SESAME Cultural Heritage Day
16 February 2022

SESAME

# (Bio)archaeological samples: Synchrotron radiation approaches

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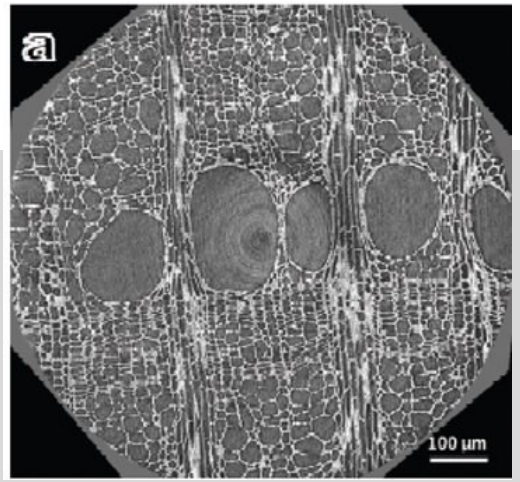
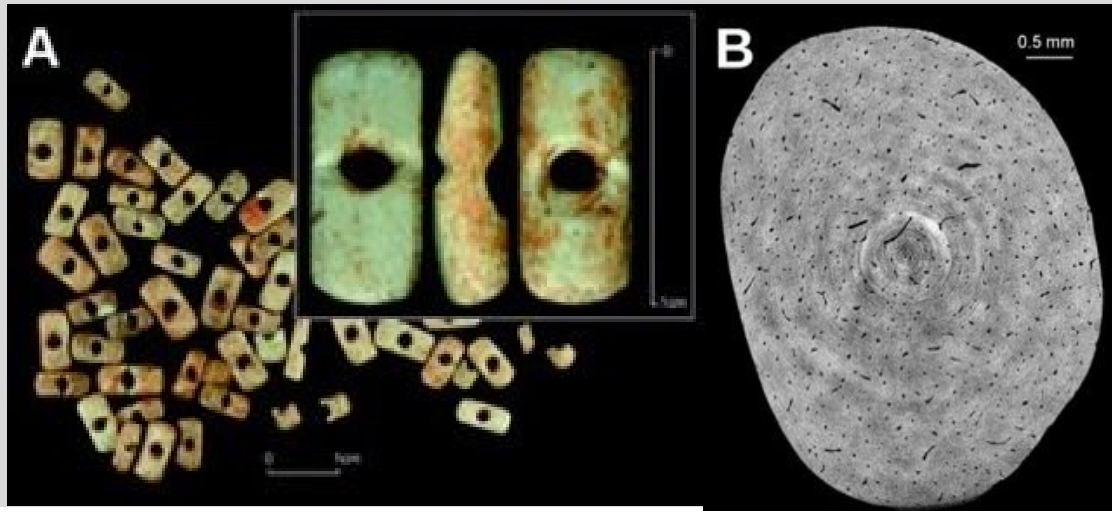
Any biological remains recovered archaeologically, e.g.:

- Animal remains
- Plant remains
- Human remains
- Cloth
- Other organic remains




Wood identification (Hwang *et al.*, 2020)

Human remains, teeth (Lorentz et al., 2020)




Animal bone, antler (Vercoutère et al. 2011)

# Examples of bioarchaeological samples: Cloth and seeds

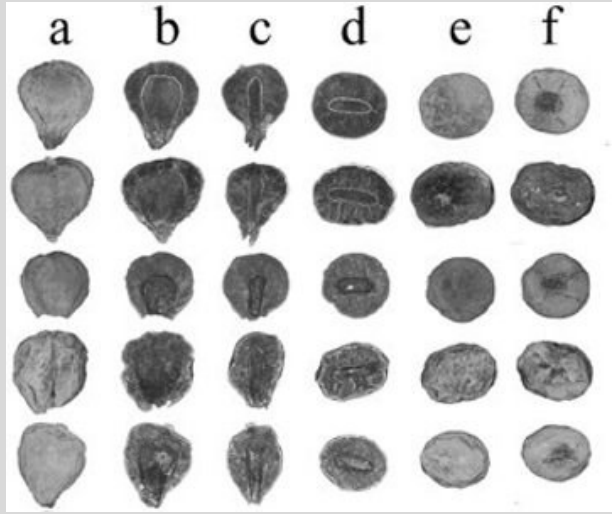
## Mineralized linen fragments (5th-2nd millennium BCE)

Mineralized textile from Italy, 7th century BCE (Gleba 2014)

The microstructures of the textile fibers themselves provide valuable information;

- Identification and interpretations based on the types of fibers (plant components, animal hair)
- Preparation and weaving techniques

## Domestication of beans




Plant remains from a fluvial shellmound (Calo et al., 2019)

- SXCT provided the evidence of seed coat thinning between 2000 BCE and 1200 BCE in southern Indian archaeological horsegram, which is one of the traits in domesticated beans (Murphy and Fuller 2017)

# Synchrotron Facilities


Salloum-Abou-Jaoude, 2014

Cultural Herita

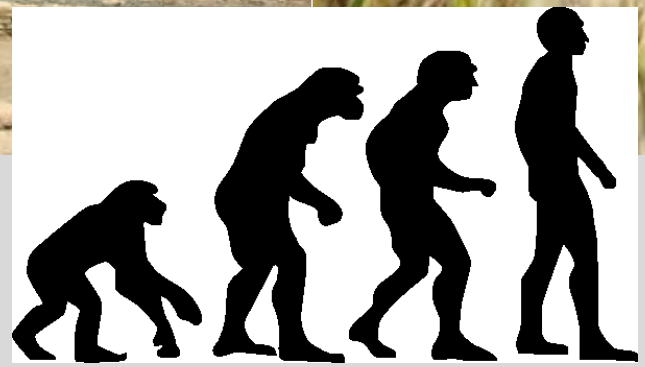

Acknowledgment: The Cyprus Institute

# Cradle of Humanity

THE AFRICAN LIGHTSOURCE

Towards a Lightsource for the African Continent


EMME region



# Focus on applications of Synchrotron Radiation to Human (Bio)archaeology: Case studies

**Examples of human bioarchaeological remains:**

- bones
- teeth
- skin
- hair

**Examples of research foci:**

- palaeopathology
- virtual histology
- age estimation
- state of preservation
- key archaeological questions: e.g. metal exposure

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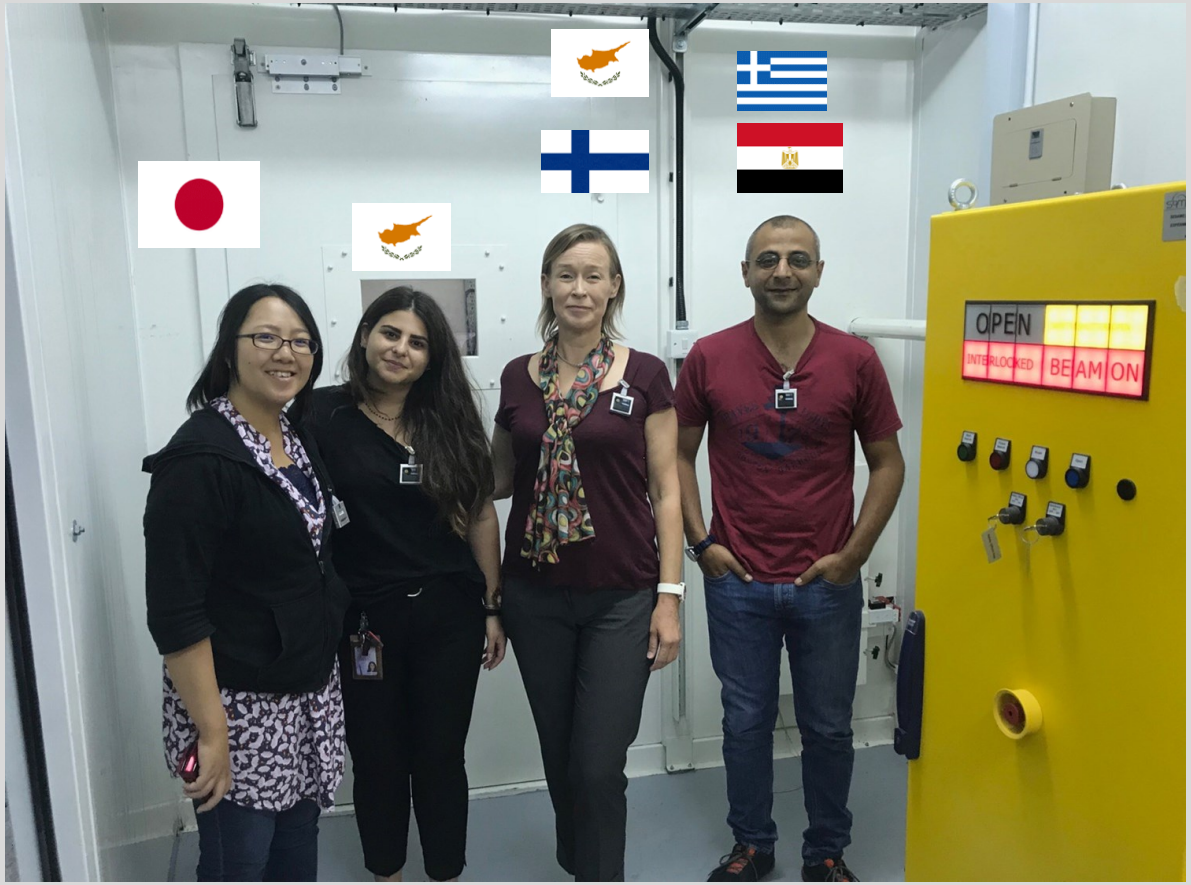
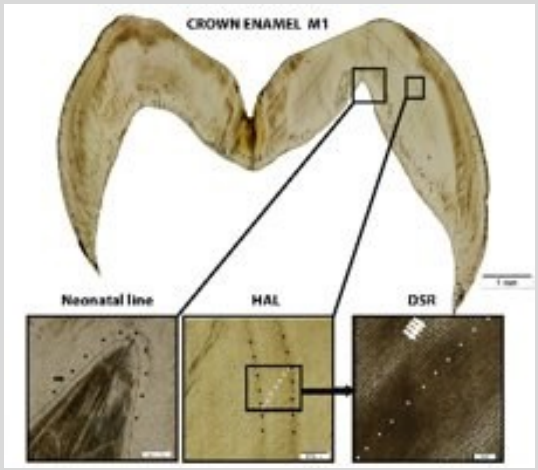
# CASE STUDY: XAFS/XRF, human bone, SESAME

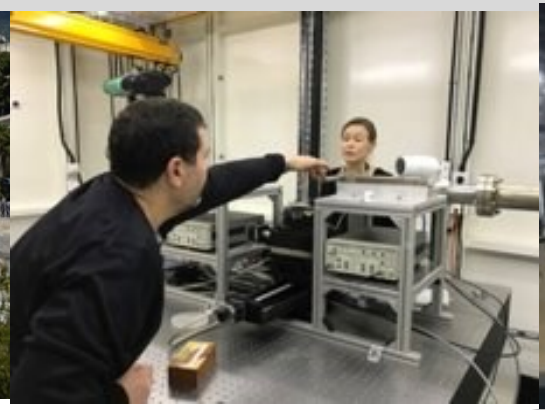
# First official beamtime at SESAME was on ancient human remains from the region




https://www.sesame.org.jo/news/sesame-hosts-its-first-users

# Case study 1: XAFS/XRF, human bone



**Shahr-i Sokhta**
**Iran**
**3rd millennium BCE**
**(c. 5000 years ago)**

**Evidence of metal working**

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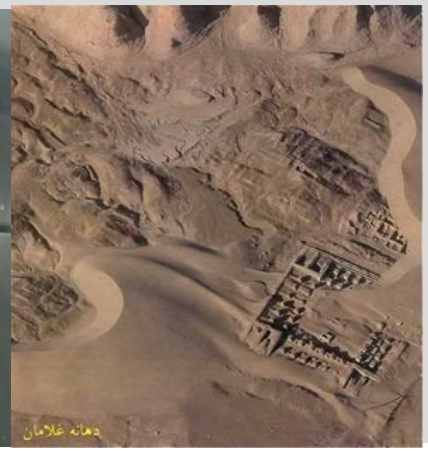
# CASE STUDY:
# μXRF mapping, ancient human hair, ESRF

# Metal element localisation in ancient hair

## Mapping metal element localisation in ancient hair using SR-µXRF: Metals and health at 3rd millennium BCE Shahr-i Sokhta



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Synchrotron radiation micro X-Ray Fluorescence (SR-µXRF) elemental mapping of ancient hair: Metals and health at 3rd millennium BCE Shahr-i Sokhta, Iran

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ARTICLE INFO

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Synchrotron radiation micro X-Ray fluorescence (SR µXRF)
Biogenic uptake
Copper (Cu)
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Health

ABSTRACT

Only a handful of studies using synchrotron radiation enabled approaches to ancient human hair have been undertaken to date, few studies explore metal element distribution within ancient hair, and none Cu in particular. This paper shows how key archaeological questions, such as effects of intensive metal and craft work on human health, can be investigated using synchrotron radiation micro X-Ray Fluorescence (SR-µXRF) in exploring biogenic versus diagenetic/environmental uptake of metals, and copper in particular, in ancient human hair. The ID21 scanning X-ray microscope optimized for 2D µXRF (elemental maps) was used at the ESRF (European Synchrotron Radiation Facility) to obtain detailed elemental maps, including Cu, in ancient hair sections (10 µm) of eight individuals (n = 8), as well as modern hair controls (n = 2). Differentiation in the levels of Cu were discovered between different skeletal individuals from the site of Shahr-i Sokhta, a 3rd millennium BCE large urban site with intensive metalwork and other craft work activities in ancient Iran. In particular, hair of a young female showed elevated levels of Cu, with highest values distributed within the cortex. This distribution of elevated levels of Cu, together with contextual data, points to biogenic, rather than diagenetic/environmental source for the uptake of Cu.

### 1. Introduction

Human health effects of intensive metal and manufacturing work, and legacy soil contamination due to mining and manufacturing are critical issues today, but have likely affected individuals and populations since the invention of manufacturing processes involving high temperatures, or compounds containing potentially toxic metal elements. The production and manufacturing of copper has an extensive history in South West Asia, and the Eastern Mediterranean. While we have written records of the detrimental effects to human health of some ancient mining practices, e.g. from the writings of Xenophon (434–359 BCE) and Lucretius (96–55 BCE) who noted that the smoke of lead mines in Attica was harmful to human health, and of Pliny who noted that 'exhalations from silver mines (i.e. galena mines) are dangerous to all animals' (Waldron, 1973; Weeber, 1990; Makra and Brimblecombe, 2004), we have very little evidence as to human health in relation to e.g. copper mining and manufacturing during the prehistoric periods. We used synchrotron radiation micro X-Ray Fluorescence (SR-µXRF) to explore biogenic versus diagenetic/environmental uptake of metals, and copper in particular, in ancient human hair, deriving from a 3rd millennium BCE site with contextual and artefactual evidence of intensive metal and craft work activities. Only a handful of studies using synchrotron radiation enabled approaches to ancient human hair have been undertaken to date (Bertrand et al., 2003; Kakoulli et al., 2014; Zvereva et al., 2017; a few historical period studies have also been conducted, by Chevallier et al., 2006; Bertrand et al., 2014), few of the studies on ancient hair

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0305-4403/

# Metal element localisation in ancient hair

## Importance

Analyses of metal element levels key to

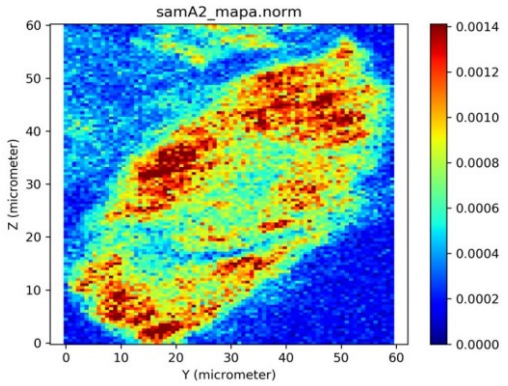
- understanding human health during periods and on sites with intensive metallurgical activity
- exploring potential sources of exposure in the past:
  - legacy soil contamination (inhalation, ingestion)
  - contaminated food and water (ingestion)
  - pigments in crafts, cosmetics etc (absorption/ingestion/inhalation)
- above issues still topical today

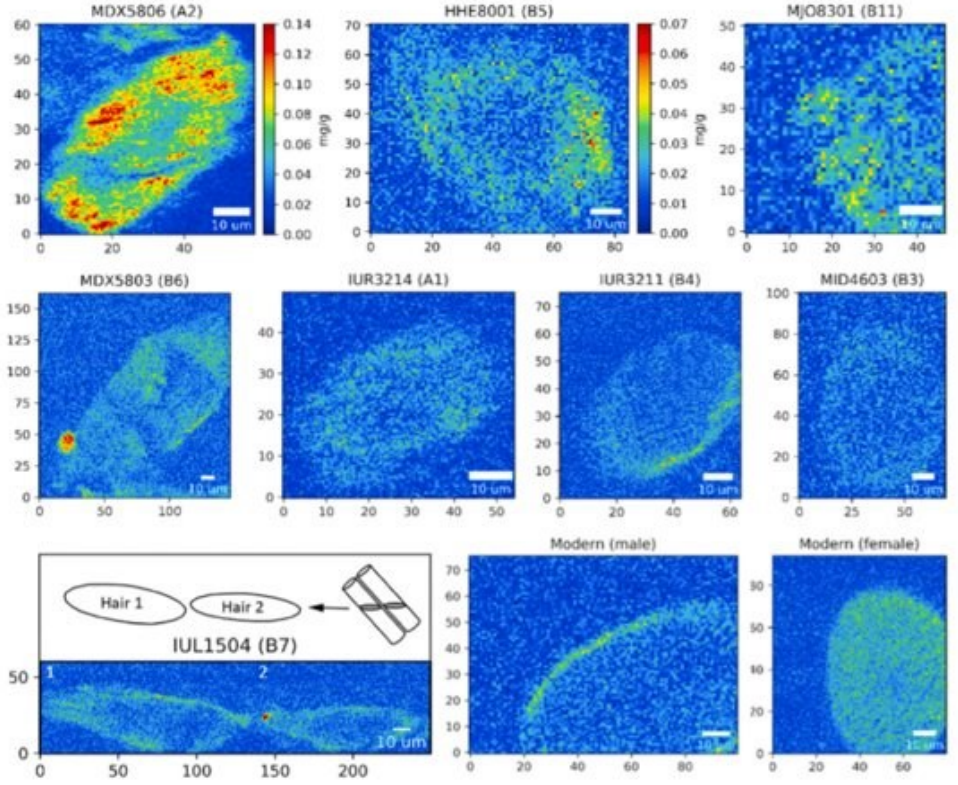
WHO website on lead exposure: https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health

# Metal element localisation on ancient hair

**Approach:**

- 31 SR-μXRF elemental maps obtained
- three to four different hair cross sections for each individual were mapped in order to confirm consistency of results




**Results:**

- Significant differentiation in the levels and localisation of Cu
- hair of a young female (c. 18-20 years old at death; MDX5806) showed particularly elevated levels of Cu
- the normalised 2D elemental maps of hair cross sections of the eight individuals analysed show that the Cu values of MDX5806 are significantly higher than in the rest of the individuals
- the highest Cu values in MDX5806 are located within the cortex, rather than the cuticle and the medulla area

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# CASE STUDY: SR-IR mapping, ancient human hair, SESAME

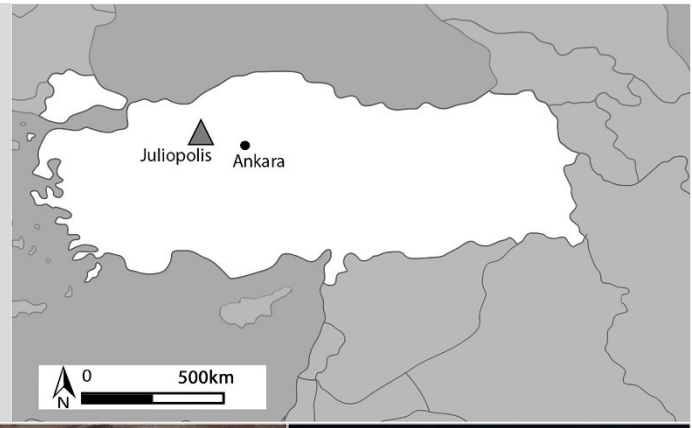
SESAME

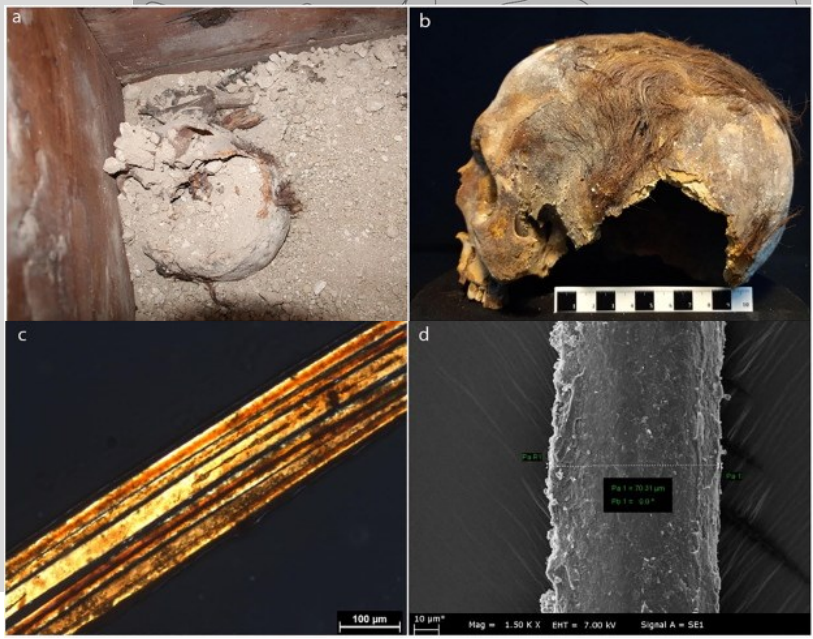
## Research aim

- Preservation status and alterations of organic compounds
- Human hair from archaeological contexts has high analytical value, with potential for analysis of:
    - diet
    - geographical origins
    - ancient DNA
    - metal exposure
    - other aspects of life in a time-resolved manner

⇨prior evaluation of preservation of sufficient amounts of organic compounds is crucial for further analyses

**Material:** Roman period hair from Juliopolis (c. 2000 years ago)



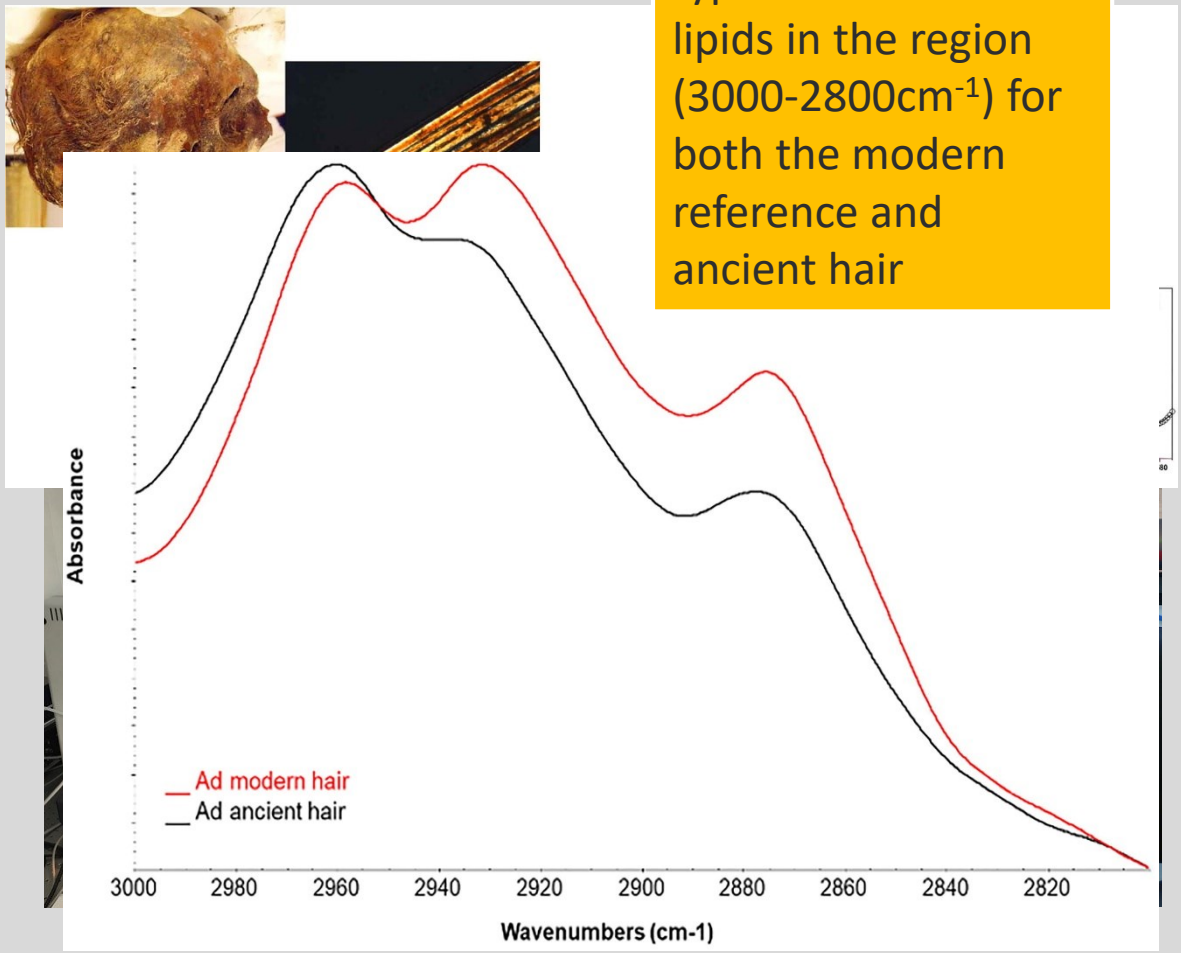
# SR-IR mapping of ancient human hair

## Method

- SR-FTIR microspectroscopic investigation at the IR beamline at SESAME
- IR chemical mapping

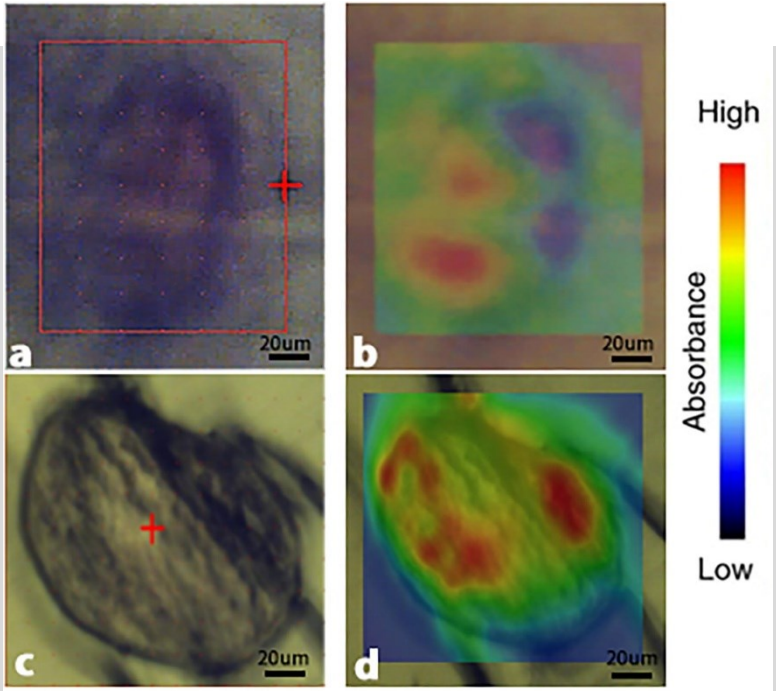
## Results

- keratin in the sample is more degraded in comparison to the modern reference sample
- however, the results also point to clear potential for further analyses with techniques relying on organic compound preservation




Transmission IR spectra showing the typical features of lipids in the region (3000-2800cm$^{-1}$) for both the modern reference and ancient hair

# Most recent paper on Cultural Heritage from SESAME: 12 Feb 2022




Optical (a, c) and FTIR (chemical) imaging (b, d) of ancient hair cross sections (sub-figures a, b) from Juliopolis (JP M196), and a modern reference (sub-figures c, d).
The chemical maps are based on normalized and baseline-corrected transmission infrared average spectra, as blended 2D map and video images.

ELSEVIER

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Available online 12 February 2022, 121026

In Press, Journal Pre-proof

## Synchrotron Radiation Fourier Transform Infrared (SR-FTIR) spectroscopy in exploring ancient human hair from Roman period Juliopolis: Preservation status and alterations of organic compounds

K.O. Lorentz [a], G. Kamel [b, c], S.A.M. Lemmers [a], Y. Miyauchi [a, d], E. Cubukcu [e], A. Alpagut [f], A.M. Buyukkarakaya [e, g]

https://doi.org/10.1016/j.saa.2022.121026

# 4

# Ongoing and future work

# Recent SESAME beamtime: Hala Sultan Tekke, Cyprus

The Project with Grant No. INTEGRATED/0609/29 is co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research and Innovation Foundation.

- currently analysing results from a beamtime at SESAME on Cypriot archaeological remains
- excavating more in May 2022


https://face2face.cyi.ac.cy/

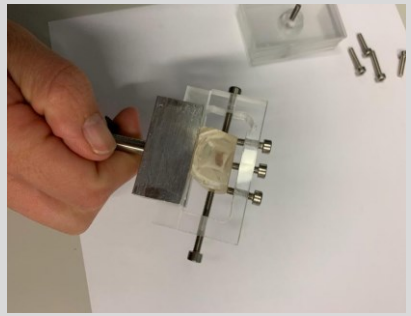
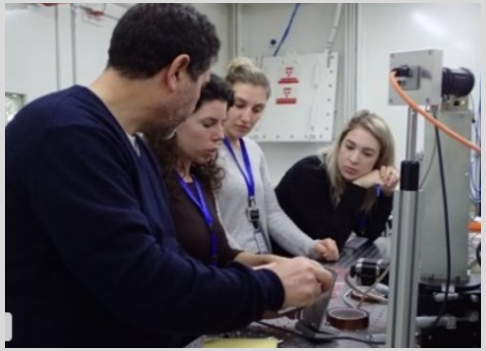

**Lorentz & FF-MAC team (The Cyprus Institute) in collaboration with Prof. Fischer (U. of Gothenburg) at HST**

# Platform for Biosciences and Human Health in Cyprus: MicroCT Enabled and Synchrotron Radiation Enabled Analyses

**PI: Kirsi O. Lorentz, The Cyprus Institute**

https://biomera.cyi.ac.cy/



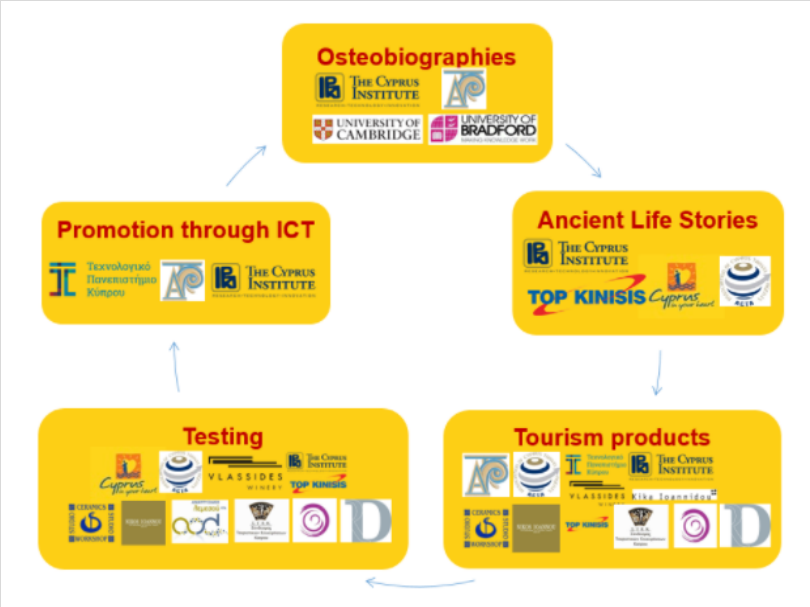




**The Project INFRASTRUCTURES/1216/0009 is co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research and Innovation Foundation**

# Face to Face: Meet an Ancient Cypriot

PI: Kirsi O. Lorentz, The Cyprus Institute

https://face2face.cyi.ac.cy/

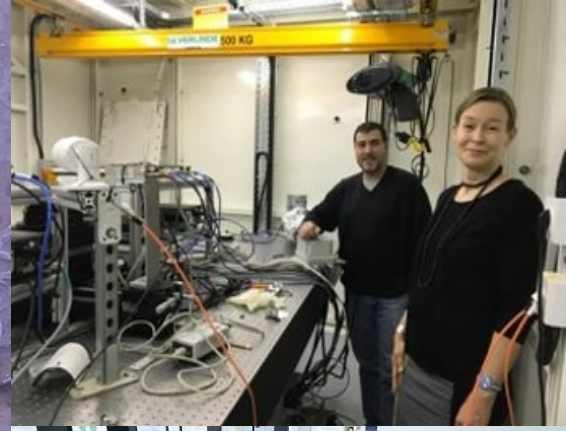



The Project with Grant No. INTEGRATED/0609/29 is co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research and Innovation Foundation.

# More to follow…

comulis
Correlated Multimodal Imaging in Life Sciences

https://www.comulis.eu/



Human remains from Hala Sultan Tekke, analysed at SESAME

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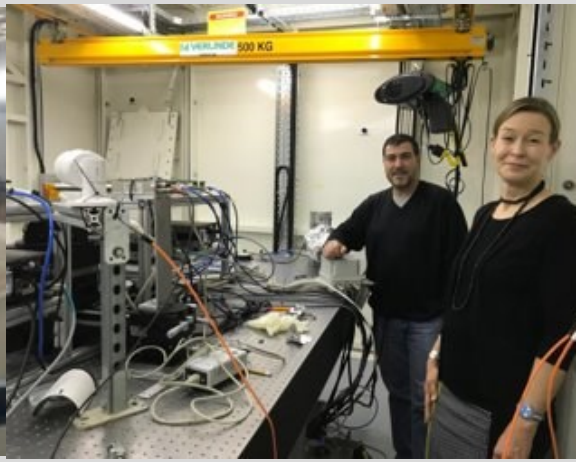
| UNPUBLISHED | UNPUBLISHED | UNPUBLISHED |

Ancient skin under 3D microscope and SEM; SR-XRF



# Thank you

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