X-ray microdiffraction and microfluorescence using synchrotron radiation as a new tool for investigating single archaeological textile fibres

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The classical approach to identify archaeological textile fibres is via optical and electron microscopy. Optical microscopy readily reveals the handedness of spun yarns. The shape of the fibres allows for the discrimination between animal and plant fibres. However, degradation may have changed the outer appearance and shape of textile fibres. In particular, the small differences between plant fibres of the bast fibre family (flax, hemp, jute, ramie) are usually not visible with microscopic techniques.

Intact textile samples can be investigated by means of synchrotron X-ray diffraction. These non-destructive techniques yield diffraction diagrams with sharp and intense powder rings from the fine adhering mineral particles. If larger beams (of the order of 0.2 mm in diameter) are used, the fibre material (cellulose or wool) produces broad diffuse rings due to the small crystallites in the material and an averaging effect over many fibres. X-ray microbeam diffraction [1], a technique with a beam size of typically 2 to 5 µm, overcomes this difficulty by providing a microscopic spatial resolution. A highly intense focused synchrotron radiation microbeam allows one to collect fibre diffraction patterns from fractions of single fibres in a few seconds. The high internal orientation of textile fibres makes the discrimination of the contributions of soil particles and fibres to the diffraction patterns straightforward.

We measured single threads of textile samples from the Caves of Qumran (inhabited by the Essenes from around 50 BC to 70 AD) [2,3] and from the Cave of the Letters (hiding place for Jews in the second revolt against the Romans around 135 AD), both located in the Dead Sea area, at the ESRF Microfocus Beamline ID13. The archaeological fibre diffraction patterns in comparison with modern reference samples made the identification of cellulose fibres and wool and in particular for the first time of different types of cellulose bast fibres possible.

Another difficult part of the analysis of archaeological textiles concerns the way they were dyed. From the textiles found in the Cave of the Letters, X-ray fluorescence spectra were recorded simultaneous to X-ray diffraction patterns. The position-resolved analysis yields elemental distributions across the fibre diameter [4]. In a preliminary analysis, adhering soil particles can be identified as well as elements that are homogeneously distributed in the fibres. Those may be associated with dyes or mordants used in the dying process.

References

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