JOURNAL OF ANCIENT HISTORY AND ARCHAEOLOGY

Institute of Archeology and Art History of
Romanian Academy Cluj-Napoca
Technical University Of Cluj-Napoca

# Journal
## of Ancient History and Archaeology

DOI: http://dx.doi.org/10.14795/j.v8i3

ISSN 2360 266x

ISSN–L 2360 266x

No. 8.3 /2021

# CONTENTS

## STUDIES




Design & layout:
Petru Ureche

# Studies

## ARCHAEOLOGICAL MATERIAL

# IDENTIFICATION OF FIBERS AND WEAVING TECHNOLOGY IN THE REMAINS OF FABRICS DISCOVERED FROM KUH-E KHWAJA, A PARTHIAN ARCHAEOLOGICAL SITE IN SISTAN, IRAN

**Alireza KOOCHAKZAEI**
Tabriz Islamic Art University, Tabriz, Iran.
Alireza.k.1989@gmail.com;
a.koochakzaei@tabriziau.ac.ir

**Mohsen Mohammadi ACHACHLUEI**
Isfahan University of Art, Isfahan, Iran.
Mohsen.mohammadi@aui.ac.ir

**Mahsa Saidi MEHRABAD**
Tabriz Islamic Art University, Tabriz, Iran
ma.saidi@tabriziau.ac.ir

DOI: 10.14795/j.v8i3.650
ISSN 2360 – 266X
ISSN–L 2360 – 266X

**Abstract:** The aim of this study is to characterize fibers, spinning and weaving techniques of fabric remains found in Kuh-e Khwaja, a Parthian archaeological site in Sistan, Iran. For this purpose, 26 samples, including fabric remains (17 cases) and separate yarns (9 cases), were examined. The fibers were identified using light microscopy and FTIR spectroscopy, and the yarn twist directions, the angle of pretwist of the fibers, and the weaving pattern of the fabrics were examined by light microscopy. The results showed that a similar type of fiber was used for both warp and weft in each fabric. Among the study, 12 cases (46%) and 14 cases (54%) have been characterized as wool and cotton respectively, which indicates the prosperity of both agriculture and animal husbandry in the Parthian period in the Sistan region. The yarn twist directions in both warp and weft were the same in all fabrics and were Z/Z type, except for one sample (Z/S). Also, single-ply (21 samples, 81%) and double-ply yarns (5 samples, 19%) showed Z-twist and S(2z)-twist, respectively. Most of the fabrics showed a plain weave; however, warp rib, irregular matt, twill, basket weave, and also knitted fabric were observed among them. In addition, the results showed that wool yarns have a lower angle of pretwist compared with cotton yarns. Therefore, this issue can be used in the primary classification of fabrics found from this archaeological site.

**Keywords:** *Kuh-e Khwaja, Parthian, Archaeological textiles and fabrics, Ancient weaving technology, Fibre identification.*

### INTRODUCTION

Fabrics have been considered as important evidence of the state of agriculture, trade, migration, art, and everyday life and culture in ancient time in different geographical areas. Study of fabrics and their manufacturing process as an indispensable part of human culture, can provide great information about in archaeological and anthropological researches. These researches can provide important information about infrastructure and resource management in ancient societies[1]. There is little information about ancient fabrics due to lesser excavated fabrics in archaeological sites compared

[1] LUKEŠOVÁ/PALAU/HOLST 2017

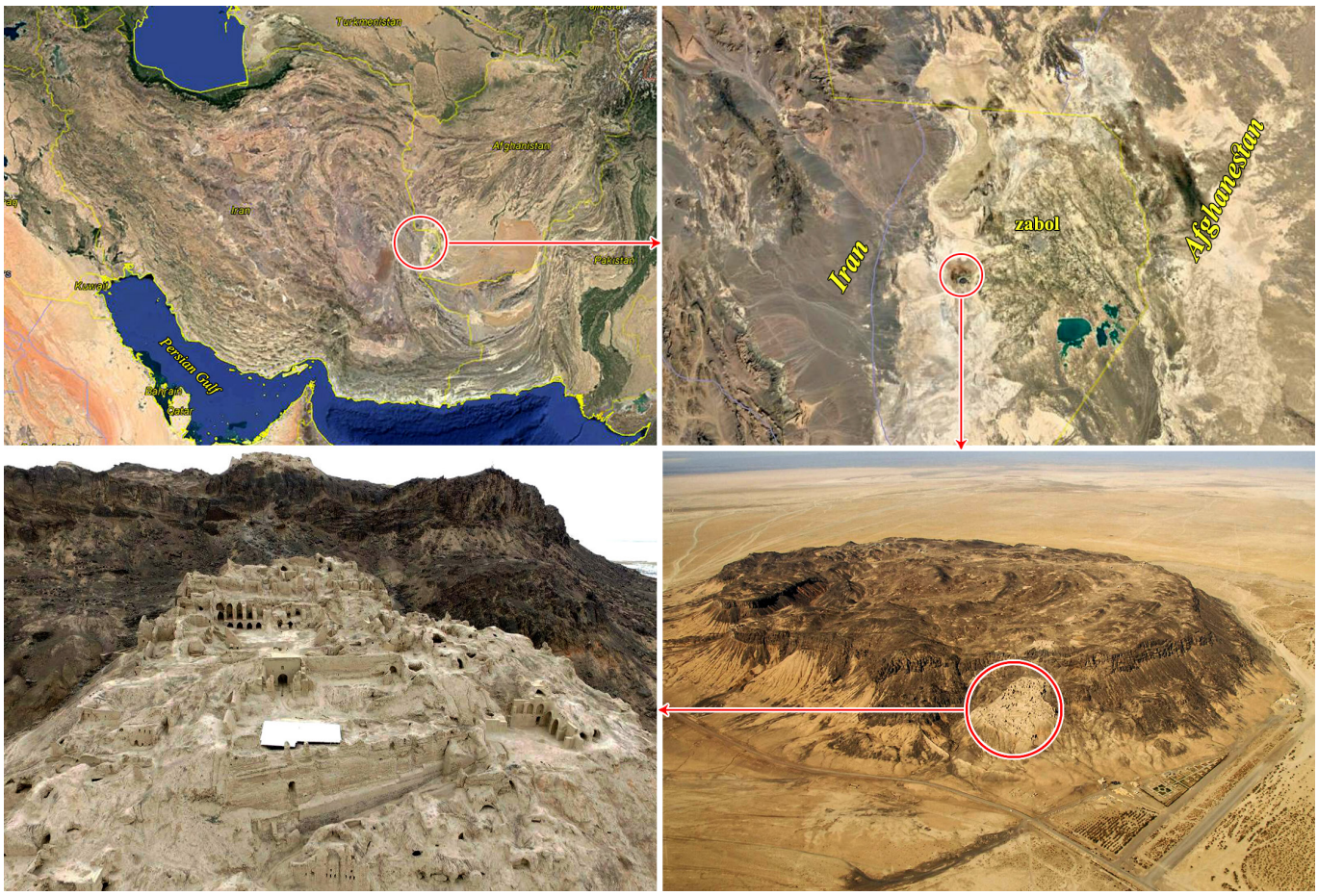


**Fig. 1.** The geographical location of Kuh-e Khwaja.

with durable artifacts such as ceramics or metal[2]. Fabrics are not very durable and usually have been affected by moisture, high temperatures, fungi, and bacteria in underground graves for thousands of years. Most archaeological textiles are dry brittle wads, collapsed waterlogged masses, or damp moldy bundles. In addition, there are the minute fragments that are carbonized[3]. In fact, aridity, high concentration of salt, waterlogging, freezing, charring, and mineralization are among the most common conditions that lead to the preservation of textiles[4]. Therefore, many ancient fabrics are commonly found in hot and dry climatic zones.

Sistan is one of these regions in eastern Iran with numerous ancient sites including Kuh-e Khwaja. Kuh-e Khwaja, mount Oshida. It is located on the slopes of a black basalt mountain rising from Lake Hamun in 30 km southwest of Zabol (a city in northeastern of Sistan and Baluchestan province, Iran) and is one of the most important tourist attractions and ancient sites of the Sistan plain in eastern Iran[5] (Fig. 1). This site has been considered in different periods of history due to its special geographical and natural location. Most studies to date show that the buildings on this site date back to the Sassanid and Parthian periods[6]. Remnants of fabrics were found in Parthian clay bricks paste in a survey at the surface of this site in 2012. There is small number of Parthian fabrics discovered in archaeological excavations. Therefore, study of manufacturing process as well as the materials and applied techniques in the samples from Kuh-e Khwaja, is very important in order to obtain more information about Sistan region in the Parthian period. But most of the studies on Iranian historical fabrics have focused on artistic studies and their decorative patterns[7]. Hence, there is a deep requirement for technical examination of these fabrics. Therefore, the purpose of this study is to investigate the techniques and materials of discovered fabrics from Kuh-e Khwaja in the Sistan region. These studies include identifying the type of fibers, yarn twist directions, the angle of pretwist of the fibers, and the weaving pattern.

## METHODS AND MATERIALS

In this study, 26 samples of yarn and fabrics found in 2012 from the archaeological site of Kuh-e Khwaja were examined. These samples included 17 fabrics and 9 separated yarns that were obtained among the Parthian bricks of this area. To microscopically identify the fibers, the fibers were first separated from each other and suspended in distilled water. It was then placed as a drop on a microscope slide and examined using an Olympus BX51 polarized light microscope

[2] CYBULSKA/MAIK 2007; LIPKIN *et alii* 2021
[3] PEACOCK 2005
[4] GLEBA/VANDEN BERGHE/ALDENDERFER 2016
[5] GHANIMATI 2000; KAWAMI/BECKER/KOESTLER 1987; VASEGH ABBASI/MEHRAFARIN/MOSAVI HAJI 2018; SARHADDI-DADIAN *et alii* 2021
[6] KAWAMI/BECKER/KOESTLER 1987
[7] HEDAYAT SHENASA 2008; HOUGHTELING 2017; KATEB/MAFITABAR 2019; MORAVEJ 2016

(Olympus Optical Co., Ltd., Japan). The morphological properties of the fibers in the longitudinal view were investigated with two magnifications of 200 and x400 in transmitted light mode. Also, due to the surface degradation of fibers as a result of their considerable antiquity, and alteration of morphological and surface properties, their chemical structure was investigated using Fourier transform infrared (FTIR) spectroscopy. After removing the surface sediments of the samples, FTIR spectroscopy was carried out using a Nicolet 680Plus FTIR spectrometer (Jasco, Japan) with KBr pellets. All Spectra were collected in the range of 4000-400 $cm^{-1}$ at 4 $cm^{-1}$ resolution with 32 numbers scans. Then, the spectral characteristics in the fingerprint region were investigated using Omnic 9 software. The yarn twist directions, the angle of pretwist (the angle of the twisted fibers relative to the yarn axis), and the weaving pattern of the fabrics were examined with an Olympus BX51 microscope. Two optical fibers with a radiation angle of 45 degrees were used as an incident light source. After capturing the images, the pretwist angles were measured using ImageJ 1.44 software. Angle measurements were repeated 15 times for each sample and the average was calculated.

## RESULTS AND DISCUSSION

Fiber identification is One of the most important measures in archaeological studies. It provides valuable information about economic conditions, agricultural or animal husbandry prosperity, contact and trade between different regions, the prevailing cultural conditions in the desired historical period, and sometimes the authenticity of materials attributed to a region. The most common natural fibers used for textiles are animal fibers like wool and silk and plant fibers like cotton and flax[8]. There are also small amounts of metal and mineral fibers[9]. Animal and plant fibers are usually identified by touch and vision, burning, solubility, microscopy, birefringence, spectrometry methods[10]. Microscopic examination of the morphological properties of the fibers makes it possible to distinguish between animal and plant fibers[11]. On the other hand, microscopic examination provides a better understanding of the degradation and structural condition of the fibers, as well as the penetration of dust and impurity into the fabric and yarn structure[12].

In the longitudinal view, the cotton fibers are flat and ribbon-like with convolutions[13]. Wool fibers also appear with a scaly surface, which is one of the most important characteristics of wool under a microscope[14]. Silk fibers have a relatively smooth surface without special bulges, and a cross-section similar to a triangle[15], and flax fibers can be identified by their nodes[16].

Based on the microscopic examination shown in Fig. 2, only two different types of fibers have been identified in the yarns and fabrics found from Kuh-e Khwaja. Examination of 26 samples (including separate yarns and fabrics) shows that 14 samples have cotton fibers (Fig. 2b) and 12 samples have wool fibers (Fig. 2a). Also, in each fabric, the warp and weft fibers were both of the same types. The results of this microscopic examination for each sample are presented in Table 1. The relatively uniform distribution of wool and cotton fibers in the samples can be attributed to the possibility of the prosperity of both agriculture and animal husbandry in the Parthian period in the Sistan region (Fig. 2c).

Many ancient fibers are sometimes severely eroded and carbonized due to prolonged burial conditions. This,

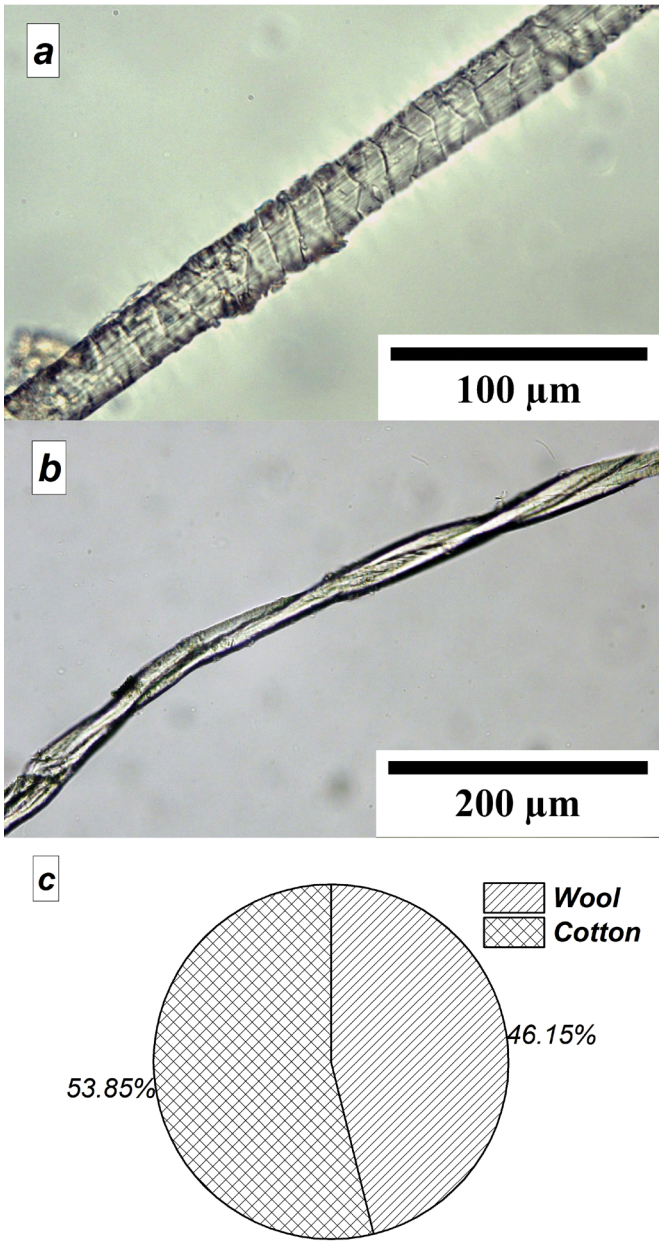


**Fig. 2.** Optical microscope image of wool fibers in sample KhM-19 (a) and cotton fibers in sample KhM-1 (b) and distribution of these fibers in the studied samples (c).

[8] BERGFJORD/HOLST 2010.
[9] CAO *et alii* 2010.
[10] CAO *et alii* 2010.
[11] BERGFJORD/HOLST 2010.
[12] GARSIDE 2009; GOLDMAN *et alii* 2018; LIPKIN *et alii* 2021.
[13] ANGIORAMA/LÓPEZ CAMPENY/TABOADA 2020; BLATT *et alii* 2011; HOUCK/SIEGEL 2015.
[14] BERGFJORD/HOLST 2010.
[15] GLEBA/VANDEN BERGHE/ALDENDERFER 2016; GOODWAY 1987.
[16] HAUGAN/HOLST 2014.

along with the limitations of light microscopes, can lead to misidentification of fibers in the laboratory. For example, as Good (2001) points to the Çatal Hüyük fabrics, an initial microscopic examination of the fibers in 1963 showed that they were wool, but two years later, in 1965, subsequent analysis confirmed that bast fibers were used in these fabrics[17]. Therefore, due to the degradation of ancient fibers that affect their optical properties, it is sometimes necessary to use more accurate analytical tools along with an optical microscope to study their chemical structure or morphology. Therefore, to reduce the possibility of misdiagnosis in microscopic examination of fibers, FTIR spectroscopy was used to determine the plant or animal nature of fibers. FTIR spectroscopy allows the determination of a fiber constitution of textiles[18]. It also allows the study of degradation in ancient fabrics[19]. The fingerprint region of the FTIR spectra was selected for the study. Initial checking of the absorption bands of the FTIR spectra of the samples indicated two distinct categories. In Fig. 3, the spectra of two samples KhM-3 and KhM-18 are presented as examples of these categories. The spectrum of KhM-3 fibers indicates vibrations related to polysaccharides. In this spectrum, absorption bands at 1638cm$^{-1}$ (related to water molecules adsorbed on cellulose), 1374cm$^{-1}$ and 1337cm$^{-1}$ (related to CH and CH2 symmetric bending vibrations), 1160cm$^{-1}$ (related to C-C stretching vibrations in glucopyranose ring), 1104cm$^{-1}$ (related to C-O-C vibrations) and 1030cm$^{-1}$ (related to C-OH vibrations) represent polysaccharide structures[20].

However, in the FTIR spectra of the second group and the KhM-18 sample, clear differences can be observed with the KhM-3 sample. The FTIR spectrum of KhM-18 fibers shows C=O stretching vibrations at 1640cm$^{-1}$ (amide I) and N-H bending and C-N stretching vibrations at 1543cm$^{-1}$ and 1240cm$^{-1}$ (amide II and III), which are characteristic of peptide bonds in proteins, such as wool[21]. Accordingly, the type of fibers can be identified more reliably, when using FTIR spectroscopy along with microscopic examination.

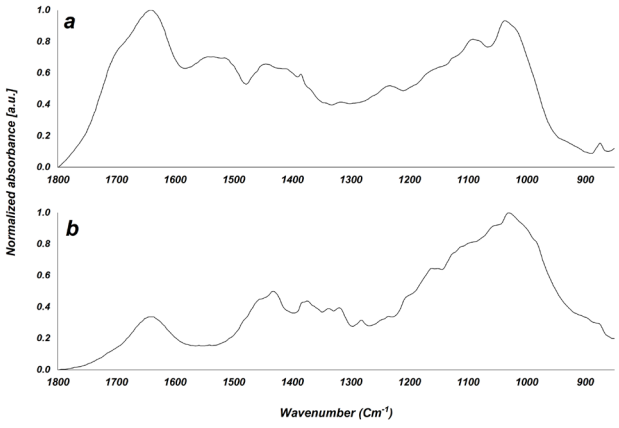


**Fig. 3.** FTIR spectra of wool fibers in sample KhM-18 (a) and cotton fibers in sample KhM-3 (b).

[17] GOOD 2001; HELBAEK 1963; RYDER 1965.
[18] CAO *et alii* 2010; COLETTI *et alii* 2021; GARSIDE/WYETH 2003; KRAMELL *et alii* 2016; MARGARITI 2019; PEETS *et alii* 2019.
[19] COLETTI *et alii* 2021.
[20] GARSIDE/WYETH 2003; MARGARITI 2019.
[21] CAO *et alii* 2010; MARGARITI 2019.

The spectra of two different groups show a clear difference of about 1540cm$^{-1}$, which is related to the amide II vibrations in protein fibers and is not seen in cellulosic fibers. Therefore, the amide II adsorption band was selected as an indicator for distinguishing protein and plant fibers from each other. The results of examining the presence of this peak, presented in Table 1, were consistent with microscopic observations.

The yarn twist was also examined to better understand the spinning and weaving process. In 9 specimens found as separate yarns, all single-ply and double-ply yarns have Z and S(2z) twists (Fig. 4b), respectively.

The size of the fabrics found is about 1 to 2 square centimeters. Due to the lack of a clear edge in the fabrics, it is difficult to accurately distinguish the direction of the warp and weft. However, previous studies on archaeological fabrics have shown if the twist direction differs, with one system Z-twist and the other S-twist, the yarn with Z-twist defined as the warp, in most instances[22]. Of course, this may not be the case for all samples. However, all fabrics found in Kuh-e Khwaja, except KhM-3, have Z-twist in both directions (Z/Z). But in the example of KhM-3, which can be seen in Fig. 4a, there are two S and Z-twist in two directions of the fabric, which are probably the warp with Z-twist and the weft with S-twist. Moreover, previous studies have shown that warp yarns generally have a higher twist than weft yarn[23]. Therefore, the angle of twist of the fibers with respect to the central axis of the yarn was calculated and their average presented in Table 1. In some cases, there is a significant difference between the twist angles of the yarn in the two directions of the fabric. Also, because of loom tension, warp yarns are more parallel and straighter, and weft yarns more waviness[24]. Therefore, three characteristics including twist type, twist angle, and yarn waviness were investigated to determine the direction of warp and weft in fabrics (Table 1).

A noteworthy point based on the results is the relationship between the twist angle of the fibers in the yarns and the type of fiber. As can be seen in Fig. 5, the type of fibers in the yarns and fabrics found in Kuh-e Khwaja have a significant relationship with the angle of twist. As shown in this figure, yarns with cotton fibers have a higher twist angle. Therefore, according to the yarn strength classification in terms of twist angle, cotton yarns are stronger than

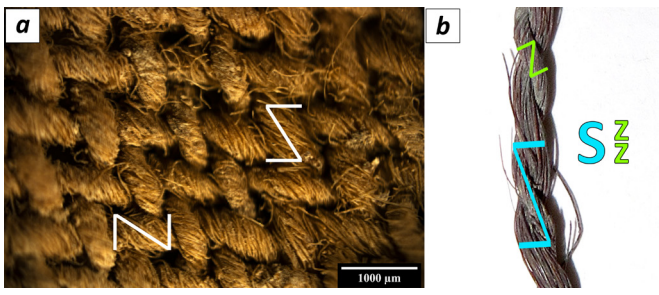


**Fig. 4.** a: Different twist in warp (Z) and weft (S) in sample KhM-3 and b: S(2z)-twist in sample KhM-22 as an example of 2-ply yarns.

[22] HENRY 1994.
[23] ISLAM/CHOWDHURY/AKTER 2018.
[24] ISLAM/CHOWDHURY/AKTER 2018; NG/HU 2018.

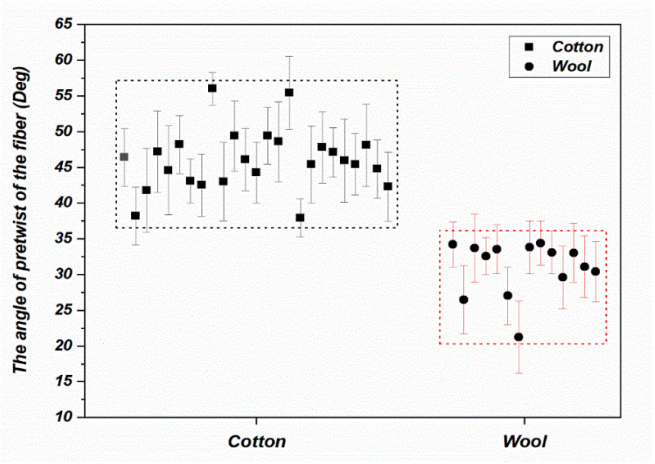


**Fig. 5.** The average angle of twisting of fibers in the studied samples including warp and weft of fabrics and separate yarns in two groups of wool and cotton.

wool[25]. The twist angle in the cotton yarns is above 37° and on average 46°. This angle is less than 35° and on average 31° in the wool yarns which shows a significant difference with the cotton yarns. Therefore, it seems that this index can be considered as a primary criterion in the separation of wool and cotton fabrics found from Kuh-e Khwaja.

The results are summarized in Table 1. In 17 examined fabrics, nine samples have a 1/1 plain weave, structures with single warps and wefts[26], similar to the KhM-11 sample shown in Fig. 6a. This study shows that most fabrics with a plain weave have cotton yarns. Also, only samples KhM-10 and KhM-19 have 2/2 matt weave or 2/2 basket weave. Fig. 6c shows an example of this weave pattern in fabric KhM-10. The examination of the fibers of these two fabrics under light microscopy showed the using wool fibers in both.

The 2/2 warp rib weave has been used in KhM-5 and KhM-13 fabrics (Fig. 6b). In addition, the 2/2 warp/weft rib weave was also used in the KhM-26, due to the lack of detection of warp and weft. Among the studied fabrics, irregular matt weave can also be seen in the KhM-17 sample (Fig. 6d). In all of these fabrics, the yarn twist in the warp and weft was the same and of the Z type. However, in the KhM-3 sample, where the warp and weft have different twist types, 2/1 twill weave pattern was identified (Fig. 4a). Apart from these samples, a simple knit-like pattern, with two colors of brown and cream wool yarn, was also observed in KhM-18 fabric.

## CONCLUSION

In this paper, we presented an examination of remnants of fabrics found in Parthian clay bricks paste of Kuh-e Khwaja archaeological site with the aim of identifying fibers and weaving techniques. The results showed that only wool and cotton fibers were used for manufacturing of the

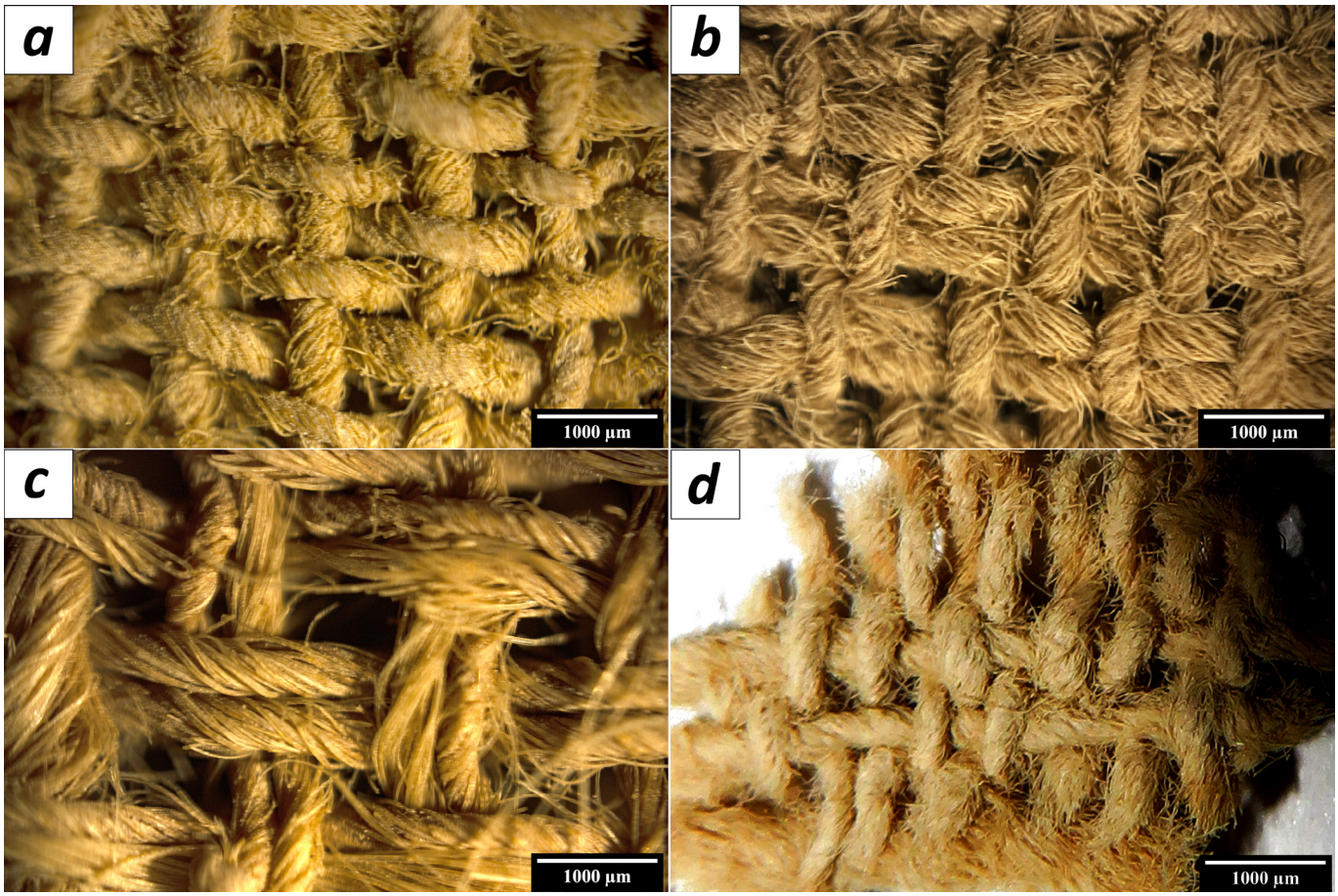


**Fig. 6.** Weaving patterns of the studied fabrics; a: plain weave in KhM-11, b: The 2/2 warp rib weave in KhM-13, c: 2/2 matt weave in KhM-10, d: irregular matt weave in KhM-17.

[25] GLEBA/VANDEN BERGHE/ALDENDERFER 2016.

[26] BONGERS/O'SHEA/FARAHANI 2018.

**Table 1.** Summary of the results obtained from the examination of yarns and fabrics found in the Parthian clay bricks paste of Kuh-e Khwaja.

| Sample code | Microscopic observations of fibers | | Amid II in FTIR spectrum | Fiber type * | Pretwist angle | | | Warp/Weft twist | Weave pattern |
|---|---|---|---|---|---|---|---|---|---|
| | twisted ribbon | scales | | | Warp | Weft | Separate yarn | | |
| KhM-1 | ✓ | - | - | C | 47.2 | 42.6 | - | Z/Z | plain weave |
| KhM-2 | - | ✓ | ✓ | W | - | - | 32.8 | Z | - |
| KhM-3 | ✓ | - | - | C | 48.2 | 44.6 | - | Z/S | 2/1 twill weave |
| KhM-4 | ✓ | - | - | C | - | - | 45.5 | Z | - |
| KhM-5 | ✓ | - | - | C | 42.5 | 43.1 | - | Z/Z | 2/2 warp rib |
| KhM-6 | ✓ | - | - | C | 56 | 43 | - | Z/Z | plain weave |
| KhM-7 | ✓ | - | - | C | 49.4 | 46.1 | - | Z/Z | plain weave |
| KhM-8 | ✓ | - | - | C | 49.4 | 44.3 | - | Z/Z | plain weave |
| KhM-9 | ✓ | - | - | C | 55.4 | 48.6 | - | Z/Z | plain weave |
| KhM-10 | - | ✓ | ✓ | W | 33.7 | 33 | - | Z/Z | 2/2 basket weave |
| KhM-11 | ✓ | - | - | C | 47.8 | 47.1 | - | Z/Z | plain weave |
| KhM-12 | ✓ | - | - | C | 45.5 | 45.9 | - | Z/Z | plain weave |
| KhM-13 | ✓ | - | - | C | 46.4 | 38.2 | - | Z/Z | 2/2 warp rib |
| KhM-14 | - | ✓ | ✓ | W | - | - | 32 | S(2z) | - |
| KhM-15 | - | ✓ | ✓ | W | - | - | 34.4 | Z | - |
| KhM-16 | - | ✓ | ✓ | W | - | - | 33.1 | S(2z) | - |
| KhM-17 | ✓ | - | - | C | 42.3 | 37.9 | - | Z/Z | irregular matt |
| KhM-18 | - | ✓ | ✓ | W | | | 29.6 | S(2z) | Knitted fabric |
| KhM-19 | - | ✓ | ✓ | W | 34.2 | 26.5 | - | Z/Z | 2/2 basket weave |
| KhM-20 | ✓ | - | - | C | 48.1 | 43.4 | - | Z/Z | plain weave |
| KhM-21 | ✓ | - | - | C | - | - | 45.4 | Z | - |
| KhM-22 | - | ✓ | ✓ | W | - | - | 31.1 | S(2z) | - |
| KhM-23 | - | ✓ | ✓ | W | - | - | 30.4 | S(2z) | - |
| KhM-24 | - | ✓ | ✓ | W | - | - | 33.8 | Z | - |
| KhM-25 | - | ✓ | ✓ | W | 27 | 21.2 | - | Z/Z | plain weave |
| KhM-26 | - | ✓ | ✓ | W | 32.6 | 33.5 | - | Z/Z | 2/2 warp/weft rib |

* C: cotton, W: wool

fabrics and yarns, with an almost equal ratio. This could be due to the prosperity of agriculture, cotton planting, as well as animal husbandry about 2000 years ago in the Sistan region. The angle of pretwist of the fibers in the cotton and wool yarns are above 37° and on average 46° and less than 35° and on average 31°, respectively. Therefore, it seems that pretwist angle can be considered as an initial way in the separation of wool and cotton fabrics found from Kuh-e Khwaja. Examination of twist type in both fabrics and yarns often showed Z-twist and S(2z)-twist in single and double-ply yarns, respectively. Only in one fabric the yarn twist was different in the warp and weft direction (Z/S), but the other fabrics of Kuh-e Khwaja showed similar twists in two directions (Z/Z). This is probably due to the better strength of Z-twisted yarns. These fabrics exhibited a variety of weaving patterns, including plain weave, twill weave, warp rib, basket weave, irregular matt, and also knitted fabric. This variety of weaving patterns shows the prosperity of the textile industry in the Parthian era in this region.

## REFERENCES


ANGIORAMA/LÓPEZ CAMPENY/TABOADA 2020

Angiorama, C. I./López Campeny, S. M. L./Taboada, C., Exceptional cases of textile mineralization in archaeological metallic objects from Santiago del Estero's lowlands (Argentina), *Journal of Archaeological Science: Reports* 33, 102478.

BERGFJORD/HOLST 2010

Bergfjord, C./Holst, B., A procedure for identifying textile bast fibres using microscopy: Flax, nettle/ramie, hemp and jute. *Ultramicroscopy* 110/9, 1192-1197.

BLATT *et alii* 2011

Blatt, S. H./Redmond, B. G./Cassman, V./Sciulli, P.W., Dirty teeth and ancient trade: Evidence of cotton fibres in human dental calculus from Late Woodland, Ohio, *International Journal of Osteoarchaeology* 21/6, 669-678.

BONGERS/O'SHEA/FARAHANI 2018

Bongers, J.L./O'Shea, C./Farahani, A., Communities of weavers: A methodology for analyzing textile and cloth

production, *Journal of Archaeological Science: Reports* 22, 223-236.

CAO *et alii* 2010

Cao, Q./Zhu, S./Zhao, H./Tu, H., Application of Fourier Transform Attenuated Total Reflection Infrared Spectroscopy to Identifying Archaeological Fibres. *Research Journal of Textile and Apparel* 14/1, 38-41.

COLETTI *et alii* 2021

Coletti, F./Romani, M./Ceres, G./Zammit, U./Guidi, M. C., Evaluation of microscopy techniques and ATR-FTIR spectroscopy on textile fibers from the Vesuvian area: A pilot study on degradation processes that prevent the characterization of bast fibers, *Journal of Archaeological Science: Reports* 36, Article 102794.

CYBULSKA/MAIK 2007

Cybulska, M./Maik, J., Archaeological Textiles – A Need for New Methods of Analysis and Reconstruction, *Fibres and Textiles in Eastern Europe* 15/5-6, 185-189.

GARSIDE 2009

Garside, P., The role of fibre identification in textile conservation. In: Houck, M. M. (ed.), *Identification of Textile Fibers* (Sawston, United Kingdom: Woodhead Publishing), 335-365.

GARSIDE/WYETH 2003

Garside, P./Wyeth, P., Identification of Cellulosic Fibres by FTIR Spectroscopy - Thread and Single Fibre Analysis by Attenuated Total Reflectance, *Studies in Conservation* 48/4, 269-275.

GHANIMATI 2000

Ghanimati, S., New Perspectives on the Chronological and Functional Horizons of Kuh-e Khwaja in Sistan, *Iran* 38/1, 137-150.

GLEBA/VANDEN BERGHE/ALDENDERFER 2016

Gleba, M./Vanden Berghe, I./Aldenderfer, M., Textile technology in Nepal in the 5th-7th centuries CE: the case of Samdzong, *STAR: Science & Technology of Archaeological Research* 2/1, 25-35.

GOLDMAN *et alii* 2018

Goldman, Y./Linn, R./Shamir, O./Weinstein-Evron, M., Micro-RTI as a novel technology for the investigation and documentation of archaeological textiles, *Journal of Archaeological Science: Reports* 19, 1-10.

GOOD 2001

Good, I., Archaeological Textiles: A Review of Current Research, *Annual Review of Anthropology* 30, 209-226.

GOODWAY 1987

Goodway, M., Fiber Identification in Practice, *Journal of the American Institute for Conservation* 26/1, 27-44.

HAUGAN/HOLST 2014

Haugan, E./Holst, B., Flax look-alikes: Pitfalls of ancient plant fibre identification, *Archaeometry* 56/6, 951-960.

HEDAYAT SHENASA 2008

Hedayat Shenasa, N., Donning the Cloak: Safavid Figural Silks and the Display of Identity. Paper presented at the Textiles as Cultural Expressions: Proceedings of the 11th Biennial Symposium of the Textile Society of America, Honolulu, Hawaii.

HELBAEK 1963

Helbaek, H., Textiles from Catal Huyuk, *Archaeology* 67, 39-46.

HENRY 1994

Henry, P.A., *Current techniques of ancient textile analysis: a critical review.* (Master thesis), Durham University.

HOUCK/SIEGEL 2015

Houck, M.M./Siegel, J. A., Chapter 15 - Textile Fibers. In: Houck, M.,M./Siegel, J.,A. (eds.), *Fundamentals of Forensic Science (3th Edition)* (San Diego: Academic Press), 381-404

HOUGHTELING 2017

Houghteling, S., Sentiment in Silks: Safavid Figural Textiles in Mughal Courtly Culture. In Rizvi, K. (Ed.), *Affect, Emotion, and Subjectivity in Early Modern Muslim Empires: New Studies in Ottoman, Safavid, and Mughal Art and Culture* (Leiden: Brill), 124-147

ISLAM/CHOWDHURY/AKTER 2018

Islam, S./Chowdhury, S./Akter, S., The Experiential Analysis of Woven Fabric for Reproduction, *Journal of Textile Science and Technology* 4/1, 18-48.

KATEB/MAFITABAR 2019

Kateb, f./Mafitabar, A., Restudying the Historical Textiles in Iran(Based on Methods of Classifying Designs and Motifs), *Glory of Art (Jelve-y Honar) Alzahra Scientific Quarterly Journal* 11/2, 67-80.

KAWAMI/BECKER/KOESTLER 1987

Kawami, T.S./Becker, L./Koestler, R., Kuh-e Khwaja, Iran, and Its Wall Paintings: The Records of Ernst Herzfeld, *Metropolitan Museum Journal* 22, 13-52.

KRAMELL *et alii* 2016

Kramell, A. E./Wertmann, P./Hosner, D./Kluge, R./Oehler, F./Wunderlich, C.-H./Tarasov, P. E./Wagner, M./Csuk, R., A multi-analytical techniques based approach to study the colorful clothes and accessories from mummies of Eastern Central Asia, *Journal of Archaeological Science: Reports* 10, 464-473.

LIPKIN *et alii* 2021

Lipkin, S./Ruhl, E./Vajanto, K./Tranberg, A./Suomela, J., Textiles: Decay and Preservation in Seventeenth- to Nineteenth-Century Burials in Finland, *Historical Archaeology* 55/1, 49-64.

LUKEŠOVÁ/PALAU/HOLST 2017

Lukešová, H./Palau, A.S./Holst, B., Identifying plant fibre textiles from Norwegian Merovingian Period and Viking Age graves: The Late Iron Age Collection of the University Museum of Bergen, *Journal of Archaeological Science: Reports* 13, 281-285.

MARGARITI 2019

Margariti, C., The application of FTIR microspectroscopy in a non-invasive and non-destructive way to the study and conservation of mineralised excavated textiles, *Heritage Science* 7/1, 63.

MORAVEJ 2016

Moravej, E., Comparative study of Graphic aspects of textiles in Indian Gurakani and Iranian Safavid eras, *Bulletin de la Société Royale des Sciences de Liège* 85, 793-806.

NG/HU 2018

Ng, W.S./Hu, H., Woven Fabrics Made of Auxetic Plied Yarns, *Polymers* 10/2, 226.

PEACOCK 2005

Peacock, E., Study of Archaeological Textiles Intimately Associated with Human Remains – Where Is the Ethical Dilemma?, Paper presented at the NESAT IX:

Archäologische Textilfunde-Archaeological Textiles, Braunwald, Switzerland.

PEETS *et alii* 2019

Peets, P./Kaupmees, K./Vahur, S./Leito, I., Reflectance FT-IR spectroscopy as a viable option for textile fiber identification, *Heritage Science* 7/1, 93.

RYDER 1965

Ryder, M.L., Report of Textiles from Çatal Hüyük, *Anatolian Studies* 15, 175-176.

SARHADDI-DADIAN *et alii* 2021

Sarhaddi-Dadian, H./Ramli, Z./Moradi, H./ Jozi, Z., Compositional Analysis Analysis of The Pottery Shards From Kuh-I Khawja Historical Site, Sistan, East of Iran, *Journal of Ancient History and Archaeology* 8/1, 127-133. DOI: 10.14795/j.v8i1.538

VASEGH ABBASI/MEHRAFARIN/MOSAVI HAJI 2018

Vasegh Abbasi, Z./Mehrafarin, R./Mosavi Haji, S.R., Analysis, Typology, and Chronology of Stuccos in the Palace of Kuh-e Khvājeh, *Historia i Świat* 7, 111-128.