. 2011). It is also considered an important cosmetic element. It is ornamented with many ornamental elements such as Geometric, Vegetal and Arabic Calligraphy ornamentation.

Figure 1. *An example of the wooden lintels in archaeological buildings in Upper Egypt (A. Wikalat Al Gedawy•, B. Sheikh Al-Arab Hammam Mosque•).*



1-3- 2. Wooden Iconostasis

The Coptic architecture resorted to the use of this kind of wooden Iconostasis (Templon) to separate the area of the Altar (sanctuary) from the church nave, as it is an area designated only for the entry of priests.

In the Monastery of The Bishop Badaba• we find that this Wooden Iconostasis (Templon) was carried out using many types of wood. The imported wood such as pine was used in the colored wooden panels in the part overlooking the church yard. The interior part overlooking the Altar was made with some types of domestic wood. Domestic wood was also used to perform some vegetal ornamentation inside the Altar.

• This Wikalat was established by Hassan Bey al-Jadawi 1207 AH / 1792 AD, located 30 meters north of the temple of the city of Esna in Luxor Governorate. It is one of the important commercial establishments (centre) that were used to accommodate the expatriates. The upper floor is a dormitory, and it was an important center for the sale and purchase at that time

• This mosque was established by the Sheikh of Arabs Hammam in 1171 AH / 1757 AD, which is located in the city of Farshout, one of the cities of Qena.

• This monastery was founded by The Bishop Badaba, nicknamed al-Jawhari. It consists of three churches of different ages and shapes dating back to the 17th / 19th century. This monastery is located about 3 km west of Naga Hammadi city.

Figure 2. *An example of the wooden Iconostasis in The Bishop Badaba monastery*.

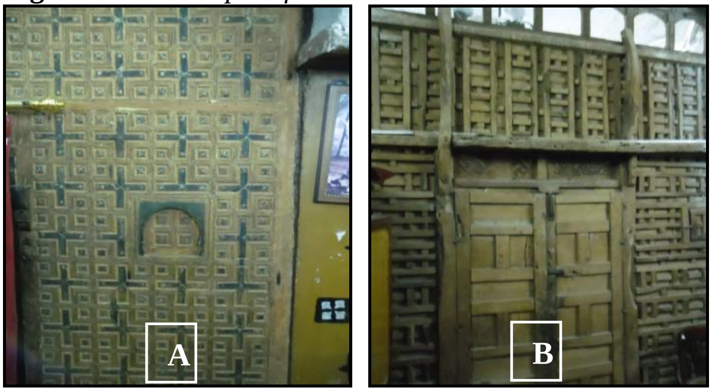
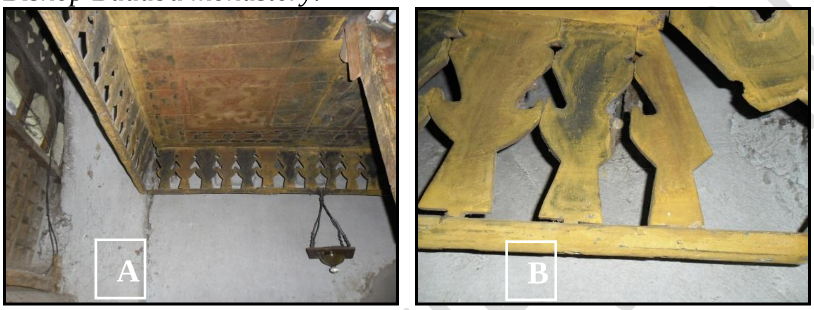


Figure 3. *An example of the wooden vegetal ornamentation within the Altar in The Bishop Badaba monastery.*



1-3-3 . Wooden butterfly joints:

This kind of wooden joints was used to bind and joint the huge stone blocks used in the construction of some ancient Egyptian temples. Despite the widespread use of minerals in the implementation of such joints, using such joints is to prevent the movement and slide of large stone blocks, especially when exposed to the impact of earthquakes.

These wooden joints are clearly visible in the Kom Ombo Temple•, the Temple of Medinet Habu• and the Temple of Dandara•.

• It is located in Kom Ambo city, Aswan Governorate in southern Egypt. This temple was built during the reign of Ptolemy VI.

• Medinet Habu temple is one of the important New Kingdom period temples; it's a Mortuary Temple of Ramesses III at, West Bank of Luxor in Egypt.

• This temple is located in Dandara village, Qena Governorate. It is one of the ancient Egyptian temples dating back to the Greco-Roman era.

Figure 4. *An example of the wooden butterfly joints (A. Temple of Dandara, B. Kom Ombo Temple, C. Temple of Medinet Habu).*

2. Literature Review

In a previous study, (Lukas, 1945) mentioned that there are some types of domestic wood growing in Egypt and imported foreign wood used in the implementation of some pharaonic monuments. In another study, (Nazir, W, 1970) mentioned some foreign and domestic wood and their multiple uses.

(Ali, 2011; 2015) studied the uses of wood in the archaeological and historical buildings in Upper Egypt, through these two studies, many wood species, used in these buildings, were identified by making different microscopic sections of wood samples and comparing them with modern reference samples. This study focused on the factors and aspects of deterioration on wood in different archaeological buildings in Upper Egypt.

(Sell; Feist, 1986) said that weathering is a long-term complex process that includes light, humidity and temperature changes. (Fiest, 1990) confirmed that the wood presented in an outdoors environment is exposed to many different and complex damage factors, such as weathering. He also explained the mechanism of damage caused by the special external surfaces of these woods and ways to protect them.

(Shrivastava, 1997) explained that weathering conditions have a detrimental effect on wood surfaces where the wood surface becomes uneven and wrinkled due to differences in rates of erosion of the wood surface, especially the erosion ratios between both early wood and late wood.

(Williams, 1999; 2005) states that weathering is a general term used to describe the damage caused to archaeological materials presented in an outdoors environment. Weathering causes damage to the surfaces of most organic materials, including wood. These factors include the process of external oxidation of surfaces by ultraviolet radiation, Temperature, Relative Humidity and Wind Effect. The UV penetration of wood depends on several factors, including wood density, as dense wood penetrated less, as well as wood type, and quantity of earlywood and latewood.

(Williams; Feist, 1999) addressed the effect of moisture on wood and stressed that the dimensions of wood changes by the content of the variable humidity, but this change depends on the type and density of wood in addition to different sectors of wood (longitudinal, transverse, tangential).

(Sudiyani, 1999) mentioned the impact of different weathering factors on exposed wood in changes of wood color, surface cracking, rough surface and destruction of mechanical and physical characteristics.

(Unger; et al, 2001) explained the effect of weathering on wood and considered it a primary cause of degradation of lignin and Hemicellulose.

(Lioyd, 2006) confirmed that the presented wood in the outdoor environment is more vulnerable to the environmental conditions and is more likely to be damaged than wood in the indoors environment such as museums.

(Lionetto, et al, 2012) mentioned that wood exposed directly to weather conditions exposed to many changes in its physical and structural characteristics.

In the literature review of (Krànitz; et al, 2016), they treated the effects of aging on wood and they discussed the changes of the aged wood characteristics.

3. Methodology

This part of the study focuses on the examination and analysis of a number of archaeological and historical wood samples used in the archaeological buildings in Upper Egypt for the purpose of classification. Furthermore, it studies the changes resulting from the exposure of domestic wood to the damage factors, where there are multiple damage factors surrounding the archaeological wood used in archaeological and historical buildings in Upper Egypt. What is produced from the mechanics of complex damage may lead in the end and over time to the total elimination of such the wooden objects with its decorative elements.

One of the most important destructive factors for the archaeological wood in the study sites is weathering, which leads to the process of slow deterioration of the various archaeological materials which are constantly exposed to weather conditions, directly or indirectly (Yildiz; et al, 2011). The process of weathering depends on many environmental factors including light (sunlight, UV light, infrared light), humidity, heat, atmospheric pollution gases and wind erosion (Erin; et al, 1991), (Liu, 1997), (Sandberg, 1999), (Huang, 2012).

3-1. Examination methods used in this study:

3-1-1. Light microscope:

The Light microscope was used to identify some of the domestic wood species selected for the study. It is based on cell forms in different sectors, through which different types of wood can be distinguished.

3-1-2. Digital USB Microscope:

This microscope was used in this research for several purposes. It was used to identify some of the domestic wood species selected for study after processing the surface to be studied in a way that can distinguish the anatomical pattern characteristic of each wood type. This microscope was used also in making a clear diagnosis for damage symptoms.

3-1-3. Scanning Electron Microscope (SEM)

The main objective of the examination using the Scanning Electron Microscope (SEM) is the accurate diagnosis of the emergency change appearance in the anatomical structure of the damaged wood (Turkulin, 2004), (Hamed, 2012), in addition to studying the effects of damage on the color layers.

3-1-4. Fourier Transform infrared spectroscopy (FTIR spectroscopy):

To study the chemical changes of domestic wood, FTIR was used (Lionetto; et al, 2012). This method is used to identify the active and functional groups found in organic materials' molecules (Nabil; et al, 2018), (Traore; et al, 2018). It is possible to trace the variation in the contents of the main chemical compounds of damaged archaeological wood (cellulosic, hemicellulose and lignin) (Picollo; et al, 2011), with emphasis on fingerprint areas between 800 - 1800 cm-1 for different samples (Lionetto, et al, 2012) this area includes particular bands to the main components of wood as cellulose, hemicelluloses and lignin (Bodîrlău; Teacă, 2009).

The sample was prepared by mixing a very fine powder of domestic archaeological wood with KBr by 1:10, where they are then grinded together and then compressed until a transparent disc is obtained.

Table 1. *Characteristic of chemical bands of FTIR spectra in the wood*

Wavenumber cm^{-1}	Functional group	Assignment
3400	O-H	O-H stretching (Pandey; Pitman,2003) (Esteves;et al,2013)
2970-2850	Ch_2, Ch and Ch_3	C-H stretching (Esteves;et al,2013)
1738 -1735	C=O stretching in unconjugated ketones aldehydes and carboxyl	Xylan (hemicellulose) (Naumann; et al,2005)(Müller,2008) (Rana,2008) (Lionetto;et al,2012)
1650	absorbed O-H and conjugated C-O	(Pandey;Pitman,2003) (Rana,2008) (El-Hadidi, N, 2017)
1605-1595	C=C stretching of the aromatic ring	Lignin (Bykov,2008) (Lionetto;et al,2012)
1510-1512	C=C stretching of the aromatic ring	Lignin (Genestar, 2006) (Lionetto,2012)
1463	Asymmetric bending in CH_3	Lignin (Lionetto;et al,2012)
1425	CH_2 bending	Cellulose (crystallized& amorphous) (Pandey; Pitman,2003) (Rana,2008) (Lionetto;et al,2012) (El Hadidi, N, 2017)
1375	CH bending	Cellulose (Rana,2008) (Lionetto;et al,2012)

1336	OH in plane bending	Cellulose(amorphous) (Lionetto;et al,2012)
1317	CH_2 wagging	Cellulose(crystallizedI) (Lionetto,2012)
1269	CO stretching	Lignin and hemicellulose (Pandey;Pitman,2003) (Lionetto;et al,2012)
1163	COC Asymmetric. bridge oxygen stretching	Cellulose (Lionetto;et al,2012)
897-898	Asymmetric. Out of phase ring stretching	Cellulose (Colom,2003) (Müller,2008) (Lionetto;et al,2012) (Esteves;et al,2013)

Figure 5. *FTIR transmission spectra of the reference sample and sample from Wikalat Al Gedawy lintel, (A) 400-4000cm-1 (B) 800-1800cm-1 (fingerprint areas).*

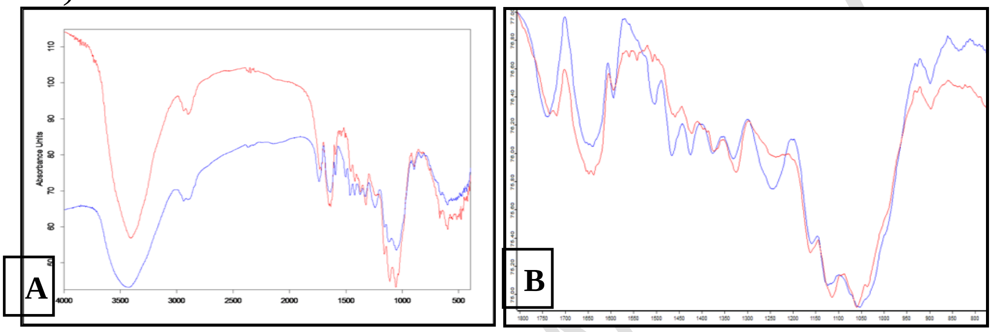


Figure 6. *FTIR transmission spectra of the reference sample and sample from Sheikh of Arabs Hammam mosque lintel, (A) 400-4000cm-1 (B) 800-1800cm-1 (fingerprint areas).*

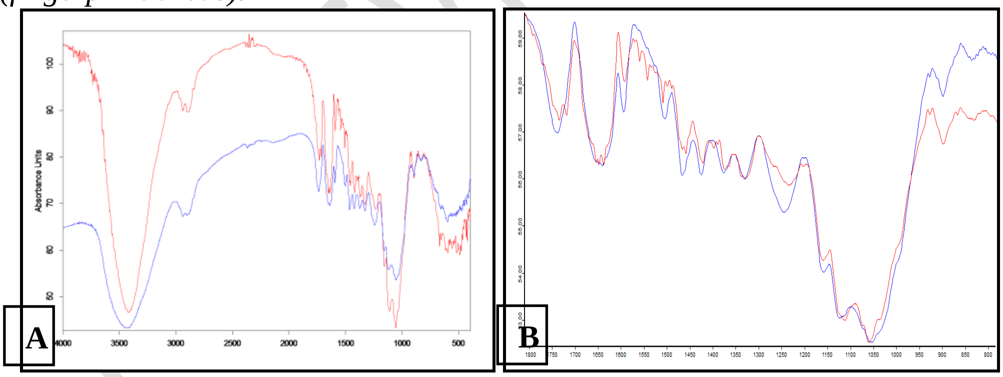


Figure 7. *FTIR transmission spectra of the reference sample and sample from the The Bishop Badaba Iconostasis, (A) 400-4000cm-1 (B) 800-1800cm-1 (fingerprint areas).*

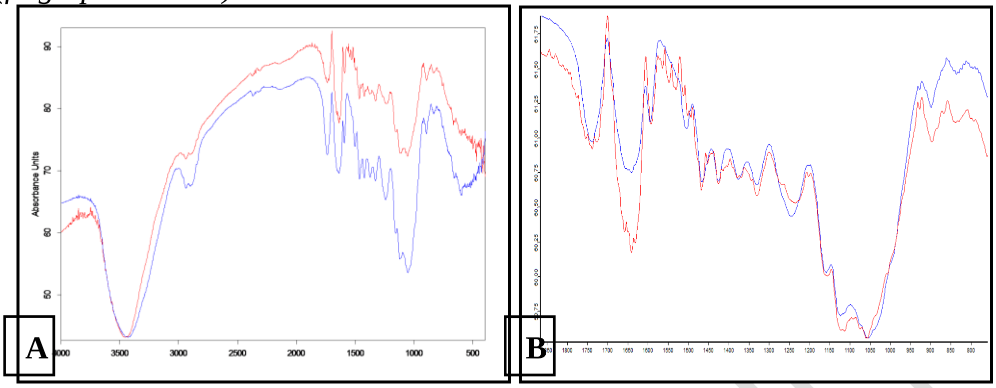
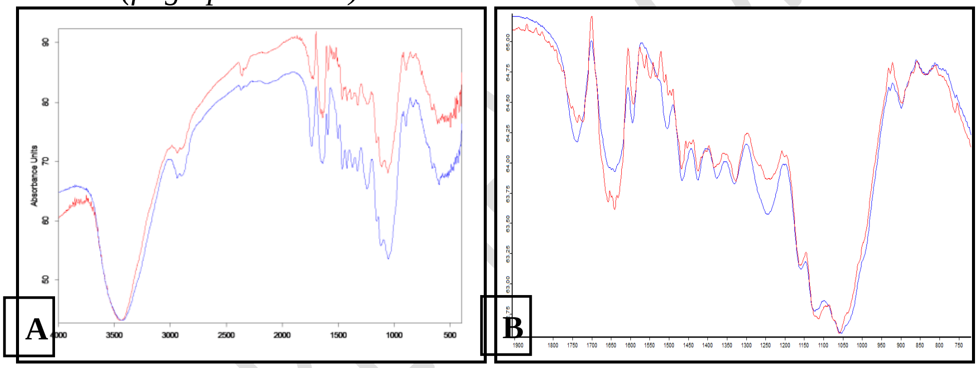


Figure 8. *FTIR transmission spectra of the reference sample and sample from the The Bishop Badaba vegetal ornamentation, (A) 400-4000cm-1 (B) 800-1800cm-1 (fingerprint areas).*



4. Results Discussion

4-1. Identification of domestic wood species used

The types of wood used in archaeological and historical buildings in Upper Egypt have been identified though Light microscope and Digital USB Microscope. The classification of these archaeological woods depends mainly on the anatomical structure of these woods. This process is the first step to understand and study the wooden cultural heritage of human civilization, the volume of trade between ancient countries, and in addition to the identification of wood obtained from domestic trees.

Through this study, some types of domestic wood used in some archaeological buildings in Upper Egypt have been identified as follow:

4-1-1. Acacia Wood:

The use of acacia wood was used for many purposes such as wooden butterfly joints in the temple of Dandara, in addition to its use in the external lintel of a historic building in the city of Esna, the house of EL-Sayed Abu Hussein.

Figure 9. (*A) Wooden butterfly joints in Dandara temple, (B) Cross-section of Acacia sp.*

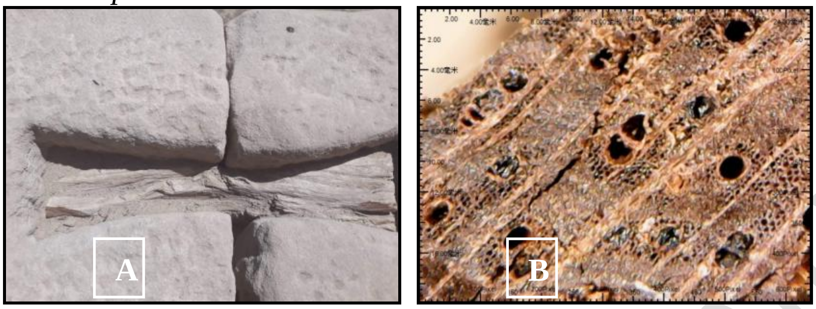
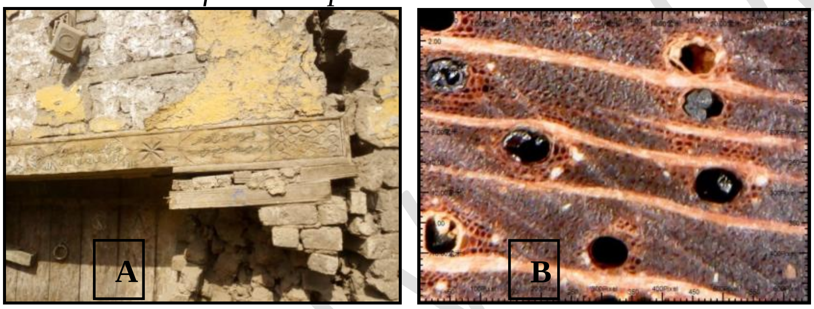


Figure 10. *(A) Wooden lintel in the house of EL-Sayed Abu Hussein*•*, (B) Cross-section of Acacia sp.*



4-1-2. Tamarisk Wood

The Tamarisk wood was used for many purposes such as the structural elements in the archaeological building in Upper Egypt, where it was used in the external threshold of many archaeological and historical building such as the external lintel of Wikalat Al Gedawi, the external lintel of Mohammed Mujahed's house and the external lintels of Sheikh Al-Arab Hammam Mosque.

• This house is one of the Historical buildings in Esna city, Luxor Governorate (18th century).

Figure 11. *(A) Wooden lintel in Wikalat Al Gedawi, (B) Cross section of Tamarix sp, (C) longitudinal section.*

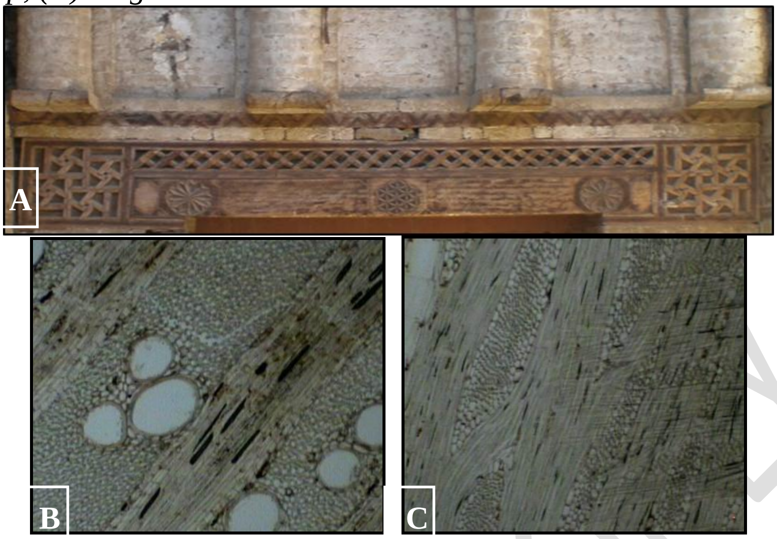
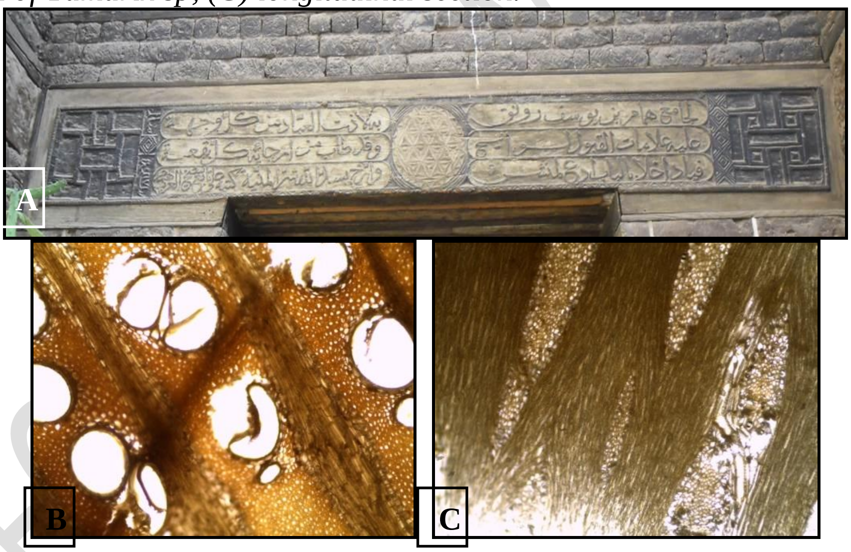


Figure 12. *(A) Wooden lintel in Sheikh Al-Arab Hammam Mosque, (B) Cross section of Tamarix sp, (C) longitudinal section.*



This wood was also used in the interior part of the wooden Iconostasis in The Bishop Badaba monastery, in addition to some interior small panels, especially in the entrance door of the Altar, which is in the middle of the Iconostasis, in addition to its use in some of the vegetal decorations within the Altar.

Figure 13. *(A) Wooden Iconostasis in The Bishop Badaba monastery, (B) Cross section of Tamarix sp.*

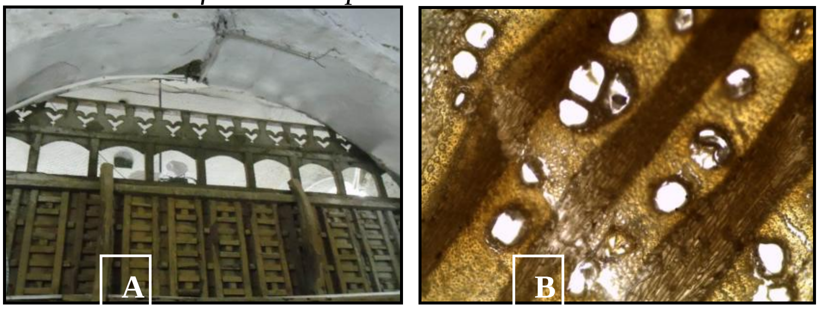
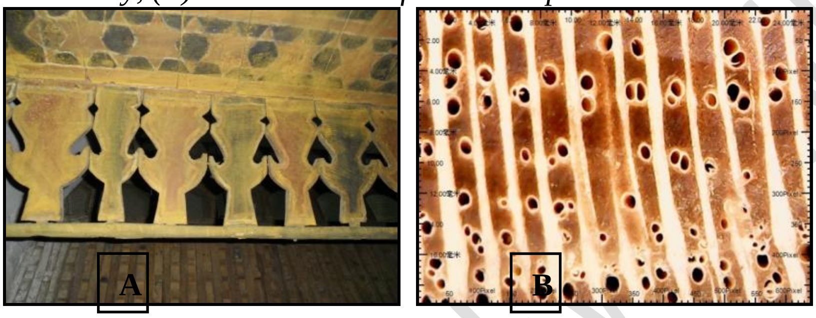


Figure 14. *(A) Wooden vegetal ornamentation in The Bishop Badaba monastery, (B) Cross-section of Tamarix sp.*



4-2. Diagnosis of deterioration

Diagnosis of deterioration and their changes in archaeological wood is very important in the field of heritage conservation (Alfieri; Correa, 2018).
Using both digital USB microscope and the scanning electron microscope (SEM), the examining revealed that the domestic archaeological and historical woods were exposed to many changes, such as:

4-2-1. Surface changes:

The surface changes of domestic wood are represented in spread of fine cracks, over time due to their continuous exposure to weathering factors (John A; et al, 1993); they are transformed into large cracks that may lead to the division of wood panels (Shrivastava, 1997), (Yildiz, et al, 2011).

The risk of this fine cracking and large cracks is that it helps to permeate the various weathering factors into the inner layers, in addition helping to facilitate the growth of fungus and what is resulting from the process of ancient wood decomposition (Sivrikaya; et al 2011).

Disintegration of fiber and loss of interconnection lead to the erosion and loss of some parts of the wood surface (Rodgers, 2004), (Williams, 2010), (Reinprecht; et al, 2018).

The weakness of the outer surface of the wood and its roughness due to exposure to the effects of high temperatures and to the sun directly (Shrivastava, 1997), (Nabil; et al, 2018).

The spread of Cracks in the cell wall layers and the middle lamella layer or lost it caused the loss of the bonding between wood fibers (Williams, 2005), (Hamed; Mohamed, 2016). This was happened for the reason of the changing of humidity levels as well as high temperatures in the surrounding environment (Williams, 1991).

The accumulation of dirt layers, their adhesion to the outer surface of the wooden objects, and their spread in different cracks, this was a result of the presence of most of the archaeological buildings, selected for study, in an open environment spread by dust. High humidity plays an important role in the adhesion of dust particles on the outside surface and within cracks spread at these wooden objects (Reinprecht; et al, 2018).

One of the changes at the surface appearance, resulting from the exposure of the ancient wood to the influence of weathering factors directly, is the phenomenon of color change of these woods' outer surface (John; et al, 1993) as a result of the light oxidation process for both lignin and wood extractives. (Feist, 1990), (Sandberg, 1999), (Williams, 2005), (Yildiz, et al, 2011), (Huang, 2012), (Kocaefe; et al, 2012).

Figure 15. *The spread of various cracks in the surface of domestic wood in archaeological buildings in upper Egypt, (A, Wooden butterfly joints in dandara temple), (B. Wooden lintel in House of Mohammed Mujahid*•*), (C. Wooden lintel in Sheikh Al-Arab Hammam Mosque), (D. Wooden lintel in Wikalat Al Gedawi).*

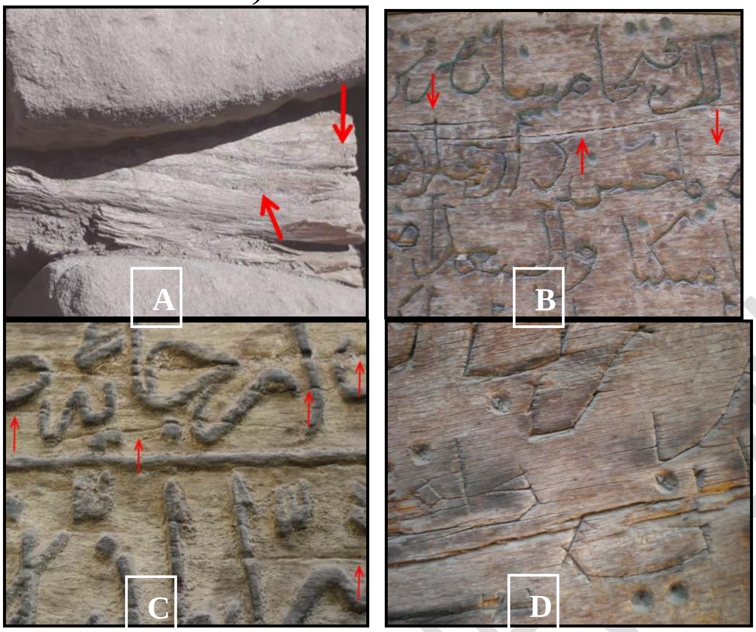


Figure 16. *The spread of various cracks in the surface of domestic wood in archaeological buildings in upper Egypt, and loss of some parts from the surface of wood (A, B, Wooden lintel in the house of EL-Sayed Abu Hussein)*

• This house (1295 AH) is one of the Historical buildings in Esna city, Luxor Governorate. This house is full of architectural and decorative details, in addition to the many Arabic calligraphy ornament.

Figure 17. *Figure 18.Loss of some parts from the surface and adhesion of dust particles on the surface of wooden butterfly joints in dandara temple.*

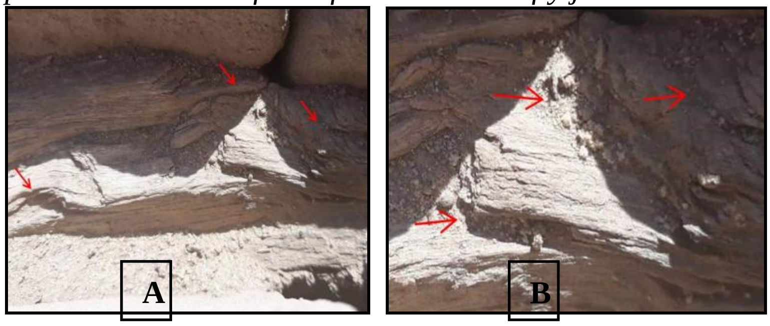


Figure 18. *The spread of various cracks in the surface of Wooden butterfly joints in dandara temple (A. Transversal surface), (B. longitudinal surface) USB Digital Microscope*

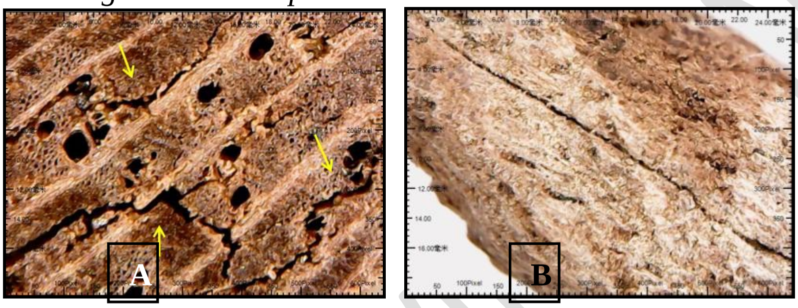


Figure 19. *The spread of various cracks in the surface of Wooden Lintel in Wikalat Al Gedawi (A, B. longitudinal surface) USB Digital Microscope*.

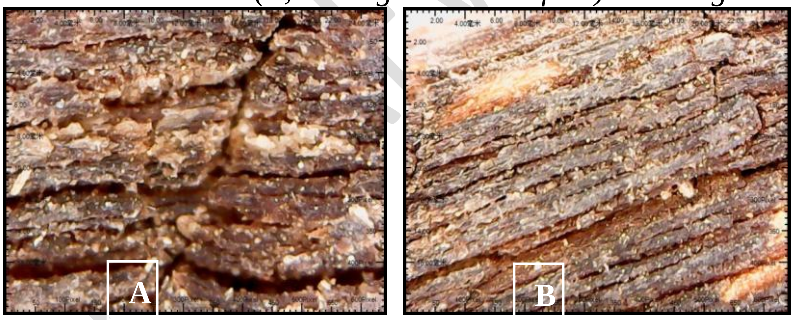


Figure 20. *The spread of various cracks in the surface (A. Wooden lintel in Sheikh Al-Arab Hammam Mosque), (B. Wooden lintel in House of Mohammed Mujahid) longitudinal surface USB Digital Microscope*.

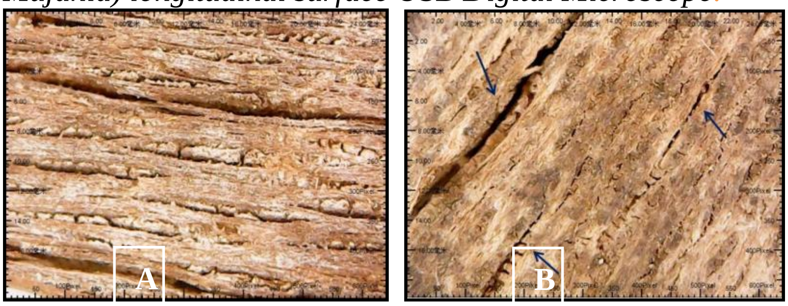


Figure 21. *The spread of various cracks in the surface and adhesion of dust particles on the surface(A. Wooden lintel in Sheikh Al-Arab Hammam Mosque), (B. Wooden Iconostasis in The Bishop Badaba monastery) longitudinal surface USB Digital Microscope.*

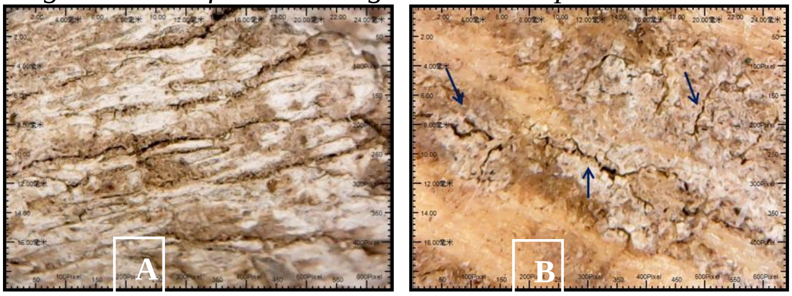


Figure 22. *SEM micrographs, the spread of various cracks in the surface, wooden lintel in House of Mohammed Mujahid, longitudinal section (A.45X), (B.60X).*

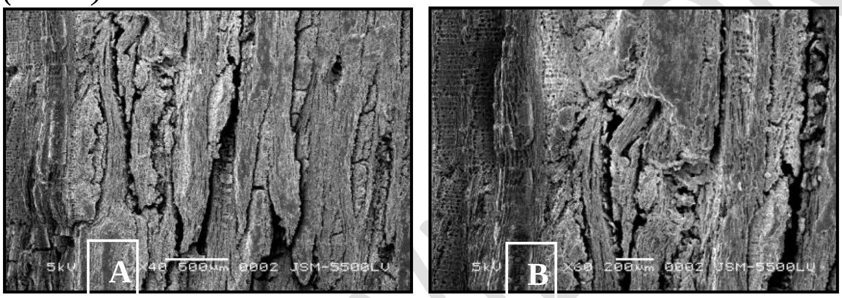


Figure 23. loss of the bonding between wood *(A. Wooden lintel in Sheikh Al-Arab Hammam Mosque), (B. Wooden Lintel in Wikalat Al Gedawi) longitudinal surface USB Digital Microscope.*

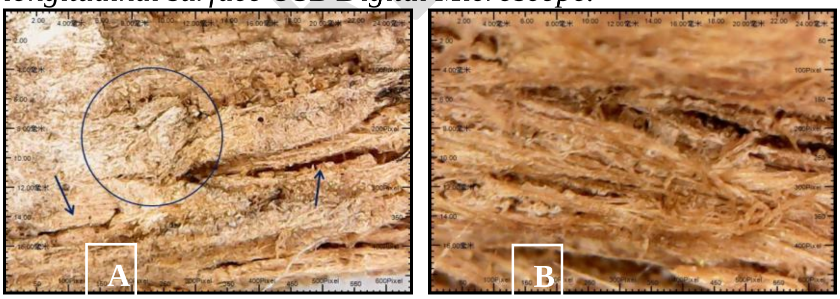


Figure 24. *adhesion of dust particles on the surface(A.B, Wooden lintel in Sheikh Al-Arab Hammam Mosque), (C. Wooden Lintel in Wikalat Al Gedawi), (D. wooden lintel in House of Mohammed Mujahid) USB Digital Microscope*

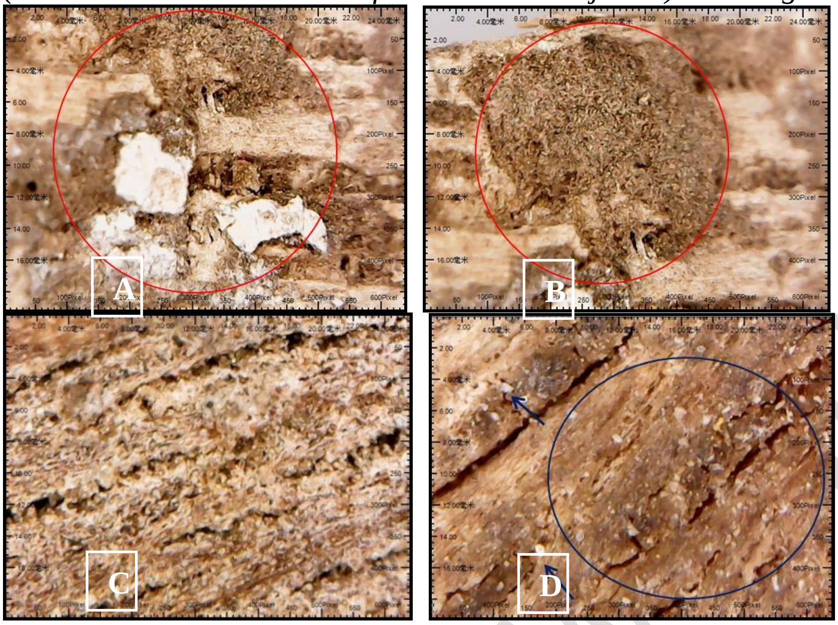


Figure 25. *Demonstrate the effect of weathering factors on the layers of color, (A) wooden lintel in House of Mohammed Mujahid,(B) Wooden vegetal ornamentation in The Bishop Badaba monastery, USB Digital Microscope.*

Figure 26. *SEM micrographs, Demonstrate the effect of weathering factors on the layers of color, Wooden Lintel in Wikalat Al Gedawi longitudinal section (A.200X), (B.170X).*

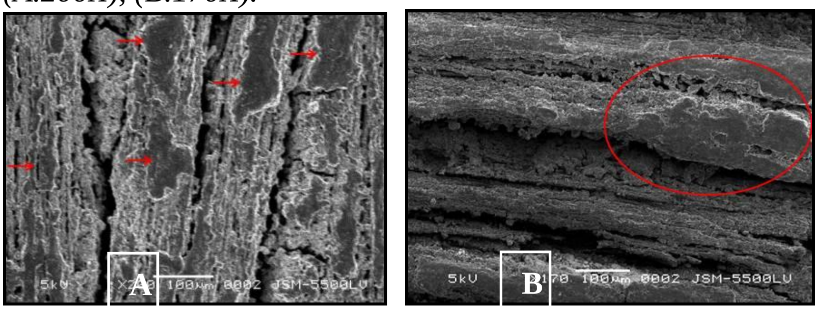


Figure 27. *Demonstrate the effect of weathering factors on the layers of color, Wooden Lintel in Wikalat Al Gedawi, USB Digital Microscope.*

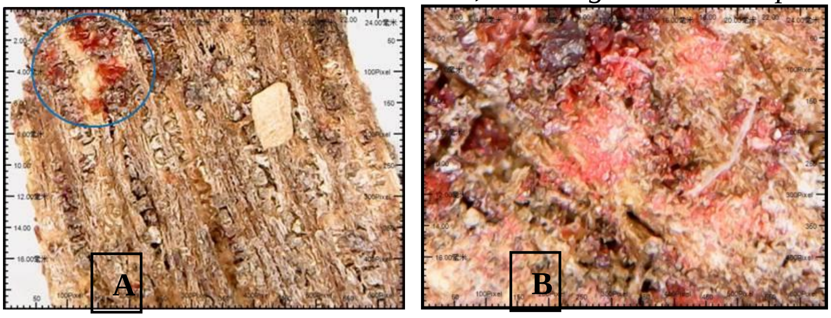
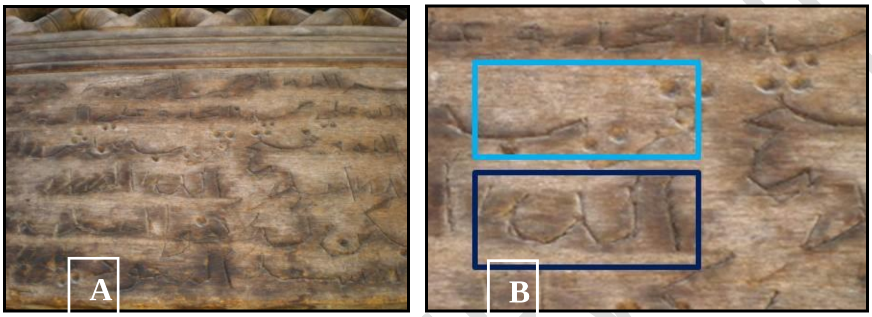


Figure 28. *Demonstrate the effect of weathering factors on wood colors, Wooden Lintel in Wikalat Al Gedawi.*



4-2-2. Anatomical changes

Weakness in the layers of the cell walls, with thinning in the layers of the cell walls, and the spread of fine cracks, especially in the areas of middle lamella layer (Feist, 1990), (Williams, 1991), (Hamed, 2012).

Separation and loss of various wood fibers are resulting from the severe dryness experienced by the external surfaces of these woods.

Separation of wood vessels with loss of surrounding wood fibers is due to severe dryness and varying expansion and shrinkage rates of these woods.

Figure 29. *SEM micrographs, Spread of fine cracks in wood tissue and breakdown in wood fibers, wooden butterfly joints in dandara temple, transversal direction, A. 58X, B. 300X.*

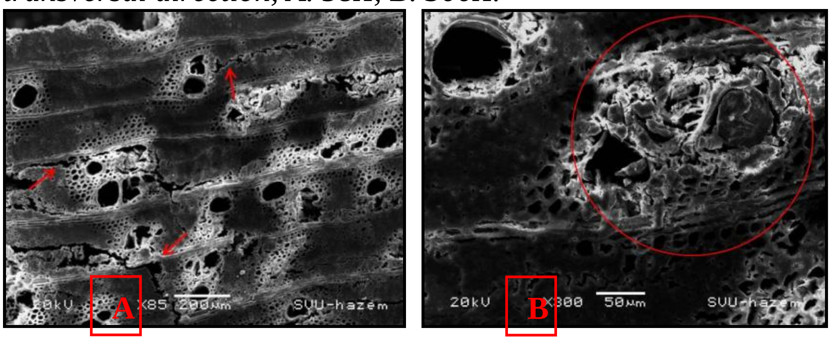


Figure 30. *SEM micrographs, dryness and loss of various wood fibers, Wooden Lintel in Wikalat Al Gedawi, transversal direction, A. 140X, B. 300X.*

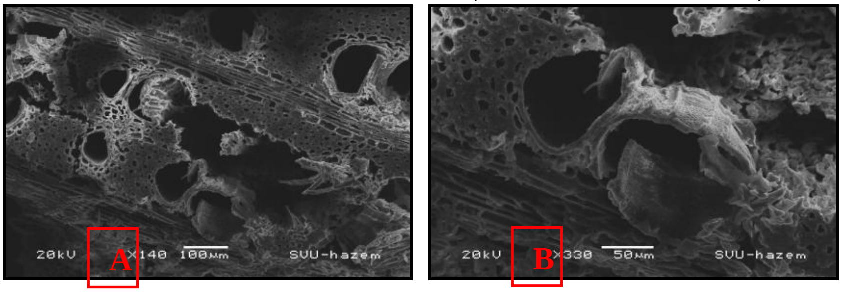


Figure 31. *SEM micrographs, dryness and loss of various wood fibers, wooden lintel in House of Mohammed Mujahid, transversal direction, A. 150X, B. 300X.*

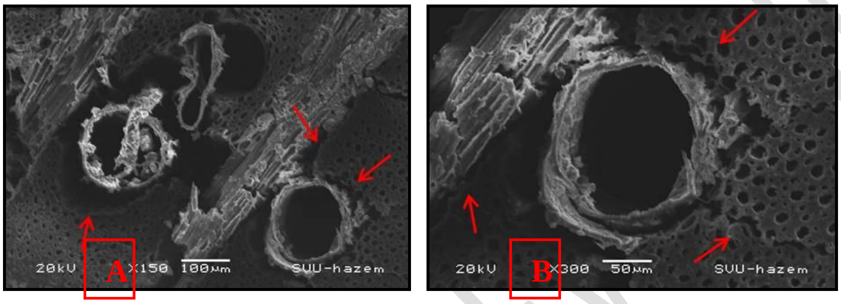


Figure 32. *SEM micrographs, Spread of different fine cracks in wood tissue and breakdown in wood fibers, wooden butterfly joints in dandara temple, longitudinal section, A. 500X, B. 500X.*

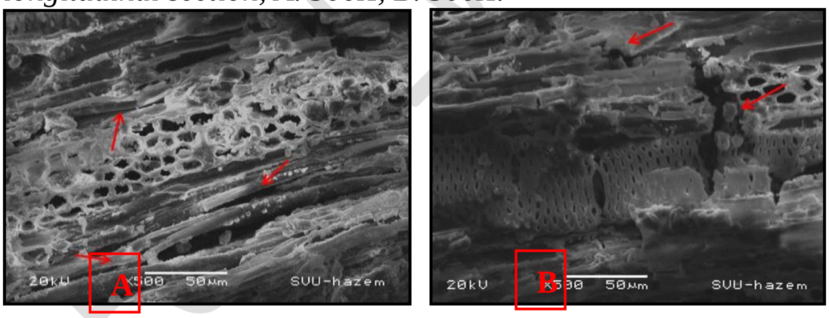
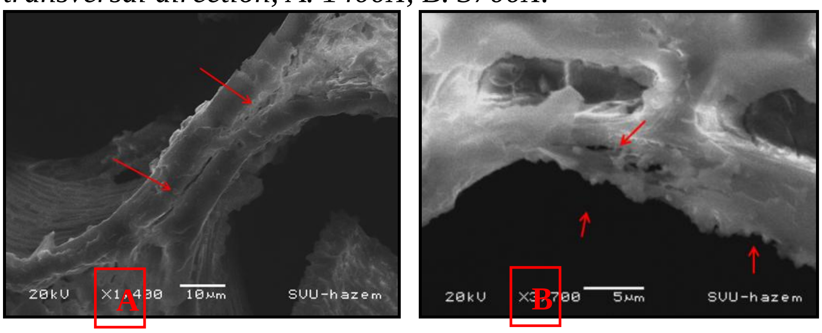


Figure 33. *SEM micrographs, spread of cracks in the areas of middle lamella layer and cell wall layers, wooden butterfly joints in dandara temple, transversal direction, A. 1400X, B. 3700X.*



4-2-3. Chemical changes:

The weathering causes severe dryness to the external surface of the domestics wood used in the archaeological building in Upper Egypt, which was observed in the previous examination method.

After examining the samples using FTIR and compared with the standard sample, significant a lot of changes can be observed especially in the fingerprint area of the FTIR in all samples.

This is also evident in the study of samples using FTIR where it was observed that the absorption spectrum in the water area 1640 cm^{-1} was decreased in all the samples compared to the standard samples (Picollo; et al, 2011), (Zidan; et al, 2016). This explains the phenomenon of the spread of micro cracks with different directions, resulting from the severe dryness suffered by these woods as a result of direct exposure to the sunlight.

- Natural weathering is a primary reason for the decomposition of lignin and Hemicellulose for various archaeological woods (Unger, 2001). As a result of lignin decomposition it's noticed the separation of the cell wall layers, especially in the middle lamella layer. This can be seen clearly in the area of lignin (1505-1515 cm^{-1}) and also in the Hemicellulose area (1735 cm^{-1}) in archeological and standard samples, where a strong decrease in the absorption spectrum of the archaeological samples compared to the standard samples is shown. This indicates the extent of the different weathering factors' influence on the domestic archaeological wood (Popescu; et al, 2011), (Abdallah; et al, 2016).

The reduction and changes in band density and discovering new shapes (New shoulders) at 1730- 1738 cm^{-1} it was a result degradation of the hemicelluloses (Xing; et al, 2015).

Its effect on Hemicellulose and lignin of these woods is reflected clearly on their external appearance. The decomposition of lignin as a result of the impact of solar radiation reflected on the significant decline in the absorption areas of lignin (1243-1261 cm^{-1}) (Popescu; et al, 2011).

The effect of the weathering factors on the domestic archaeological wood cellulose is observed in the study of the FTIR spectrum characteristic of the crystallization of cellulose in the region (1155-1165 cm^{-1}). It is noted that the absorption is clear in the standard sample with a decrease and weakness in the archaeological samples, which indicates the cracking of cellulose chains As a result of weathering effect (Lionetto; et al, 2012), (Zidan; et al, 2016). The changes in the peaks at 898 cm−1 for all the samples are related to CH distortion in amorphous cellulose (Reinprecht; et al, 2018).

5. Conclusions

The exposure of domestic wood in the archaeological building to the various weathering factors led to the appearance of many appearances of deterioration that can be seen with the naked eye, such as the spread of cracks extended to the end of the wood panels, which may lead to the split of these woods by constantly exposed to weathering conditions.

In addition to the appearances of deterioration that have been explained using different microscopes, especially the scanning electron microscope (SEM), which showed the extent of deterioration to the domestic archaeological wood used in the archaeological buildings in Upper Egypt, especially for the external surface, which is directly exposed to the weathering conditions, where fine cracks are spread in the different directions in addition to the fibers separation. This leads to be easily lost as a result of the severe dryness experienced by the domestic wood used in the archaeological buildings in Upper Egypt, in addition to the impact of weathering factors on different chemical compounds of wood especially Hemicellulose and Lignin (Hamed, 2012). This has been evident in all domestic wood samples that have been studied using FTIR, both external elements exposed to weathering conditions directly such as wooden Lintels, Wooden butterfly joints or internal elements exposed to indirect weathering conditions such as wood used inside Bishop Badaba monastery (Belie; et al, 2000).

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