Invisible writing on antique Nile papyrus revealed by multiple methods

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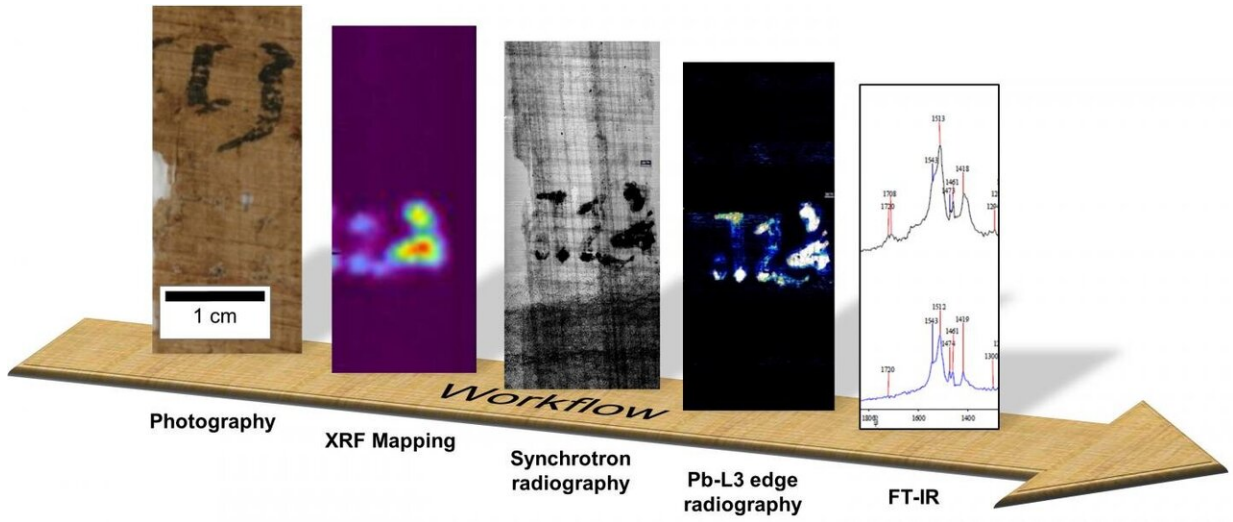

A team of researchers examined an ancient papyrus with a supposed empty spot. With the help of several methods, they discovered which signs once stood in this place and which ink was used. Credit: HZB

Researchers from the Egyptian Museum and Papyrus Collection, Berlin universities and Helmholtz-Zentrum Berlin studied a small piece of papyrus that was excavated on the island of Elephantine on the River Nile a little over 100 years ago. The team used several methods, including non-destructive techniques at BESSY II. The researchers' work, reported in the *Journal of Cultural Heritage*, blazes a trail for further analyzes of the papyrus collection in Berlin.

The first notable feature of the small piece of papyrus from Elephantine Island on the Nile is an apparently blank patch. Researchers from the Egyptian Museum, Berlin universities and Helmholtz-Zentrum Berlin used the synchrotron radiation from BESSY II to analyze it, thereby developing new techniques for analyzing the giant Berlin papyrus collection and many others.

For more than a century, numerous metal crates and cardboard boxes have been stored at the Egyptian Museum and Papyrus Collection Berlin, all of which were excavated by Otto Rubensohn from 1906 to 1908 from an island called Elephantine on the River Nile in the south of Egypt, near the city of Aswan. Eighty percent of the texts on the papyrus in these containers have yet to be studied, s it is not possible using conventional methods.

Thousands of years ago, the Egyptians would carefully roll up or fold together letters, contracts and amulets to a tiny size so that they would occupy the least possible space. In order to read them, the papyri would have to be just as carefully unfolded again. "Today, however, much of this papyrus has aged considerably, so the valuable texts can easily crumble if we try to unfold or unroll them," says Prof. Dr. Heinz-Eberhard Mahnke of Helmholtz-Zentrum Berlin and Freie Universität Berlin.

Testing the fragile papyrus with nondestructive methods

The physicist at Helmholtz-Zentrum Berlin have known from experience how to analyze the fragile papyrus without destroying it: shining a beam of X-ray light on the specimen causes the atoms in the papyrus to become excited and send back X-rays of their own, much like an echo. Because the respective elements exhibit different X-ray fluorescence

behavior, the researchers can distinguish the atoms in the sample by the energy of the radiation they return. The scientists long ago developed laboratory equipment using X-ray fluorescence to analyze sensitive specimens without destroying them.

Scholars in ancient Egypt typically wrote with a black soot ink made from charred pieces of wood or bone, and which consisted mainly of elemental carbon. "For certain purposes, however, the ancient Egyptians also used colored inks containing elements such as iron, copper, mercury or lead," Heinz-Eberhard Mahnke explains. If the ancient Egyptian scribes had used such a metallic ink to inscribe the part that now appears blank on the Elephantine papyrus, then X-ray fluorescence should be able to reveal traces of those metals. Indeed, using the equipment in their laboratory, the researchers were able to detect lead in the blank patch of papyrus.

In fact, they even managed to discern characters, albeit as a blurry image. To capture a much sharper image, they studied it with X-ray radiography at BESSY II, where the synchrotron radiation illuminates the specimen with many X-ray photons of high coherence. Using absorption edge radiography at the BAMline station of BESSY II, they were able to increase the brightness of this technique for the sample studied, and thus better distinguish the characters written on the papyrus from the structure of the ancient paper. So far, it has not been possible to translate the character, but it could conceivably depict a deity.

Composition of the invisible ink resolved in the Rathgen laboratory

The analysis at BESSY II did not identify the kind of leaded ink the ancient scribes used to write these characters on the papyrus. By using a Fourier-transform infrared spectrometer, the scientists of the Rathgen

Research Laboratory Berlin finally identified the substance as lead carboxylate, which is, in fact, colorless. But why would the ancient scribe have wanted to write on the papyrus with such invisible ink? "We suspect the characters may originally have been written in bright minium (red lead) or perhaps coal-black galena (lead glance)," says Heinz-Eberhard Mahnke, summarizing the researchers' conclusions.

If such inks are exposed to sunlight for too long, the energy of the light can trigger chemical reactions that alter the colors. Even many modern dyes similarly fade over time in the bright sunlight. It is therefore easily conceivable that, over thousands of years, the bright red minium or jet black galena would transform into the invisible lead carboxylate, producing a conspicuously blank space on the papyrus fragment.

With their investigation, Dr. Tobias Arlt of Technische Universität Berlin, Prof. Dr. Heinz-Eberhard Mahnke and their colleagues have pushed the door wide open for future studies to decipher texts, even on finely folded or rolled papyri from the Egyptian Museum, without having to unfold them and risk destroying the artifacts.

More information: Heinz-Eberhard Mahnke et al, Virtual unfolding of folded papyri, *Journal of Cultural Heritage* (2019). DOI: 10.1016/j.culher.2019.07.007

Tobias Arlt et al. Absorption edge sensitive radiography and tomography of Egyptian Papyri, *Journal of Cultural Heritage* (2019). DOI: 10.1016/j.culher.2019.04.007

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