BAST FROM THE PAST

WHEN ARCHAEOLOGY MEETS MATERIAL SCIENCE

30-31 oct. 2025 - Université de Bretagne Sud,
Lorient (France)

Supported by the ANUBIS and ASGARD projects, an original conference bridging archaeology and materials science

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PROGRAMME

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Thursday 30 October

08:30 – 08:45: Registration

08:45 - 09:00: Welcoming note

SESSION 1: Plant fibre structure and identification
(09:00 – 10:55) – Chair A. Bourmaud

09:00 – 09:45
Introductive and invited Talk: Liudmila Kozlova, INRAE, Nantes: ***"Textiles, wood, papyrus: what features of plant fibers dictate their usability?"***

09:45 - 10:30
Invited Talk: Hana Lukesova, University Museum of Bergen: ***"Unraveling Textile Heritage: Interdisciplinary Approaches to Fibre Species Identification"***

10:30 – 11:00: COFFEE BREAK

11:00 – 11:25
Emeline Retournard, Université Clermont Auvergne : ***"New light on fibres. The use of the reflection optical microscope to determine archaeological textile fibres"***

SESSION 2: Focus on collaborative research projects
(11:25 – 12:25) – Chair J. Müssig

11:25 - 11:45
Anita Quiles, CEA, Laboratoire des Sciences du Climat et de l'Environnement:***"MERYT : linen textiles as chronological markers for modelling a chronology of Ancient Egypt"***

11:45 - 12:05
Emmanuelle Delqué-Kolic, CEA, Laboratoire des Sciences du Climat et de l'Environnement: ***"ISOPALIN : A multi-isotopic approach to reconstructing the growth media of flax fibres used in Ancient Egypt"***

12:05 - 12 :25
Alain Bourmaud, Université Bretagne Sud: **"ANUBIS :** ***Understanding the durability of flax fibres through the study of ancient Egyptian yarns"***

12:30 – 14:00: LUNCH

SESSION 3: Plant fibres in human societies I
(14:00 – 15:35) - Chair A. Quiles

14:00 - 14:45
Invited Talk: Sabine Karg, Institut für Prähistorische Archäologie, Berlin: ***"Flax as a Multipurpose Resource in European and Egyptian Prehistory"***

14:45 - 15:10
Carlo Santulli, University of Camerino:***"Hemp fabric of pictures' canvases from art gallery in Ascoli Piceno, Italy"***

15:10 - 15:35
Jörg Müssig, University of Bremen: ***"Fibre forensics: Unravelling History's textiles with DNA"***

15:35 – 16:00: COFFEE BREAK

SESSION 4: Mechanical and structural properties of ancient plant fibre materials
(16:00 – 17:15) – Chair D. Shah

16:00 – 16:25 - Camille Goudenhooft, ENSTA Bretagne: ***"Mechanical and biochemical features of archaeological plant fibres"***

16:25 – 16:50 - Sofiane Guessasma, INRAE, Nantes: ***"Advanced numerical models for the understanding of mechanical behaviour of ancient plant fibres and yarns"***

16:50 – 17 :15
Sanaa Galballah, Institut Français d'Archéologie Orientale, Le Caire**:** ***"Development of flax fibre characterization at IFAO"***

17:15 – 18:00
Tour of IRDL laboratory / Short demos of fibre characterization

Friday 31 October

SESSION 5: Advanced techniques for plant fibre characterization
(08:30– 10:00) – Chair H. Lukesova

08:30 - 09:15 - Invited Talk: Loïc Bertrand, ENS Paris-Saclay: ***"Intriguing directions to studying mineralised textiles"***

09:15 – 09:40
Alessia Melelli, Synchrotron Soleil**:** ***"Use of Synchrotron tools for ancient plant fibres characterization"***

09:40 – 10:05
Camille Berruyer, NOVITOM, Grenoble: ***"The use of microtomography in Archaeology: applications on ancient textile"***

10:05 - 10:30: COFFEE BREAK

SESSION 6: Plant fibres in human societies II
(10:30 – 11:35) - Chair S. Karg

10:30 – 11:15 - Invited Talk: Camila Alday, University of Cambridge: ***"Archaeobotany of textile plants: Cases from South America"***

11:15 – 11:40 – Lucile Beck, CEA, Laboratoire des Sciences du Climat et de l'Environnement:**"** ***Flax as a tool for dating painting canevas of the XXe century "***

Continuing the conversation: Pathways for collaboration and shared research
(11:35 - 12:30) – D.Shah & A. Bourmaud

11:40 - 11:50 - Introduction: ***Brief recap of the conference, identify shared research directions and explain the breakout format and expected outcomes***

11:50 - 12:15 - Breakout Group Discussions

12:15 - 12:30 - Wrap-Up & Closing Remarks

12 :30 - 14:00: LUNCH

14:00 - 18:00: SOCIAL ACTIVITY

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Cambridge
UK

Abstracts

SESSION 1: PLANT FIBRE STRUCTURE AND IDENTIFICATION

TEXTILES, WOOD, PAPYRUS: WHAT FEATURES OF PLANT FIBERS DICTATE THEIR USABILITY?

Liudmila Kozlova[1, 2, 3,*]

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ABSTRACT

Plant fibers are one of the oldest and most versatile renewable materials, and their structural diversity largely determines their applications. This presentation will compare different types of plant fibers, referencing their anatomical origin, cell morphology, and cell wall properties to highlight the biological basis of their technological uses.

Extracted from the phloem of crops such as flax and hemp, bast fibers are characterized by their extreme length, which is achieved through intrusive growth, and their thick tertiary cell walls, the architecture of which is optimized for tensile strength. These properties explain their historical and current use in textiles and high-performance composites. Wood fibers, found in the xylem of trees, are shorter cells, though they are also capable of intrusive growth. Their thick, lignified secondary cell walls provide compressive strength, making wood an essential structural material in construction. Papyrus illustrates monocot fibers, which are not actually fibers from a botanical perspective. This example contrasts the developmental strategies of monocots and dicots in producing reinforcing elements and illustrates how plant anatomy, cellular morphology, and cell wall biochemistry define the possible applications of plant material. If time permits, I will also briefly discuss the processing steps that modify raw biomass to produce fibers suitable for industrial use.

KEYWORDS

Plant fiber, plant cell wall, polysaccharide, intrusive growth

PLANT FIBER, PLANT CELL WALL, POLYSACCHARIDE, INTRUSIVE GROWTH

Hana Lukesova[1,*]

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ABSTRACT

Research on cultural heritage objects is an expertise demanding an interdisciplinary approach. Even though specialists from disciplines such as Art History, Cultural History, and Archaeology still have the key responsibility of dating and interpreting heritage objects, they need experts from conservation and natural sciences to enhance the development of the fields. Conversely, applying advanced analytical methods such as radiocarbon dating requires a thorough knowledge of the material to be analysed to avoid misleading interpretations, for instance, due to alterations and/or former conservation treatments of heritage objects. Sampling and sample preparation of cultural heritage is critical since it can directly influence a result or even lead to damage. The ethical dimension of sampling is an undeniable part of the decision-making process when planning the material identification of a cultural heritage object.

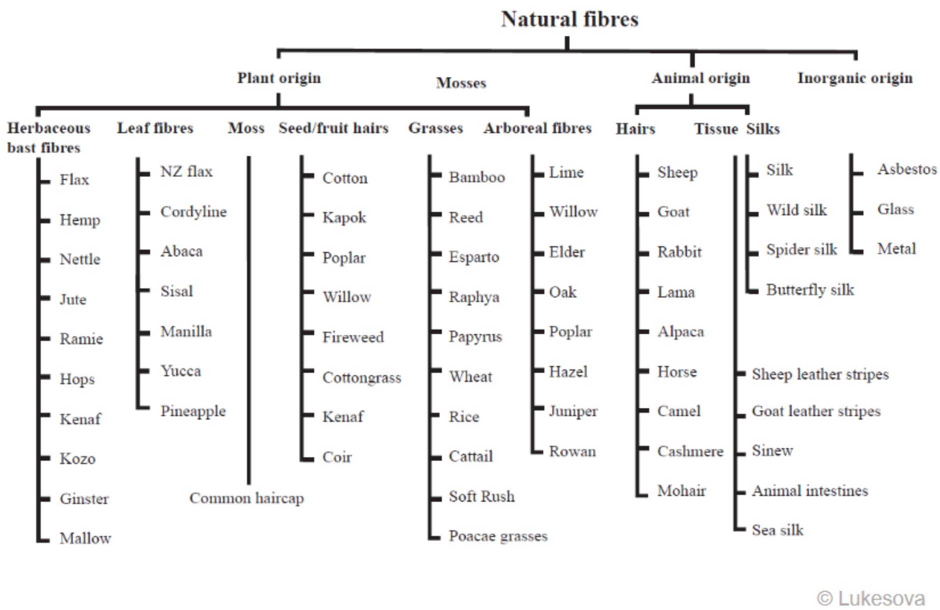

Figure 1. Overview of soft materials in textiles

The possibilities and limits of light- and electron microscopy for fibre identification will be explained. The aim is to focus on different interpretations of characteristic- and distinguishing features by different fibre species and discuss the consequences of discrepancies when working with fibre identification data. Recent research has seen increased interest in clothing, textiles, and related organic materials, prompting the integration of digital tools, media technologies into heritage studies. These innovations are transforming traditional methodologies and enabling more precise, non-invasive analysis. The consolidation of art technological research, archaeometry, and conservation science within the broader field of heritage science has led to significant progress. As technological advancements continue, interdisciplinary collaboration remains key to safeguarding and understanding the rich legacy of organic materials in cultural heritage.

KEYWORDS

Fibre Identification, Light Microscopy, Electron Microscopy, Characteristic and Distinguishing Features

REFERENCES

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Marková, I. (2019). *Textile fiber microscopy: a practical approach (1st edition. ed.)*. Wiley

NEW LIGHT ON FIBRES. THE USE OF THE REFLECTION OPTICAL MICROSCOPE TO DETERMINE ARCHAEOLOGICAL TEXTILE FIBRES

Émeline Retournard[1,*]

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ABSTRACT

Microscopy is a scientific way of determining the nature of textile fibres (Markova 2019, p. xiii). Most of the time, fibres in archaeological textiles are identified using a light microscope and/or SEM (Rast-Eicher 2016, p. 11).

As part of several textile studies with the French National Institute for Research in Preventive Archaeology (INRAP), we wanted to know whether the use of an optical reflection microscope would make it possible to identify the nature of the fibres in textiles that could not be sampled for observation using a transmission optical microscope or SEM, because of their fragility or small size. The advantage of the optical reflection microscope is that it is a non-invasive tool: the fibres do not need to be sampled and treated to be analysed. Depending on the material available, two types of preservation were observed with this microscope: slightly mineralised and highly mineralised fibres. The fibres studied were those from textiles discovered in burials from the modern era in a cemetery at Aulnat (Puy-de-Dôme) and at Beaumont Abbey in Tours (Indre-et-Loire), and strings found in a Bronze Age monetary deposit from the Amboise oppidum (Indre-et-Loire).

The results obtained using this type of microscope on these three textile collections are promising. Indeed, it was possible to determine the presence of several fibre types, including bast fibres (Figure 1). The purpose of this poster is to present the results, conclusions and limits of this method, which will be continued on other textile collections and various types of conservation.

KEYWORDS

Archaeology, Archaeometry, Reflection optical microscope, Textiles, Bast fibres

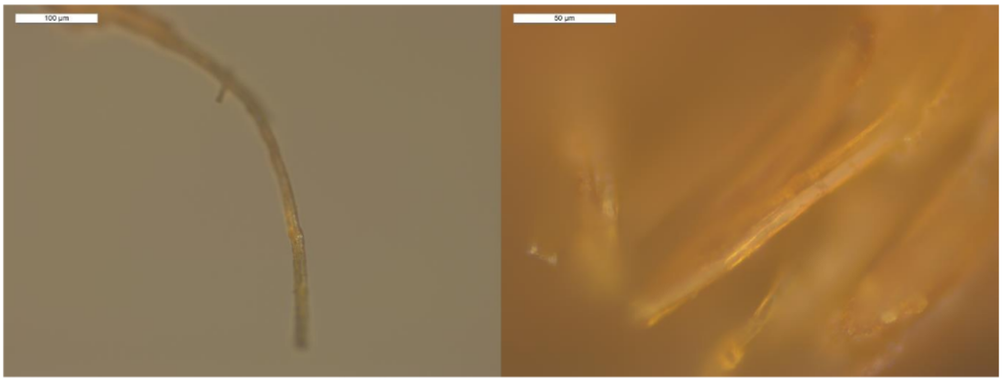

Figure 1. Details of bast fibres under a reflection optical microscope (Amboise oppidum, Iso 45634 and 45636). Photos: É. Retournard

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Markova I. *Textile fiber microscopy. A practical approach.* Hoboken, Wiley, 2019, 212 p.
Rast-Eicher A. Fibres. *Microscopy of archaeological textiles and furs*, Budapest, Archaeolingua, 2016, 359 p.

SESSION 2: FOCUS ON COLLABORATIVE RESEARCH PROJECTS

MERYT: LINEN TEXTILES AS CHRONOLOGICAL MARKERS FOR MODELLING A CHRONOLOGY OF ANCIENT EGYPT

Anita Quiles [1, 2, 3,*], N. Mounir [2], S. Gaballah [2], M. Abd-elfattah [2], M. Gamil [2], E. Mahmoud [2], L. Beck [1], L. Bellot-Gurlet [4], I. Caffy [1], E. Delque-Kolic [1], J-P. Dumoulin [1], M. Ferrant [2, 4], M. Perron[1].

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ABSTRACT

The MERYT project aims to establish an accurate, high-resolution, multi-technique chronological model of the Egyptian Old Kingdom (~2900-2200 BCE), reigns by reigns, by building a statistical model based on Bayesian inferences, that reconciles Egyptological and analytical data.

Using an archaeometrical approach, series of more than 100 radiocarbon dates have been carried out at the Ifao laboratory on samples collected directly from several ongoing archaeological excavations in Egypt, the discovery contexts of which were clearly associated with a particular historical reign (from the 1st to the end of the 6th dynasty). Textiles, among other archaeomaterials, are frequently excavated in different contexts, from funerary to everyday life. They are therefore accurate chronological markers, as long as a close correlation can be established between the death of the linen plant and the historical event to be dated. Moreover, in the funerary context, they can be "contaminated" by materials used in the embalming ritual, such as resin or bitumen, which can distort radiocarbon analyses if not properly removed.

This presentation will focus on analytical developments based on cross- and integrative analysis protocols carried out as part of the ANR Meryt and Anubis projects, in order to ensure radiocarbon dating results from a chemical point of view, but above all in their interpretation from a historical and archaeological point of view. First results of the Meryt model will be presented and supplemented by open perspectives, bringing new insights on the start of the Egyptian state.

AKNOWLEDGEMENTS

This work has been supported by the ANR-19-CE27-0010 Meryt, the ANR-21-CE43-0010 ANUBIS and the Institut français d'archéologie orientale.

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Ferrant M., Bellot-Gurlet L., Delqué-Količ E., Quiles A., "A versatile integrated protocol to extract organic balms from archaeological linen: A new way to provide reliable radiocarbon dating for contaminated textile", Journal of Archaeological Science, Volume 177,2025. https://doi.org/10.1016/j.jas.2025.106203.

iSOPALIN: A MULTI-ISOTOPIC APPROACH TO RECONSTRUCTING THE GROWTH MEDIA OF FLAX FIBRES USED IN ANCIENT EGYPT

E. Delqué-Količ[1, *], A. Quiles[1,4], M. Ferrant[2], P. Jame[2], J.-P. Dumoulin[1], E. Pons-Branchu[1], C. Jose[2], C. Oberlin[3], I. Caffy[1], S. Gaballah[4], N. Mounir[4],

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ABSTRACT

Flax fiber is a natural material that has been used for thousands of years in Egypt. It is frequently unearthed during archaeological excavations in funerary and residential contexts, where the arid climate has allowed it to be well preserved. Its many uses in ancient Egyptian society make it a particularly relevant source for reconstructing the history of ancient techniques and practices, but also as a marker of past environments and climates. Launched in 2024, the iSOPALIN project (ANR-23-CE29-0014-01) aims to use a multi-isotopic approach of flax fibers ($\delta^{13}C$, $\delta^{2}H$, $\delta^{18}O$, $^{87}Sr/^{86}Sr$), to investigate this ancient material in order to reconstruct paleo-environmental data that will enable the identification of the areas of origin of the raw material used in archaeological textiles, and thus provide a better understanding of ancient practices.

Building on the results obtained in recent projects investigating flax fiber from a morphological and structural perspective (ANUBIS, ANR-21-CE43-0010) and as a chronological marker (MERYT, ANR-19-CE27-0010), the iSOPALIN project approaches this natural material using the most innovative tools of isotopic geochemistry that have been developed in recent years in archaeometry. The project is structured around three main areas 1/ the development and installation at the IFAO's archaeometry center of an instrument for measuring carbon 13, 2/ the analysis of light isotopes (($\delta^{13}C$, $\delta^{2}H$, $\delta^{18}O$) in cellulose extracted from modern and archaeological linen, and 3/ isotopic measurements of strontium in fibers and associated soils.

We will outline the objectives of the project, detailing the means used and report on the initial achievements.

KEYWORDS

Linen, Ancient Egypt, Isotopic geochemistry

ANUBIS PROJECT: THE (SECRET) STORY

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ABSTRACT

ANUBIS brings together four academic partners: the University of South Brittany, INRAE, the SOLEIL Synchrotron, and the French Institute of Oriental Archaeology in Cairo (IFAO). Its objectives are ambitious, as flax is currently used in an increasing range of industrial applications — from textiles to composite material reinforcements, such as in automotive components or in the sports and leisure sectors.

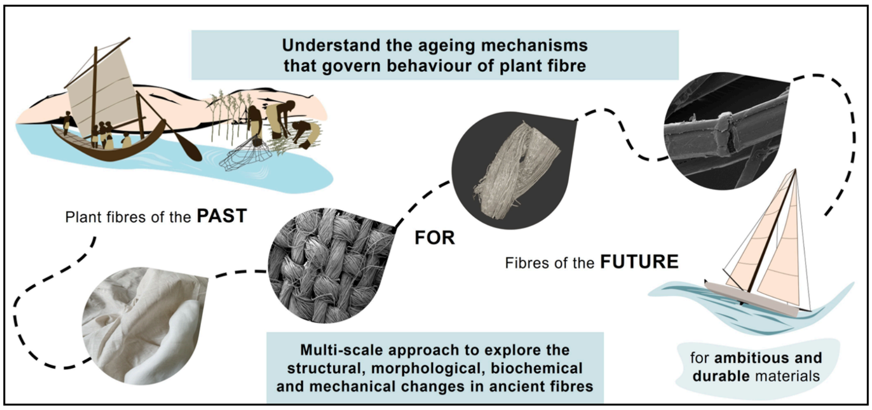

Figure 1. The spirit of Anubis project: to use ancient fibres ultrastructure and properties to help in designing tomorrow's plant fibre composite materials (original figure by Loren Morgillo).

This presentation invites the audience on a journey from the project's origins to its main scientific outcomes. Beyond its results, ANUBIS has brought together two, or even three, research communities that were initially far from one another, fostering dialogue, mutual understanding, and collaboration toward a common goal: to better understand, accumulate knowledge and characterize archaeological flax fibres, and consequently, modern ones.

Scientific protocols — some of them entirely novel — have been developed and are now being applied in other projects and to other types of fibres. The project has also sparked new, rich, and stimulating collaborations, and the story is clearly not over yet.

KEYWORDS: Flax fibres; Archeological artefacts; Mechanical properties; Ultrastructure; Ageing

REFERENCES

Morgillo, Melelli, Goudenhooft, Shah, Quiles, Beaugrand, Bourmaud et al. Inside the kink-bands of archaeological flax artefacts via sub-micrometer resolution micro-CT: A comprehensive microstructural analysis to better understand degradation mechanisms of fibres. Composites Part B, 298, 2025

SESSION 3: PLANT FIBRES IN HUMAN SOCIETIES I

FLAX AS A MULTIPURPOSE RESOURCE IN EUROPEAN AND EGYPTIAN PREHISTORY

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ABSTRACT

Textile plants such as flax and hemp are usually identified at archaeological sites through seed analysis. The conditions necessary for preserving textiles are rarely met, and even when they are, textile fibres are not always identified as specialists in this field are scarce. The cultural history of flax (*Linum usitatissimum*), the first cultivated textile plant in Europe, is well documented by seed finds. Flax has been an important crop for 8,000 years, used for both oil and fibre. In my lecture, I will present our current thinking on how to distinguish between oil and fibre flax in the archaeological record. However, little is known about when and where fibre flax was first selected. I will also provide a brief overview of the history of flax domestication and present notable prehistoric textile tools discovered in Europe which were most likely used for processing fibre flax.

Little is known about ancient Egyptian flax cultivation practices. Nevertheless, new research on ancient flax seeds and capsules found at ten archaeological sites in Egypt and stored at the Botanical Museum of the Free University of Berlin sheds light on the use of oil and fibre flax.

Thanks to the numerous depictions found in tombs, we can reconstruct the labour-intensive process of converting flax into linen in ancient Egypt. This includes everything from harvesting the plant stems to weaving the fabric. Some interesting techniques can be identified in this process. Written sources also provide information about the quality of linen fabrics, who wore linen clothing in ancient times, and the occasions on which it was worn.

KEYWORDS

Flax, *Linum usitatissimum*, Cultural History, Archaeobotany, Europe, Egypt

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HEMP FABRIC OF PICTURES'CANVASES FROM ART GALLERY IN ASCOLI PICENO, ITALY

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ABSTRACT

Samples from canvases of pictures of XVII-XVIII century removed from the Art gallery in Ascoli Piceno have been extracted and analyzed, concentrating on those manufactured using hemp fibers. These have been recognized by their geometrical characteristics and also by comparing with more modern samples of the same fiber, despite the fact that the original samples did not present any contemporary chemical treatment. The type of fabric and warp-weft regularity has been analyzed and correlated to the Italian tradition of the time, and the degree of damage and contamination has been evaluated, also investigating microscopically the mode of fracture of the fibers and their geometrical variability. This would offer suggestions on their preservation, and on whether the canvas would still fulfill its service over time. This is a part of a larger study on assessing the characteristics of canvases and historical fabrics in the context of the Marche region.

SESSION 4: MECHANICAL AND STRUCTURAL PROPERTIES OF ANCIENT PLANT FIBRE MATERIALS

MOLECULAR IDENTIFICATION OF PLANT BAST FIBRES – AN ADDITION TO FIBRE MICROSCOPY

Jörg Müssig[1,*], Lothar Kruse[2,].**

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ABSTRACT

Natural fibres are increasingly used as lightweight composites in the automotive industry, as sustainable insulation materials in the construction sector, and as high-quality raw materials in the textile trade. At the same time, there is growing interest in the analysis of historical textiles, whose fibre composition provides valuable insights into trade routes, processing techniques and cultural history. However, identifying the plant species is difficult, especially when the fibres are mixed or heavily processed. Conventional fibre microscopy has long been the established method, yielding valuable results; however, it is time-consuming, costly, and reaches its limits with certain fibre types.

The approach presented here relies on molecular tracing within the fibres. By developing specific PCR systems, the most commercially relevant bast fibres – such as hemp and flax, ramie and nettle, or jute and kenaf – can be distinguished from one another at the DNA level. Of particular significance is the reliable differentiation of hemp and flax, which frequently occur together in both modern and historical contexts. A critical factor is a reproducible DNA extraction method (CTAB–chloroform–isopropanol) that yields PCR-compatible material even from dyed, bleached or mechanically treated samples. In the case of heavily chemically treated fibres, problems arose with the identification of ramie and nettle fibres.

The results demonstrate that molecular methods are a valuable addition to light and scanning electron microscopy. Each technique has its strengths and weaknesses, combining them allows for faster, more precise and more scalable identification of natural fibres. This not only opens new perspectives for quality control, consumer protection, and regulatory compliance in the textile trade, but also for archaeological and cultural-historical research on historical textiles.

KEYWORDS

Bast fibres; PCR-based identification; Fibre microscopy; Historic textiles

REFERENCES

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MECHANICAL FEATURE OF ARCHAEOLOGICAL PLANT FIBRES

Camille Goudenhooft[1,2,*] ,S. Durand[3], A. Melelli[4], C. Caër[2], A. Magueresse[1], O. Arnould[5], E. Balnois[6], A. Quilès[7,8], D. U. Shah[9], J. Beaugrand[3] and A. Bourmaud[1].

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ABSTRACT

Flax (Linum usitatissimum L.) has long been valued for its fibres, traditionally used in textiles, fishing nets as well as mummy wrappings [1], and more recently as reinforcements in composite materials [2]. Investigating ancient flax fibres from Egyptian archaeological textiles offers key insights into their long-term durability, relevant for current material developments. This study combines nanoindentation (NI) and atomic force microscopy (AFM) to assess the ultrastructure and local mechanical properties of ancient flax fibres (figure 1).

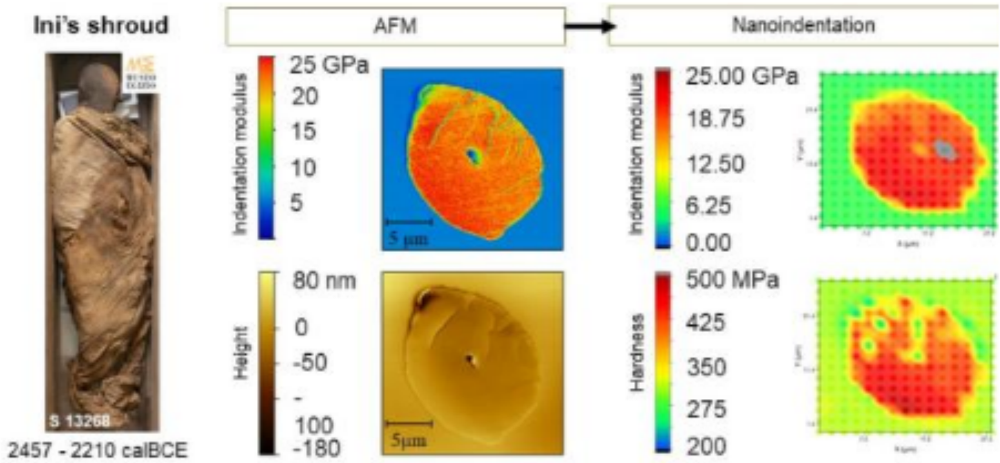

Figure 1. Overview of the experimental approach, adapted from [3].

NI provides rapid evaluation of indentation modulus and hardness across multiple fibres, revealing intra-sample homogeneities and heterogeneities. AFM enables higher-resolution imaging of ultrastructural details such as porosities, cracks, lumen dimensions, or thin surface coatings observed in specific samples. Together, these methods allow thorough analysis of fibres available only in small quantities and sometimes highly degraded [3]. The results highlight that certain fibres exhibit mechanical properties comparable to modern flax despite being several millennia old, emphasizing the durability of this material. Beyond archaeology, this methodology provides a valuable framework for both heritage science and materials research, offering tools to explore ancient materials and to better understand fine-scale characteristics of innovative bio-based composites.

KEYWORDS

Plant cell wall; Ageing; Ultrastructure; AFM; Nanoindentation.

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ADVANCED NUMERICAL MODELS FOR THE UNDERSTANDING OF MECHANICAL BEHAVIOUR OF ANCIENT PLANT FIBRES AND YARNS

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ABSTRACT

Flax fibres have served human civilizations for thousands of years, and their relevance is being renewed today amid growing concerns about global warming and pollution from non-biodegradable materials. These natural, biodegradable fibres are increasingly explored as reinforcements in sustainable bio-composites. Understanding the durability of flax fibres is currently the focus of extensive research. Advanced numerical modelling provides an essential framework for analysing the complex mechanical behaviour of ancient plant fibres and yarns, where degradation, anisotropy, and heterogeneity play dominant roles. Finite Element Models (FEM), coupled with image-based geometries obtained from X-ray microtomography and SEM, enable the reconstruction of realistic fibre morphologies, including lumen shape, kink-bands, and micro-porosity. By simulating the effects of microstructural features such as porosity, kink-bands, and surface roughness, modelling helps reveal the underlying mechanisms that govern stress distribution, crack initiation, and failure evolution over time. For instance, finite element simulations quantify how surface roughness, porosity, and kink-bands act as critical sites for stress concentration, promoting crack initiation and fibre rupture.

Future developments in numerical modelling should be directed towards nonlinear constitutive laws to capture microstructural degradation to macroscopic mechanical performance. At higher structural levels, improved multi-fibre and yarn models need to integrate advanced contact–friction formulations and interface damage criteria to better describe load transfer, slippage, and progressive failure mechanisms. Coupling these models with in situ experimental data from X-ray microtomography during mechanical testing will allow for more accurate calibration and validation. Ultimately, these next-generation modelling approaches will not only provide predictive insight into the long-term behaviour of archaeological fibres but also guide the design of sustainable, high-performance bio-composites inspired by natural and historical fibre architectures.

KEYWORDS

Ancient flax fibres, Egypt, finite element computation, X-ray micro-tomography, Synchrotron radiation, kink bands

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CHARACTERIZATION OF FLAX FIBRES CULTIVATED IN EGYPT

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ABSTRACT

Flax (*Linum usitatissimum*) is among the oldest cultivated fiber crops, with a legacy in Egypt dating back more than five millennia. This study aims to characterize the physical, chemical, and structural evolution of Egyptian flax fibers throughout their growth stages, providing modern reference data that can also support archaeometric comparisons with ancient textiles.

Within the framework of the ANUBIS ANR Project, two flax varieties, **Eden** and **Malika**, were cultivated in **Zefta (Nile Delta)** to be sampled at successive growth stages from sowing to fiber extraction. A multi-technique analytical approach was developed, combining **polarizing microscopy**, **scanning electron microscopy (SEM)**, **energy-dispersive X-ray spectroscopy (EDX)**, **Fourier-transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR)**, and **X-ray diffraction (XRD)**. Physical measurements confirmed progressive fiber thickening and elongation during maturation. Polarizing microscopy revealed birefringence color changes correlating with increased fiber thickness, while SEM demonstrated morphological compaction and wall organization. EDX analysis showed high carbon (≈55%) and oxygen (≈34%) contents, typical of cellulose, with stable elemental composition across stages. FTIR spectra identified characteristic cellulose and lignin functional groups, and XRD patterns revealed the presence of **cellulose Iα and Iβ** crystalline forms, together with minor potassium and carbon phases.

The integrated results highlight the **gradual enhancement of fiber crystallinity and structural order** during growth, without major compositional changes. This comprehensive characterization contributes to understanding the microstructural development of modern Egyptian flax and forms a scientific basis for future comparisons with archaeological linen materials.

KEYWORDS

flax fibers, Egypt, SEM, FTIR-ATR, XRD, EDX, cellulose, archaeometry

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SESSION 5: ADVANCED TECHNIQUES FOR PLANT FIBRE CHARACTERIZATION

INTRIGUING DIRECTIONS TO STUDYING MINERALISED TEXTILES

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ABSTRACT

Mineralised textiles—organic textile remnants preserved through the diffusion of metallic cations from nearby artefacts or environmental sources—have become crucial evidence for understanding textile production, use, and economy in past societies particularly in Prehistoric and Protohistoric periods. Often representing the sole surviving evidence of textile traditions known only through associated tools or of entirely unknown productions, these materials offer unique insights into past technological developments and trade networks. We will discuss several recent analytical advances that have deepened our understanding of these objects, revealing detailed information about ancient textile production, usage and preservation mechanisms while also raising questions about their archaeological significance and the potential for recovering data on heavily altered fragmentary material.

USE OF SYNCHROTRON TOOLS FOR ANCIENT PLANT FIBRES CHARACTERIZATION

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ABSTRACT

The study and preservation of archaeological textiles have always been challenging due to their organic nature and limited preservation compared to materials like glass, ceramics, or stone. Only recently textiles, cordages and yarns have gained attention and are being studied more in-depth. It has been demonstrated that characterisation techniques using synchrotron radiation, widely applied to inorganic materials, are also suitable for investigating plant-based fabrics and yarns.

Notably, combining deep ultraviolet (DUV) fluorescence imaging with high-resolution synchrotron X-ray micro-computed tomography (micro-CT) in phase contrast has offered new insights into flax fibre deterioration. DUV imaging detects and maps autofluorescent molecules such as lignin and proteins in the fibres cell walls, revealing changes in their distribution and intensity, which are correlated with environmental degradation conditions and the use of the object (Melelli et al. 2024). Since these chemical alterations impact fibre integrity, synchrotron micro-CT complements the analysis by visualizing internal microstructural features, such as kink-bands and porosities linked to the state of preservation (Morgillo et al. 2025). Additional techniques like second harmonic generation microscopy (SHG) and two-photon excitation fluorescence (TPEF) can provide complementary data on cellulose ultrastructure (Melelli et al. 2024). In this study, the techniques will be presented and also their application to the study of several flax fibres objects from le Louvre museum and the Egyptian museum of Turin.

Together, these synchrotron techniques provide a multi-scale approach to understand fibre degradation, linking structural damage with chemical evolution and help to develop new strategies for historic flax-based artefacts.

KEYWORDS

Synchrotron radiation, textiles, degradation, autofluorescence, microtomography

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THE USE OF MICROTOMOGRAPHY IN ARCHAEOLOGY/ APPLICATION ON ANCIENT TEXTILES

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ABSTRACT

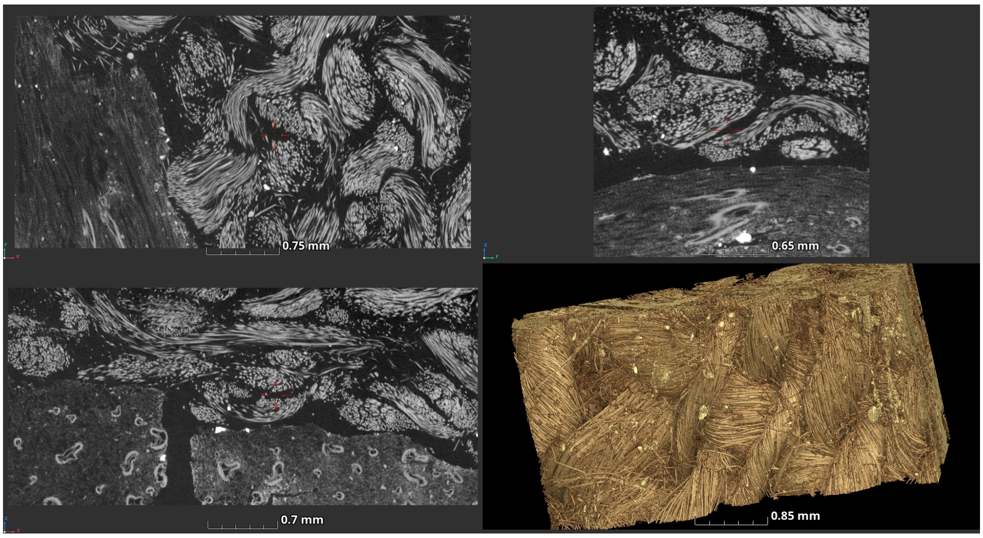
Microtomography (µCT) is a non-invasive imaging technique that allows the visualization of internal structures of objects. The 2D radiography obtained are then reconstructed to produce a 3D volume, from which detailed cross-section images, known as virtual slices, can be extracted. When applied to ancient archaeological remains, this technique offers insights into both manufacturing processes and degradation mechanisms.

This is particularly useful when studying ancient textiles and fibres. In this talk, we will present case studies focusing on the study of archaeological textiles from ancient Egyptian cult and European Iron Age burials where µCT was used to gain a better understanding of these ancient textiles and their manufacturing processes, thereby advancing research.

KEYWORDS

X-ray tomography – ancient textiles – 3D imaging – Archaeology

Figure 1. Microtomographical 3D rendering detail of ancient Egyptian textile of a crocodile mummy.



SESSION 6: PLANT FIBRES IN HUMAN SOCIETIES II

ARCHAEOBOTANY OF TEXTILE PLANTS: CASES FROM SOUTH AMERICA

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ABSTRACT

Textile plants have been used for thousands of years by humans (Hardy, 2007; Hardy et al., 2020; Kvavadze et al., 2009, Nadel et al., 1994). Many species have been gathered and cultivated for this purpose, providing critical sources to various aspects of past lifestyles as it has been noticed in different geographies and at different times in Antiquity (Barber,1992; Gleba and Harris, 2019; Rast-Eicher et al., 2021).

In South America Pre-Columbian groups developed specific expertise in textile production using plant materials such as cotton (*G. barbadense*) which is well known for its superior fibre strength, length and fineness, wetland plants such as cattail (cf. *Typha*) and sedges (*Scirpus* sp., cf. *Schoenoplectus americanus*), bast fibres from milkweed (*Asclepias* sp.), and leaf fibres from the *Agaveceae* family (cf. *A. americana*, cf. *F. andina,* and cf. *F. occidentalis*), and *Tillandsias* for crafting fishing artefacts and fabrics. These materials would be suggesting an ecological diversity of native plants used in the dawn of textile traditions in Ancient South America.

In this talk, I offer a comparative analysis of plant identification from archaeological materials and reference collection aiming to further discuss the relevance of plant materials in the exercise of textile tradition in South America and equally reflecting on the impact of plant resources in the development of technological systems when used as fibre.

KEYWORDS

Fibre technologies, Archaeobotany; South America, Pre-columbian; Microscopy

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FLAX AS A TOOL FOR DATING PAINTING CANEVAS OF THE 20th CENTURY

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ABSTRACT

Flax plays an important role in art, especially for painters. Flax seeds are ground into linseed oil, which is used as binder for oil paints, and fibers are used to make linen canvas as a support for paintings. Linen is preferred to other fabrics for its strength, dimensional stability and durability, making it considered the best quality support.

Because of the rapid growth of flax, linen canvas fiber and linseed oil are considered as good candidates for the radiocarbon dating of paintings (Caforio et al. 2014. Hendriks et al. 2018; Beck et al. 2022). However, the time necessary to transform flax into a linen canvas must be estimated in order to determine the completion date of paintings (Brock et al. in 2019)

Based on the paintings of the French painter Pierre Soulages (1919-2022) (Hélou-de La Grandière et al. 2023, Coustet et al. 2023), who titled his works with the day on which he considered them finished, the time elapsed between completion of the painting and harvesting of the flax was determined for 25 canvases and 13 oil binders by using ^{14}C dating. Using the post-bomb atmospheric calibration curve, the results show a time lag of 2 and 7 years up to 1968, and more than 10 years from 1971 to 1986 (Beck et al. 2024).

The method of producing linen fibres and canvases, the market for art materials and the Soulages's own practice will be discussed in order to clarify the time frame and the duration of the various stages.

KEYWORDS

Linen, canvas, oil, painting, ^{14}C dating

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