ESRF	**Experiment title:** Quantitative analyses of ancient Egyptian make-up powders by X-ray diffraction	**Experiment number:** CH 347
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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 the present work, cosmetic powders, dated between 2000 and 1200 BC have been studied out of their original containers supplied by the Louvre Museum. The exceptionally good state of conservation of these artefacts has enabled quantitative crystallographic and chemical analyses to be carried out on both their organic and mineral contents. Two well-known natural lead-based compounds were identified and weighed: crushed ore of galena (PbS) and cerussite ($PbCO_3$). In addition, our analyses reveal two unexpected main constituents: laurionite (PbOHCl) and phosgenite ($Pb_2Cl_2CO_3$). We demonstrate that these are not extracted natural ores and do not result from subsequent ageing or chemical modification. One key conclusion of this work is that laurionite and phosgenite are synthetic products that the Egyptians intentionally manufactured by wet chemistry.

In order to decipher the composition and the elaboration methods of these cosmetics, the mineral content was analyzed by Scanning Electron Microscopy, IRTF spectrometry and powder X-ray diffraction. Standard laboratory quantitative X-ray diffraction was impeded by several factors: 1) owing to the high archaeological value of the powders, only small quantities can be extracted and analyzed; 2) the as-found cosmetics are highly absorbing mixtures of lead-based compounds; 3) most mixtures contain as many as 10 phases, i.e. the resulting diffractograms display a complex series of overlapping Bragg lines. The measurements carried out at the ESRF (BM16) could significantly benefit from the high flux, the high energy and the high resolution. The Rietveld refinement method (fullprof software package) was applied to work out the respective crystalline phase mass fractions (table 1). Taking into account the anisotropic line profile of some phases, the agreement factors could be significantly improved far below 10% and amounts of minerals as low as 0.5% could be weighed. Furthermore the X-ray line broadening caused by the mineral microstructure (grinding, annealing) is being analyzed and related with the origin and the elaboration process of the archaeological powders.

- *Ph. Walter, P. Martinetto, G. Tsoucaris, R. Bréniaux, M.A. Lefebvre, G. Richard, J. Talabot, E. Dooryhee, "Manufacturing cosmetics in ancient Egypt", Nature 397, 483-484 (1999).*
- *P. Martinetto, M. Anne, E. Dooryhee, Ph. Walter, "Analysis of X-ray diffraction line profile of galena powders: a clue to some practices of mineral crushing in ancient Egypt", Proceedings of the 6-th European Conference on Powder Diffraction (EPDIC6), Materials Science Forum (1998).*

	Galena	Cerussite	Anglesite	Phosgenite	Laurionite	Sphalerite	
AF167	90	-	8.5	-	-	1.5	
AF6769	56	12	15	17	-	-	
e11048b	49	13	-	36	-	-	palmierite 2
e11048c	19	43	8	30	-	-	
e11048d	28	48	-	24	-	-	
e11048e	42	27	1.5	28.5	1	-	
e11301	57	6	6	-	14	-	Suzannite 16
e14569	17	22	16	13	31	-	
e21562	26	24		33	17	-	
e23106	64	8	5	20	2	-	
e25257	20	46	34	-	-	-	
n1139	22	-	-	29	48	-	
n1193	-	-	-	-	-	-	Calcite
n1332	93	2	-	4	1	-	
n1333	-	-	-	-	-	-	Halite
n1352.1	64	19	-	9	7	-	

Table 1: Proportion of the main mineral phases (Rietveld refinement of the powder diffraction patterns). The samples were taken from containers dated from the Middle and the New Empires (from the Louvre Museum).