ESRF	**Experiment title:** **Heavy metal ions in hair and skin of Egyptian mummies: from cosmetics and therapeutics to poisoning.**	**Experiment number**: CH1056
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Shifts: 15	**Local contact(s)**: Alexandre SIMIONOVICI	*Received at ESRF:*

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Report:

During the experiment, we have studied archaeological samples from Egyptian mummies and modern samples (hair and skin), which have been treated in Cu and Pb enriched solutions. The main results concern the fixation of Pb^{2+} in modern hair and the trace element mapping in Egyptian hair.

Lead-revealed lipid organization in human hair

Our micro fluorescence and micro diffraction experiments at ID 22 (and at ID13 with J. Doucet) shown that appropriate lead treatment considerably enhances organized lipid features observed by X-ray diffraction, the lipids being present as calcium soaps in native hair. The results have been published in
BERTRAND L., DOUCET J., SIMIONOVICI A., TSOUCARIS G., WALTER P. – Lead revealed lipid organisation in human hair. Biochemica et biophysica acta. 1620, 218-224 (2003).

Microbeam imaging of hairs from Ancient Egyptian mummies

Elemental analysis of Egyptian mummy hairs, compared to native modern hair, shows a significant trace increase in element content. Elemental distribution across hair section differs noticeably between Mende and Marseilles hairs.

- X-ray fluorescence study ofMende mummy hairs shows a notable increase in calcium (146 µmol/g on average), zinc (37 µmol/g), iron (14 µmol/g) and lead (1,1 µmol/g) contents, compared to maximum contents observed in native samples. Some other elements of lower occurrence in native hair as manganese (1,8 µmol/g), bromine (1,1 µmol/g), titanium (1,1 µmol/g) and strontium (0,62 µmol/g) show a significant increase.

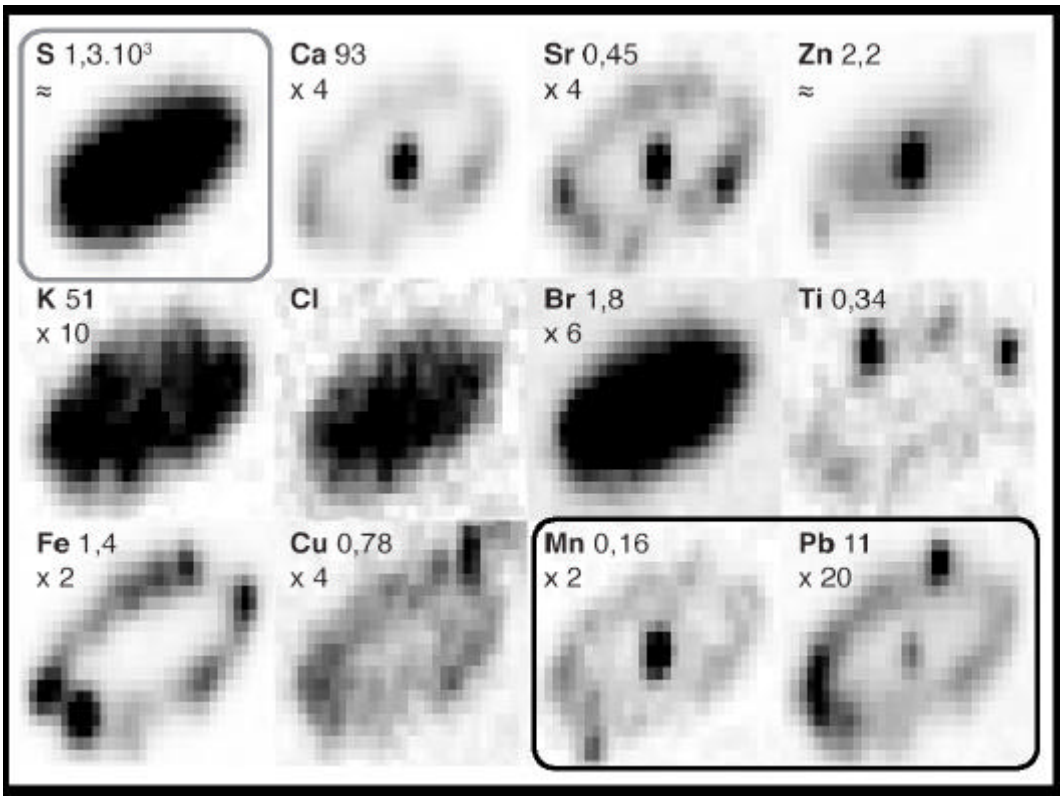
- Element distribution across hair section from the Marseilles mummy shows a very heterogeneous distribution (see figure). The localization of sulfur, mainly originating from hair proteins, enables a clear determination of hair section contour. We distinguished three distinct schemes for elemental distribution:

1. Some elements are distributed in the fiber section as in current hair: calcium in the medulla.
2. Others are concentrated specifically in some of the histological zones: in the medullar canal (zinc, manganese, lead, strontium) and/or in a crown at the hair periphery (iron, copper and lead);
3. We observe unambiguously the presence of impurities deposited on hair surface (particularly titanium and zinc).

Interestingly, part of the trace elements most probably originates from the mummification treatment. The natron used during this process was shown to be a complex mixture associating in varying proportions chloride, sulfate, carbonate and bicarbonate of sodium, as well as small quantities of calcium carbonate. Significant contents of calcium and chlorine are actually observed in our samples1. All the trace elements (calcium and its analogue strontium, bromine, chlorine, iron and magnesium) mentioned in natron samples of the Greco-Roman period are present in excess in Marseilles mummy hairs.

The diffusion of certain ions in the whole section of Marseilles fiber suggests that this hair could have been washed or treated with a liquid or pasty solution, unlike the body for which the solid application of natron is accepted by most of the authors.

We additionally noted a very high content of manganese and lead in hair strands from both mummies, not mentioned as components of natron by A. Macke. These elements are particularly concentrated at the hair periphery and in the medulla of Marseilles sample. Lead and manganese content could result from cosmetic treatments. Let us recall that the use of lead-based make-up is well documented in Ancient Egypt and that the production of manganese-based hair dyes is also known. The specific concentration of lead, calcium and other cations within the medullar canal, where the lipids were concentrated before mummification, could be related to the saponification of hair lipids. The absorption of exogenous metal cations within the fiber may have locally increased the electronic density of the material. The diffusion of metal ions can moreover have had a structuring effect, by regularly organizing the keratins around the metal sites. This could explain the increase in contrast observed in the hair diffraction pattern.



X-ray fluorescence cartography of an hair section from Marseilles mummy. Elemental content is indicated, followed by the ration to average native hair trace element content