

# Structural analysis of black inks from Ancient Egyptian papyri

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Starting as early as the fourth millennium B.C., Egyptian writings on papyrus spread knowledge all around the Mediterranean Sea. Carbon-based pigment from Egyptian period were used as a base for ink manufacturing dedicated to writing [1]. Although a large number of papyri have been collected during archaeological excavations, the complexity of the amorphous nature of black inks limits our understanding of Old Egyptian writing techniques. Recent studies on papyri fragments from both Herculaneum and ancient Egypt showed the presence of metallic element such as copper and lead, their origin remains unanswered [2,3].

The purpose of this study is to get a better understanding of the process of black ink manufacturing in Ancient Egypt. For this, the investigation focuses on tracking the origin of amorphous carbon as well as any traces of metallic elements in a corpus of fragments of papyrus. These fragments were made available by the Champollion Museum, located in Vif, under the responsibility of the department of Isère. In order to analyze the structure of the ink deposited on the surface of the fragments, only non-destructive techniques are suitable. Synchrotron X-ray diffraction and fluorescence techniques associated with the pair distribution function were performed at the ESRF on ID22 and ID11 beamlines. Complementary analyzes of Raman and infrared spectroscopy have also been used to try to reveal the presence of binders in the ink. Finally, scanning electron microscopy has been exploited to compare the microstructure of ink deposits with a series of standards.

The first results of scanning electron microscope imaging show a great similarity between the ink deposited on the surface of the papyrus and the lampblack, obtained by collecting the residue of organic compound combustion. The X-ray diffraction demonstrates the presence of a structure in correlation with the ink deposited on the papyrus. X-ray fluorescence indicates a low contrast of metallic elements between the ink-covered areas and empty areas. Finally, the microscopy techniques remain to be better examined. Combining X-ray analysis, spectroscopy and imaging data is essential to clarify the nature of cultural heritage materials.

## References

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