ESRF	**Experiment title:** Trace element analysis by X-ray microfluorescence to find the origin of mineral phases in make-up of Anceint Egypt	**Experiment number**: CH-862
Beamline: ID 22	**Date of experiment**: from: 12/04/2000 to: 16/04/2000	**Date of report**: 22/08/2000
Shifts: 12	**Local contact(s)**: A. Simionovici	*Received at ESRF:*

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Report:

The extensive use of green, white and black make-up has been known since the earliest periods of Egyptian history for their aesthetic and therapeutic purposes. In previous works, we have studied the inorganic and organic contents of the cosmetics dated between 2000 and 1200 BC, kept in their original containers and preserved in the Louvre Museum. Two well-known natural lead-based compounds were identified: crushed ore of galena (PbS) and cerussite ($PbCO_3$). In addition, our analyses have revealed two unexpected synthetic products: laurionite (PbOHCl) and phosgenite ($Pb_2Cl_2CO_3$).

For the experiment, the powdered cosmetics made of isolated grains are spread on kapton foils and are examined by optical microscopy to identify/locate the minerals prior to X-ray analysis. Then the focused X-ray beam (2x5 μm^2) is successively tuned at 11 keV, below the L_{III} absorption edge of Pb, and 31.8 keV, above the K absorption edge of Sb (figure 1). The impurity signal integrated over each single grain is detected against the X-ray micro-diffraction pattern collected in transmission with a bi-dimensional detector.

The natural ores of galena and cerussite incorporated into the cosmetics originate from different mines, in particular from the Pb-Zn ores or from “the Punt country” (Yemen, Somalia or Ethiopia). From the identity and the respective abundance of the trace elements present (Fe, Ni, Cu, Zn, Ag, Sb), it is possible to classify the samples according to their extraction provenance.

We have observed a high proportion of antimony in galena grains of one sample (E23106), which are different of those contained in three other samples (AF167, E20514, E11048b). These grains are characterised by a relatively high content of zinc and the presence of iron traces. Exploiting of Pb-Zn ores is well-known in Antiquity and several Ancient mines

are located in Egypt along the Red Sea coast. The presence of Sb in lead ores cannot be related to an Egyptian origin and shows the trade of these materials to prepare make-up in Egypt.

For synthetic compounds, we have observed that the natural galena and the synthesised phosgenite exhibit different impurity patterns. The observed trace elements Cu and Fe have to be linked to the minerals used during the preparation process (natron, sea or rock salt). These data allow us to find the origin of the raw materials involved in the chemical synthesis.

Furthermore, for galena grains rich in Zn, the XANES signal at the K absorption edge of Zn (figure 2) can show the immediate nearest-neighbour environment (ZnS nanocrystals or Zn^{2+} substitution).

In combining micro-diffraction, micro-fluorescence and micro-XANES techniques, we emphasise the capability of synchrotron micro-beam to track minerals of great archaeological interest and to identify the provenance of manufactured materials in Antiquity.

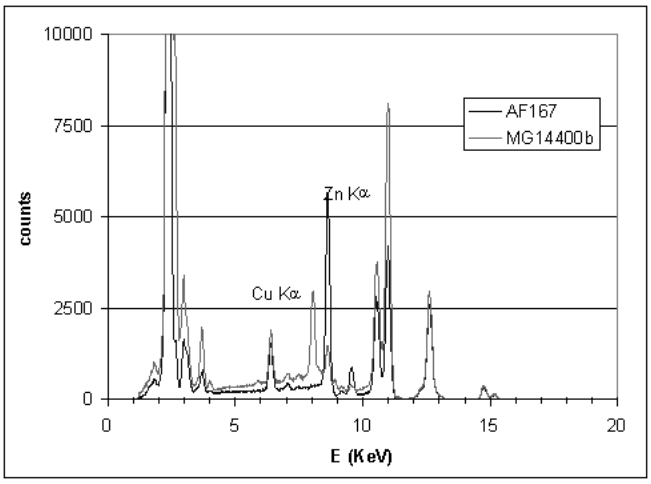

Fig 1a : Impurities in galena (AF167) and phosgenite grains (MG14400b) - acquisition at 11 keV, 10 minutes

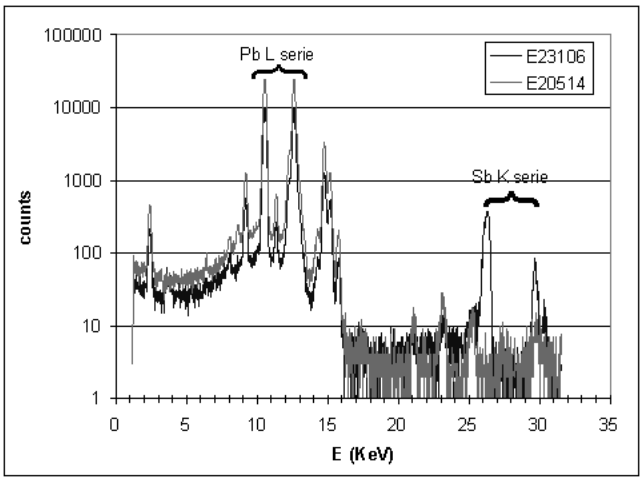

Fig 1b : Impurities in both galena ores - acquisition at 31.8 keV, 5 minutes

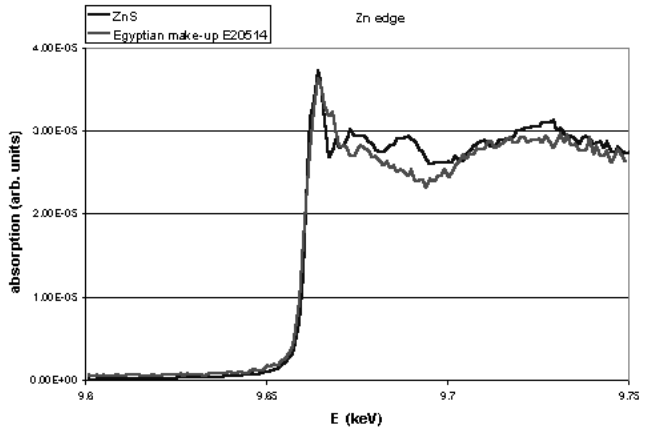

Figure 2 : XANES signal at the K absorption edge of Zn in ZnS nanocrystals and in Egyptian galena (sample E20514).