

The French Knight Bayard (1473?-1524) Was Treated For Syphilis : Sem-Edx Evidence Of Mercury-Rich Particles Loaded On His Tooth

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Abstract—In this study, the little metallic particles that are mercury-rich, which are located on the surface of a tooth extracted from the cranium of the knight Bayard (1473?-1524), were investigated. These particles (a total number of nineteen of them were detected) were characterized in SEM-EDX, which permit both their visualizations in electron microscopy and the semi-quantitative study of their elemental compositions. The particles so detected are effectively mainly constituted of mercury (73.5%), and their morphological aspects indicate that they are micro-ashes of a sort of mercury vapour. Because the main treatment for syphilis at Bayard's time was mercury fumigations, it was deduced that he was treated for this disease in that way.

Keywords—tooth of the Knight Bayard (1473?-1524) ; SEM-EDX analyses of the tooth surface ; particles of mercury ; treatment against syphilis.

1. Introduction

The famous French "Chevalier Bayard" (1473?-1524) has been known as "the knight without fear and beyond reproach". He lived at the transition between the Middle Ages and the Renaissance, and was considered at this period as the epitome of French chivalry [1].

We have discovered his cranium , which is at present kept in the Dauphin  Museum of Grenoble (France). A molar tooth was extracted from his mandible, and genomic DNA obtained from this tooth permit us to study the mitochondrial DNA (mtDNA) of Bayard [2] : his corresponding mtDNA haplogroup is the same that of a today living male related (to 32 generations) to the Bayard matrilineal ascendance. The ¹⁴C evidence dating from one of the root tooth provides a date of calendar of 1430-1510 years (at 95% of probability) interval, consistent with a mean date of 1486 for an individual who had started eruption of his first molars.

We have previously published [3] a study by SEM-EDX of the dental plaque of the lateral lingual face of the tooth, and found microscopic particles indicating the diet habits of Bayard ; recently we have concentrated on these particles involved in ballistic

[4]. The present study concerns the detection on the tooth surface of particles mercury rich, which are indicative of syphilis treatment.

2. Material and Methods

Bayard's tooth extracted from the cranium is the first mandibular at the left side (the tooth number 36, according to the "Nomenclature dentaire internationale"). The jugal exterior lateral face of the tooth were examined by SEM (Scanning Electron Microscopy). Mineral and metallic mercury-rich detected on the tooth surface were analysed by EDX (Energy Dispersive X-ray spectroscopy).

The SEM apparatus used is the FEI model Quanta FEG (an environmental electron microscope) of the Laboratory of Physico-Chemical Analyses of the Compi gne UTC (France). The CBS (Circular Back Scattering) procedure was used to better detect heavy elements.

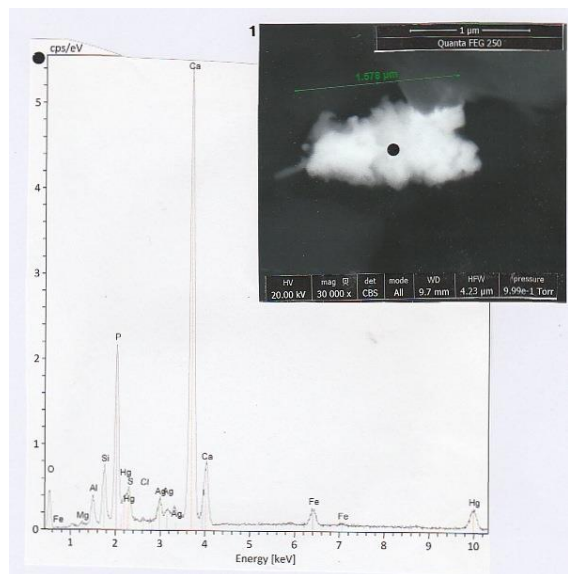
Elemental analyses of the structures observed with this apparatus were carried out, because it is equipped with a probe of the model X-flash 6/30. Each elemental analysis is given in the form of a spectrum, with kiloelectrons/Volts (keV) on the abscissa and elemental peak heights (cps/eV) in ordinates ; highly-resolutive spectras are obtained by enhancing the ordinate values. Semi-quantitative measurements of the normalized mass of the heavy elements were so obtained, based on their main X-ray peaks.

3. Results

Figure 1 shows the first mercury-rich particle detected at the tooth surface. In SEM it is an elongated structure (of about 1.5  m of length and of less than 1  m of wide), with irregular outlines. Its spectrum shows that it is mainly constituted of calcium sulphate (the main component of the osseous structures) in an alumina-silicate mineral. The main metallic element found in it is the mercury (Hg) ; there are also iron (Fe) and silver (Ag).

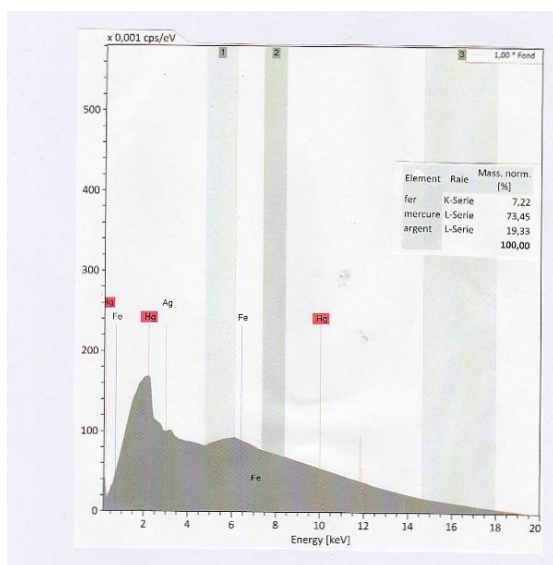
Fig. 1 : Study of the first (1) mercury particle detected. *Above* : SEM photograph (in CBS, 30000x) of this particle (dimensions is in  m) ; the black dot indicates the area of the particle analysed by EDX. *Below* : spectrum at the black dot. O : oxygen ; Fe (three peaks) : iron ; Mg : magnesium ; Al : aluminium

; Si : silicium ; P : phosphorous ; Hg (three peaks) : mercury ; S : sulphur ; Cl (traces) : chlorine ; Ag (three peaks) : silver ; Ca (two peaks) : calcium.



The normalised mass of mercury is about 73.5% (Figure 2), while those of iron and silver are of 19.3% and 7.2% respectively. There is no evidence that this particle is of mercury dichloride ($HgCl_2$), nor of mercury proto-iodide (Hg_2I), the two products that were commonly used for syphilis treatment from the 17th to the 19th century.

Fig. 2 : Quantitative study of the highly-resolutive spectrum of the first mercury particle detected. The three mercury peaks are in red, the two iron peaks are in blue and the silver peak is in green. Zones 1, 2 and 3 "fond" : the background is indicated in the upper photograph of the graph. Insert gives the normalized mass of mercury ("mercure") at the L-ray ("raie"), of silver ("argent") at the L-ray, and of iron (fer) at the K-ray.



A total number of nineteen of such mercury-rich particles were detected on the jugular face of the tooth (Table) ; in each of them mercury is the main metallic element. Their spectras are greatly similar to that of

the first particle observed, and they differ only in subtle quantities in the three elements carbon (C), sodium (Na) and potassium (K), which indicates possible external contaminations.

Table 1 : Numbers, morphologies and supplementary elements in the 19 observed particles.

Particles	Forms	Maximal dimensions (in μm)	C, Na and K	Corresponding figures
1	elongated	1.5	-	figure 1
2	rounded	0.6	-	
3	quadriform	1.9	+	
4	rounded	0.3	+	
5	fusiform	1.2	-	
6	rounded	0.3	-	
7	rounded	0.4	+	figure 3
8	rounded	0.9	-	
9	rounded	0.5	+	
10	rounded	0.2	+	
11	quadriform	0.4	-	
12	elongated	1.3	-	
13	rounded	1.0	-	
14	rounded	0.7	+	
15	ovaloid	0.4	-	
16	squared	0.6	-	
17	elongated	1.7	+	figure 4
18	rounded	1.0	-	
19	rounded	0.4	-	

They are very little particles (dimensions between 0.2-1.9 μm), differing mostly by their morphological aspects : most of them are rounded, and some others are more elongated in form. Figure 3 and 4 show examples of two of them (numbers 7 and 17).

Fig. 3 : Study of the seventh (7) mercury particle detected. *Above :* SEM photograph (in CBS, 12 000x) of this particle. *Below :* spectrum at the black dot. C : carbon ; Na : sodium ; K : potassium.

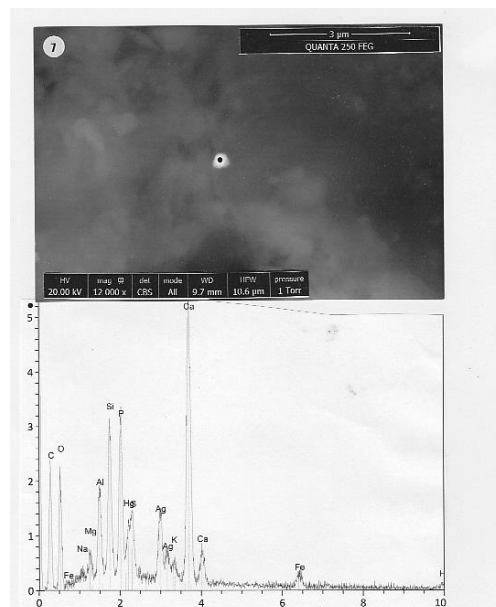
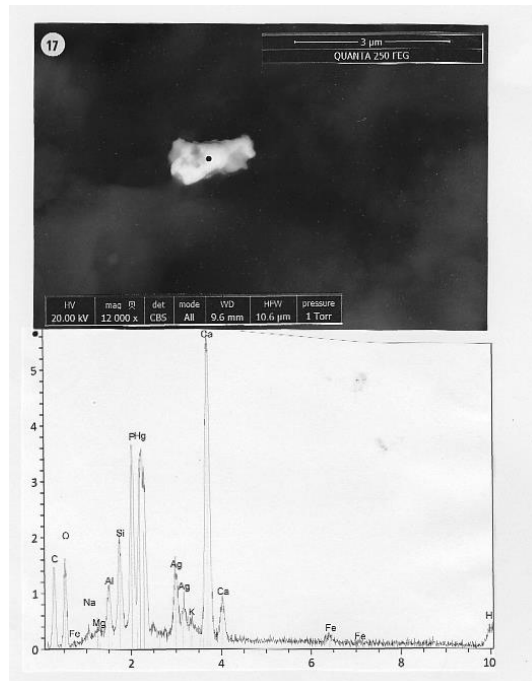


Fig 4 : Study of the seventeen (17) mercury particle detected. Above : SEM photograph (in CBS, 12 000x) of this particle. Below : spectrum at the black dot.



The nineteen mercury rich particles detected on the tooth surface represent , from the chemical composition, an homogeneous group of formations constituting a sort of powder ; the observation that most of them are rounded in form indicate they represent particles in fusion. These particles are micro-ashes of a mercury vapour, where mercury is loaded by iron and stabilized by silver.

4. Discussion

At Bayard's time, the main treatments for syphilis were *guaiacum* ("the holy wood") and mercury skin inunctions or ointments [5] ; treatments were by and generally the speciality of barbers and some surgeons.

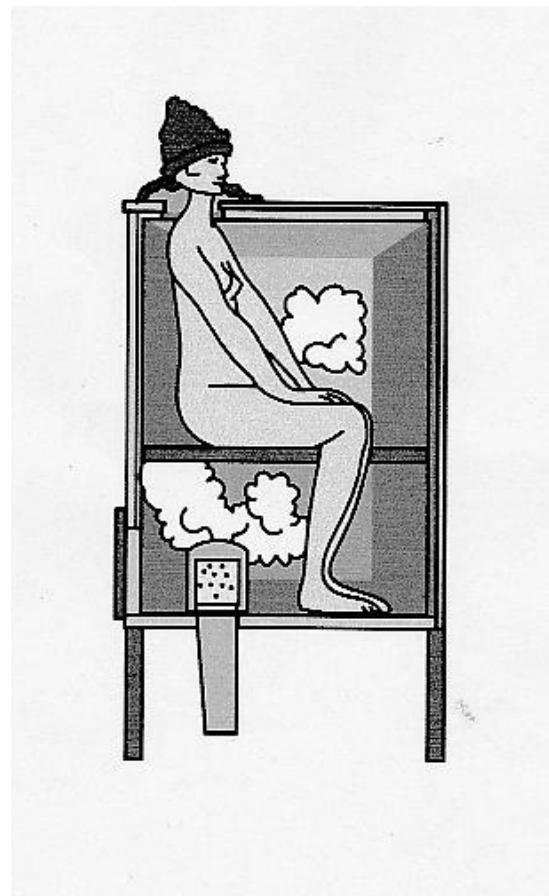
The mercury was used according to four modalities : in frictions, in emplatres, in washings and in fumigations [6]. Concerning the fumigation process, the patient undergoing this sort of treatment was secluded in a cabin (named "the archet"), or in a closed room ; on his feet was an inferno, and by a hole was thrown away in the cabin some sticks of mercurial "perfumes" (Figure 5). This process went on for a week to a month (or more), and would later be repeated if the disease persisted .

This terrible sort of treatment had many by-side undesirable effects. Particularly fumigations damaged all of the interior of the patient mouth, causing "mercurial glossites" (with deformation of the tongue) and sometimes tooth alterations. Fernel [7] maintained that, when the patient's teeth were extracted, he observed "sometimes mercury droplets at the levels of the corresponding dental alveolus".

The many mercury-rich particles detected in the present study at the tooth surface are the proof that

Bayard was treated for syphilis – until the end of his life- by these sorts of mercury fumigations.

Fig 5 : Schematic representation of an archet, with a patient inside (From P. Lalouette, 1776).



Our studies , which began in 2017 [3], on particles deposited on the tooth surface clearly demonstrated that Bayard paid a great attention to his dental cares ; we have then deduced that he was worried by his health-in general-and the fact established here that he cured his syphilitic symptoms is illustrative of that. Bayard could be attained by a moderate form of the disease, because careful examination of the bones of his cranium do not show osseous lesions characteristics of tertiary syphilis [8]. Probably he contracted the disease from soldiers of Charles VIII (of France) when they invaded Naples, in the first of the Italian Wars where he participated [1].

5. Conclusion

In this study exploring the dental surface of one of Bayard's tooth, were detected a total number of nineteen similar metallic particles that are mercury-rich.

In these particles, where mercury is the main metallic element (73.5%) ; other associated metals are silver (19.3%) and iron (7.2%). The particle morphologies in SEM suggest that they constitute a powder of micro-ashes of mercury vapours. As the main treatment against syphilis at Bayard's time was fumigations of mercury, it is deduced that he was treated against this disease in that way.

Detailed studies of the molecular detection of *Treponema pallidum* DNA in the genomic DNA

extracted from the tooth are now in progress, in order to establish that Bayard was effectively parasite by such a germ.

6. Acknowledgment

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7. References

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