

CNESTEN

Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

Rachad ALAMI

**1st International Conference on Applications of Radiation
Science & Technology
ICARST**

IAEA, Vienna - April 24th – 28th 2017

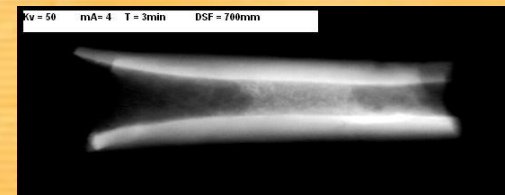
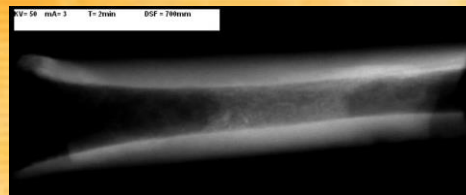
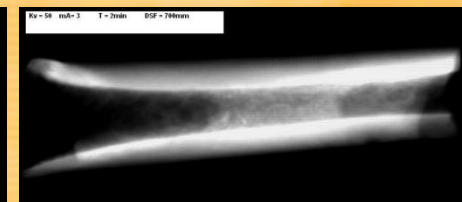
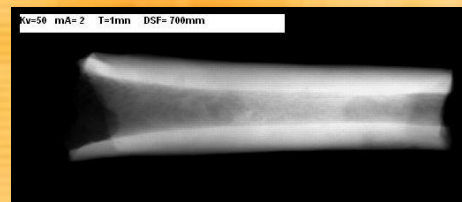
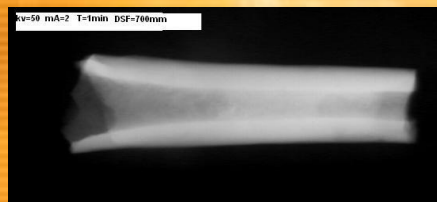
Principles of Museum Curators - Scientists Relationship



Controlling without altering
Diagnose to preserve

Assistance to archeologists

*Homo Sapiens
Femur*





Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

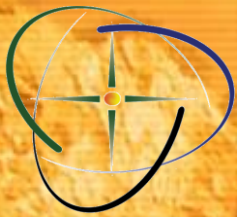
Assistance to museum curators in verifying the state of conservation of artifacts



**Statue of Ptolémée
(King of Morocco, 40 a. J.C.)
"Last Pharaon"**

Rabat Archeological Museum





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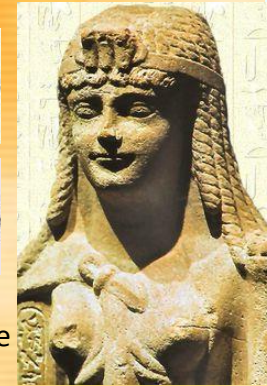
Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage



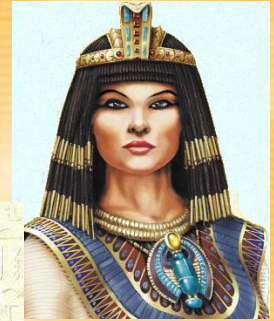
Juba II King of Morocco -
(25b.J.-C.-23a.J.-C)



Drachme Juba II-
Cleopatra Sélénée



Cleopatra Sélénée



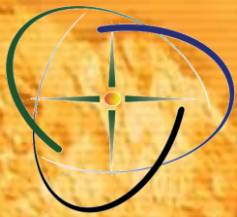
Cleopatra



Ptolémée
(King of Morocco, 40 a. J.C.)
"Last Pharaon"



Drachme Juba II-Ptolémée



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Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

Assistance to museum curators to better know about previous restores without trace in the archives



Rabat Archeological Museum

Statue of Ptolémée (King of Morocco, 40 a. J.C.)
“Last Pharaon”

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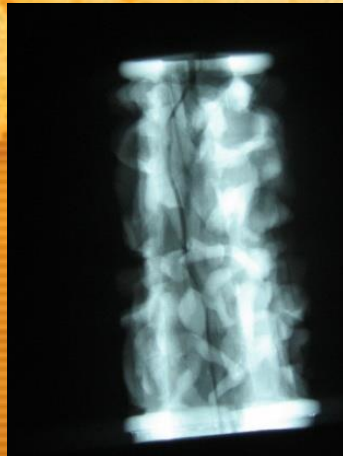
Checking the overall stability of Statue of Ptolémée (King of Morocco, 40 a. J.C.)
“Last Pharaon”



All parts checked !

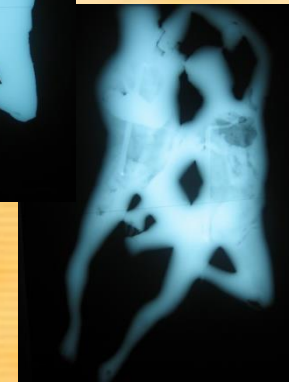
Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

Assistance to museum curators in verifying the state of conservation of artifacts



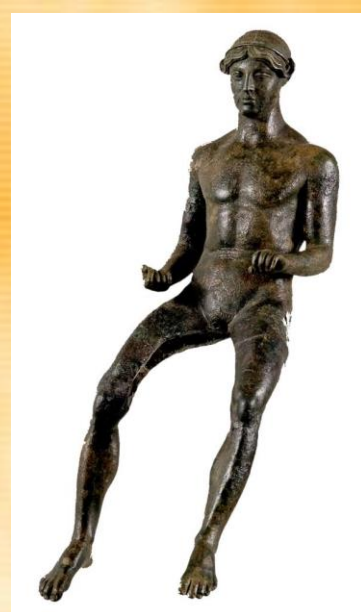
Ivory Pyxide with story-telling sculpture - Sala

Thésée & Minotaure (bronze) -
Lixus

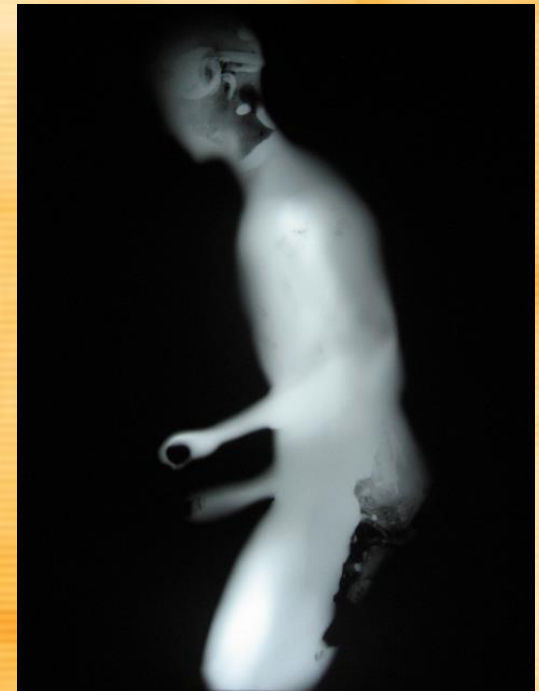




Assistance to museum curators
in verifying the state of
conservation of artifacts



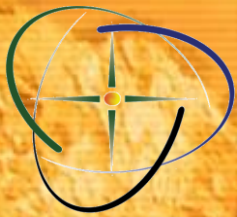
Horse and Rider (bronze)



Rabat Archeological Museum

The background of the slide features a stone archway on the left side, constructed from large, irregular blocks of stone. The entire image is bathed in a warm, golden-yellow light, creating a soft, ethereal atmosphere. The archway leads into a tunnel that recedes into the distance, with the light becoming brighter and more intense as it moves away from the viewer. The overall composition is simple and evocative, suggesting a journey or a path through history or art.

When radiography becomes ... art!

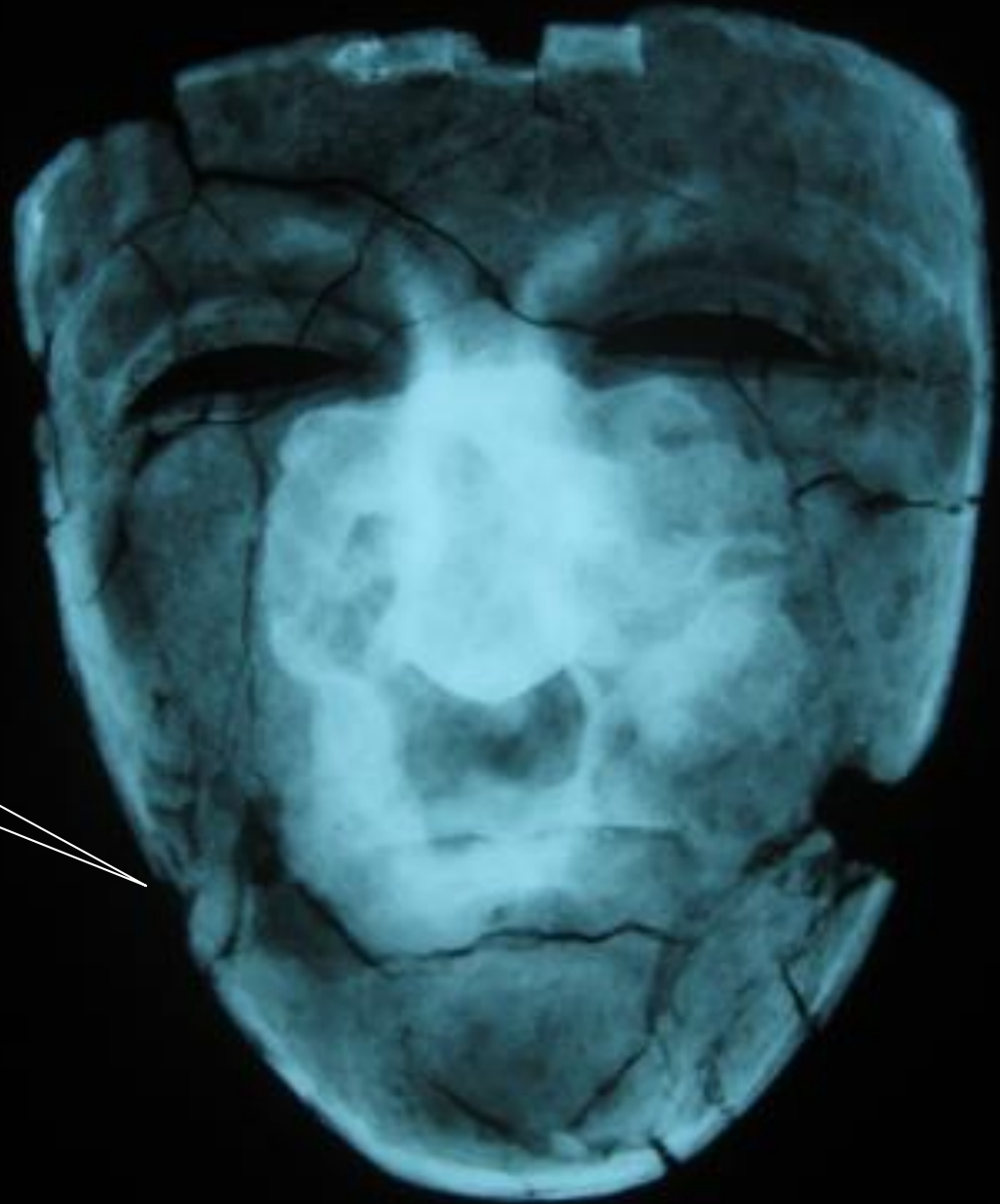


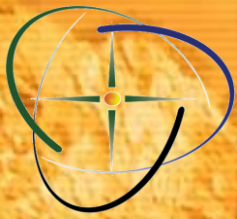
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Assistance to museum curators
in verifying the state of
conservation of artifacts



Why are you
looking at me ?





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*Fragment of a helmet in bronze - Volubilis
Roman period (60-80 ap. J.C.)*

Rabat Archeological Museum

Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

Assistance to curators in verifying the state of conservation/ to better know about previous restores

**X Ray Radiography
+
X Ray Fluorescence Analysis (PMI)
without sampling & without contact**

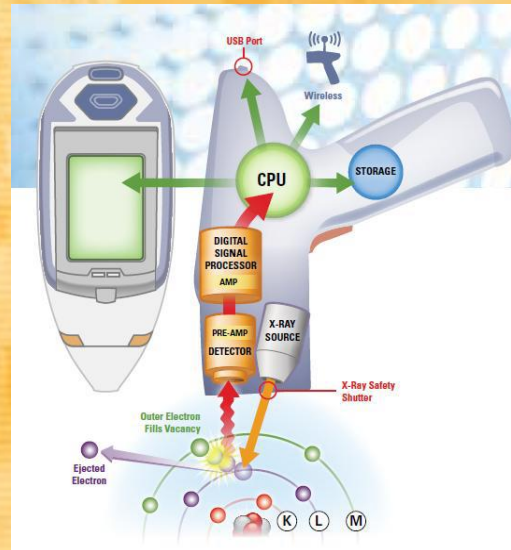
Thermo Scientific
X-RAY ENERGY REFERENCE

Key to Energy Values: K_{L_1} , K_{L_2} , K_{L_3} , L_{L_1} , L_{L_2} , L_{L_3}

H Hydrogen 1.00794	He Helium 4.002602	Key to Energy Values																He Helium 4.002602																													
Li Lithium 6.941	Be Beryllium 9.012182																	Ne Neon 20.1797																													
Na Sodium 22.98976928	Mg Magnesium 24.304																	Ar Argon 39.948																													
K Potassium 39.0983	Ca Calcium 40.078	Sc Scandium 44.955912	Ti Titanium 47.88	V Vanadium 50.9415	Cr Chromium 51.9961	Mn Manganese 54.938044	Fe Iron 55.845	Co Cobalt 58.933195	Ni Nickel 58.6934	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.64	As Arsenic 74.9216	Se Selenium 78.96	Br Bromine 79.904	Kr Krypton 83.80																														
Rb Rubidium 85.4678	Sr Strontium 87.62	Y Yttrium 88.90584	Zr Zirconium 91.224	Nb Niobium 92.90638	Mo Molybdenum 95.94	Tc Technetium 98	Ru Ruthenium 101.07	Rh Rhodium 102.90550	Pd Palladium 106.42	Ag Silver 107.8682	Cd Cadmium 112.411	In Indium 114.818	Sn Tin 118.710	Sb Antimony 121.757	Te Tellurium 127.6	I Iodine 126.90547	Xe Xenon 131.29																														
Cs Cesium 132.90545196	Ba Barium 137.327	Hf Hafnium 178.49	Ta Tantalum 180.94788	W Tungsten 183.84	Re Rhenium 186.207	Os Osmium 190.23	Ir Iridium 192.222	Pt Platinum 195.084	Au Gold 196.966569	Hg Mercury 200.59	Tl Thallium 204.38	Pb Lead 207.2	Bi Bismuth 208.9804	Po Polonium 209	At Astatine 210	Rn Radon 222																															
Fr Francium 223	Ra Radium 226	<table border="1"> <tr> <td>La Lanthanum 138.90547</td> <td>Ce Cerium 140.12</td> <td>Pr Praseodymium 140.90766</td> <td>Nd Neodymium 144.242</td> <td>Pm Promethium 145</td> <td>Sm Samarium 150.36</td> <td>Eu Europium 151.964</td> <td>Gd Gadolinium 157.25</td> <td>Tb Terbium 158.92534</td> <td>Dy Dysprosium 162.50015</td> <td>Ho Holmium 164.930329</td> <td>Er Erbium 167.259</td> <td>Tm Thulium 168.93032</td> <td>Yb Ytterbium 173.05448</td> <td>Lu Lutetium 174.967</td> </tr> <tr> <td>Ac Actinium 227</td> <td>Th Thorium 232.0377</td> <td>Pa Protactinium 231.036888</td> <td>U Uranium 238.02891</td> <td>Np Neptunium 237</td> <td>Pu Plutonium 244</td> <td>Am Americium 243</td> <td>Cm Curium 247</td> <td>Bk Berkelium 247</td> <td>Cf Californium 251</td> <td>Es Einsteinium 252</td> <td>Fm Fermium 257</td> <td>Md Mendelevium 258</td> <td>No Nobelium 259</td> <td>Lr Lawrencium 262</td> </tr> </table>																La Lanthanum 138.90547	Ce Cerium 140.12	Pr Praseodymium 140.90766	Nd Neodymium 144.242	Pm Promethium 145	Sm Samarium 150.36	Eu Europium 151.964	Gd Gadolinium 157.25	Tb Terbium 158.92534	Dy Dysprosium 162.50015	Ho Holmium 164.930329	Er Erbium 167.259	Tm Thulium 168.93032	Yb Ytterbium 173.05448	Lu Lutetium 174.967	Ac Actinium 227	Th Thorium 232.0377	Pa Protactinium 231.036888	U Uranium 238.02891	Np Neptunium 237	Pu Plutonium 244	Am Americium 243	Cm Curium 247	Bk Berkelium 247	Cf Californium 251	Es Einsteinium 252	Fm Fermium 257	Md Mendelevium 258	No Nobelium 259	Lr Lawrencium 262
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Legend:
■ Requires GOLD technology for metal alloys
■ Requires GOLD technology for mining & minerals work

Mg up to U



Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

Assistance to curators
to better know about previous restores /
material characterization



*Ephebe with ivy crown –
Bronze (H.: 140 cm)*



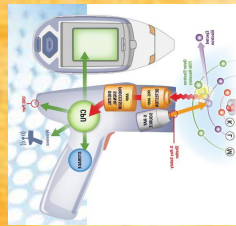
*Gold Almoravid dynasty Dinar
(Au: 95%; Ag: 5%)*

Rabat Archeological Museum

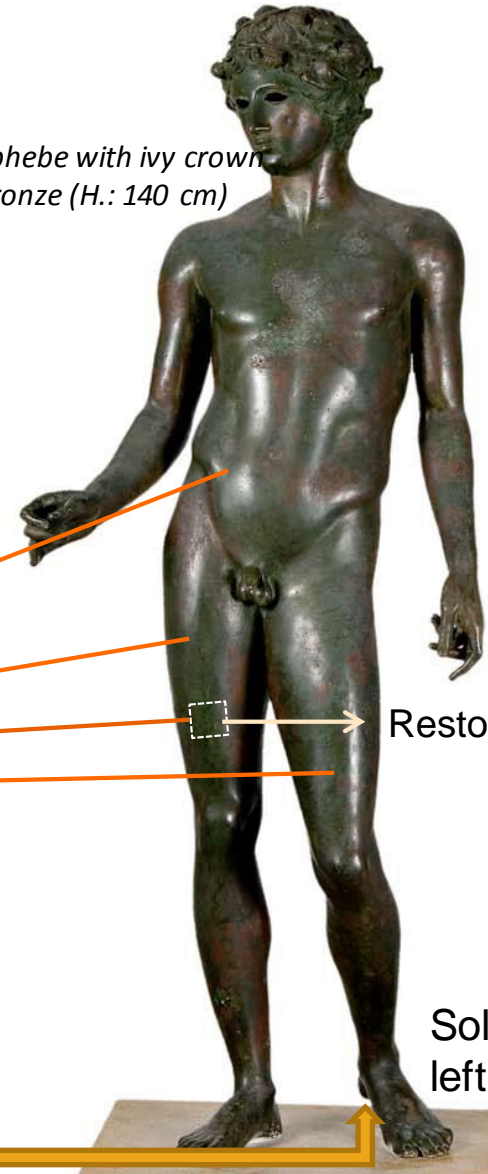
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Material characterization

X Ray Fluorescence Material Characterization



Ephebe with ivy crown
Bronze (H.: 140 cm)



Same material

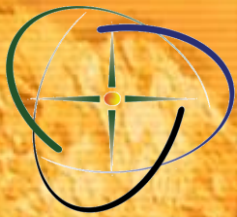
Restored part

Sole of
left foot !

Material origin of restored part?

After deep checking



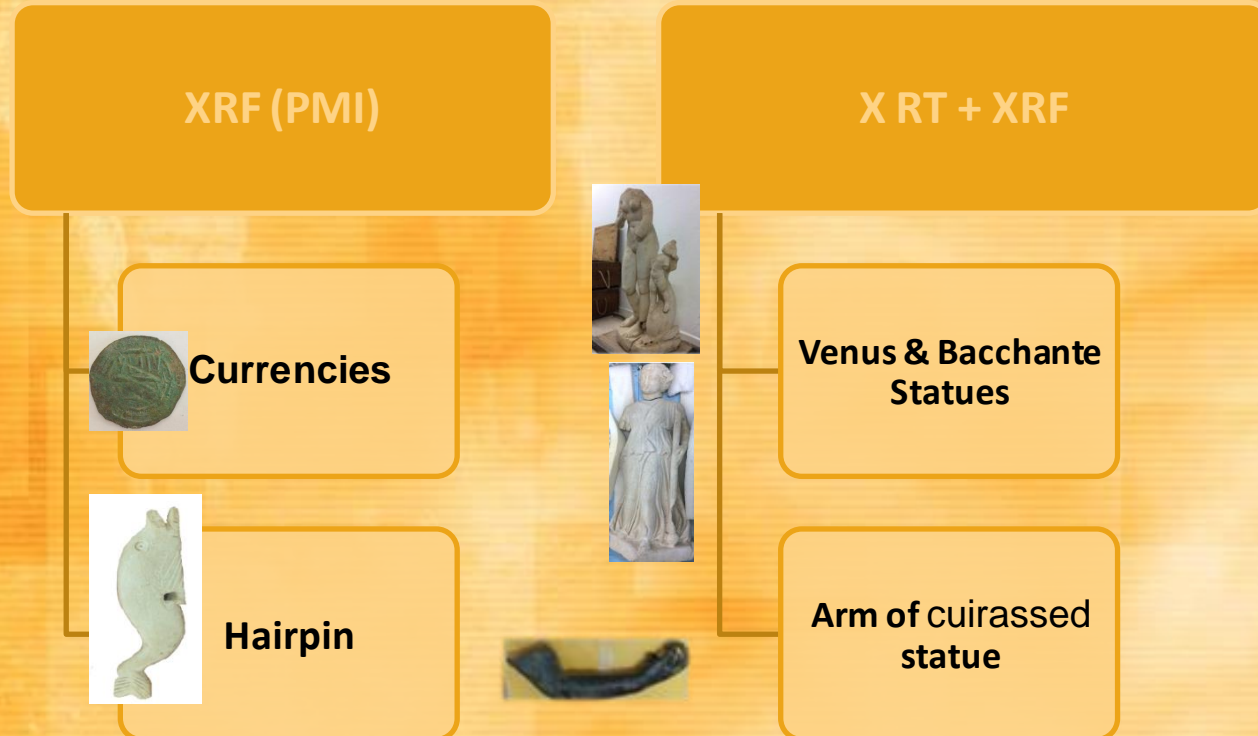


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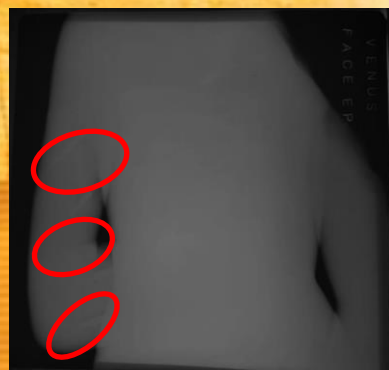
Volubilis Archeological Site





Vénus statue with Eros overcoming a dolphin.

X RT

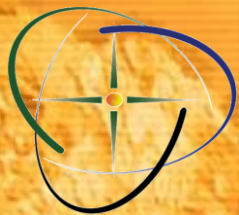


XRF

Elément	Teneur (%)
Blal	63
Ca	37,033± 0,104
S	0,089± 0,057
Fe	0,046± 0,005
Ag	0,026±0,002
Te	0,015±0,003
Mn	0,022± 0,006
Cs	0,009±0,001
Sr	0,009±0,001

Material Characterization





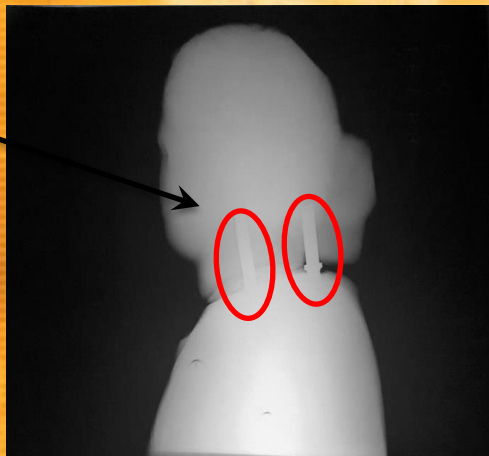
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Volubilis Archeological Site

X RT

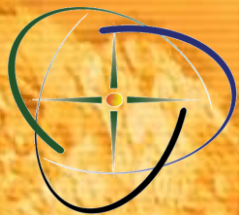


Bacchante wearing a long gown and holding a scepter

XRF

Elément	Teneur (%)
Bal	54%
Ca	45,91±0,126
S	0,115±0,069
Fe	0,054±0,005
Ba	0,039±0,005
Ag	0,020±0,002
Mn	0,018±0,005
Sr	0,013±0,005
Ti	0,012±0,005
Ni	0,013±0,003
Te	0,010±0,002
Pb	0,006±0,001
Cs	0,006±0,001
Sb	0,004±0,001
Sn	0,003±0,001

Material characterization



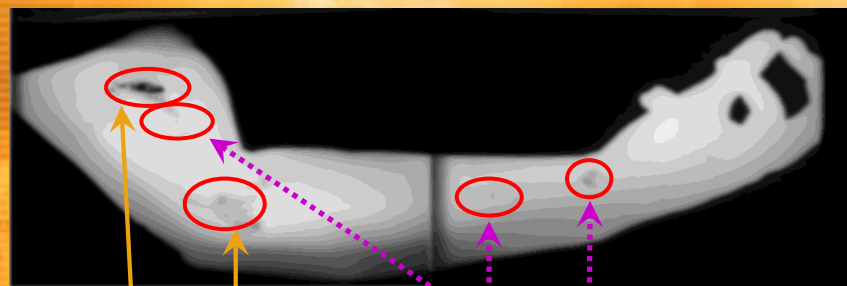
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Volubilis Archeological Site

X RT



Cracks

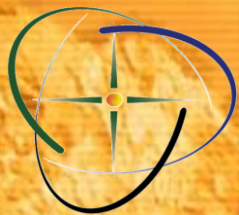
Corrosion

Right arm half-lifted from a cuirassed statue

XRF

Elément	Teneur(%)
Cu	40,215±0,198
Pb	36,236±0,192
Sn	10,26±0,077
Si	8,354±0,149
Al	2,737±0,339
Ti	0,966±0,016
Fe	0,641±0,017
Zn	0,277±0,017
Sb	0,138±0,010
V	0,126±0,008
Cr	0,027±0,007
Zr	0,018±0,003

Material characterization



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Roman currency

Vespasian Emperor



Front side



Pile side

Objet contrôlé	Monnaie romaine Empereur Vespasian
Elément	Teneur (%)
Au	99,14
Fe	0,742
Cu	0,020

Idrissid dynasty currency



Front side

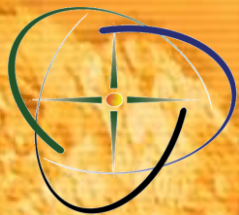


Pile side

Objet contrôlé	Monnaie Idrisside
Elément	Teneur (%)
Au	-
Fe	0,155
Cu	51,009
Ni	-
Cr	0,038
Ag	44,055
Si	3,518
Pb	0,377
Ti	0,161
P	0,136
V	0,088



Volubilis Archaeological Site



CNESTEN

Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage



Volubilis Archaeological Site



Hairpin (dolphin) -
Roman period

Bone ?

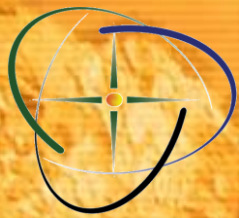
Ivory ?

Mg?

Question from the curator: bone or ivory ?

Only difference in composition: Mg !

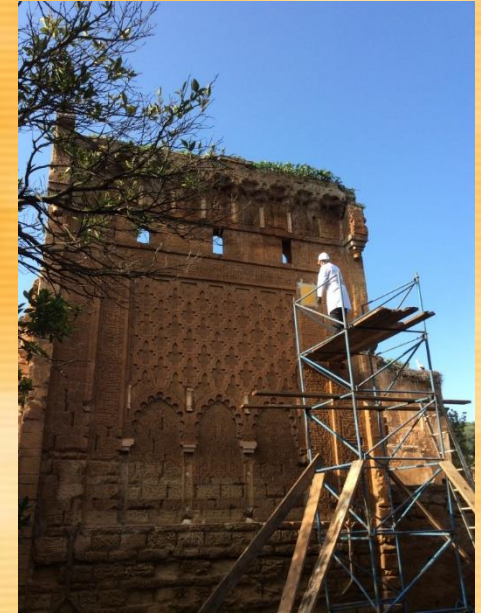
Echantillon	Epingle dauphin (%)	La phase inorganique de l'os (%)
Elément		
Bal	48,991	
Ca	32,176	39
P	16,283	17
Si	1,076	2,4
S	0,541	-
F	0,520	-
Cl	0,130	0,1
K	0,065	0,2



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Radiography and other radiation related techniques in the service of the Preservation of the Moroccan Historical Heritage

*Abu Al-Hassan Al Marini
mausoleum - Chellah*



*Timel Mosque
Almohads dynasty
(XIIth C.)*

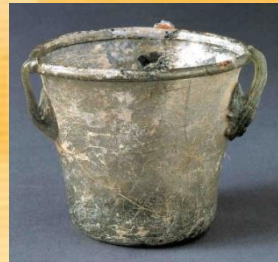
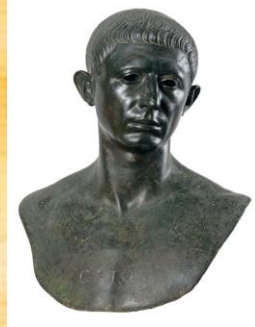


Planned studies

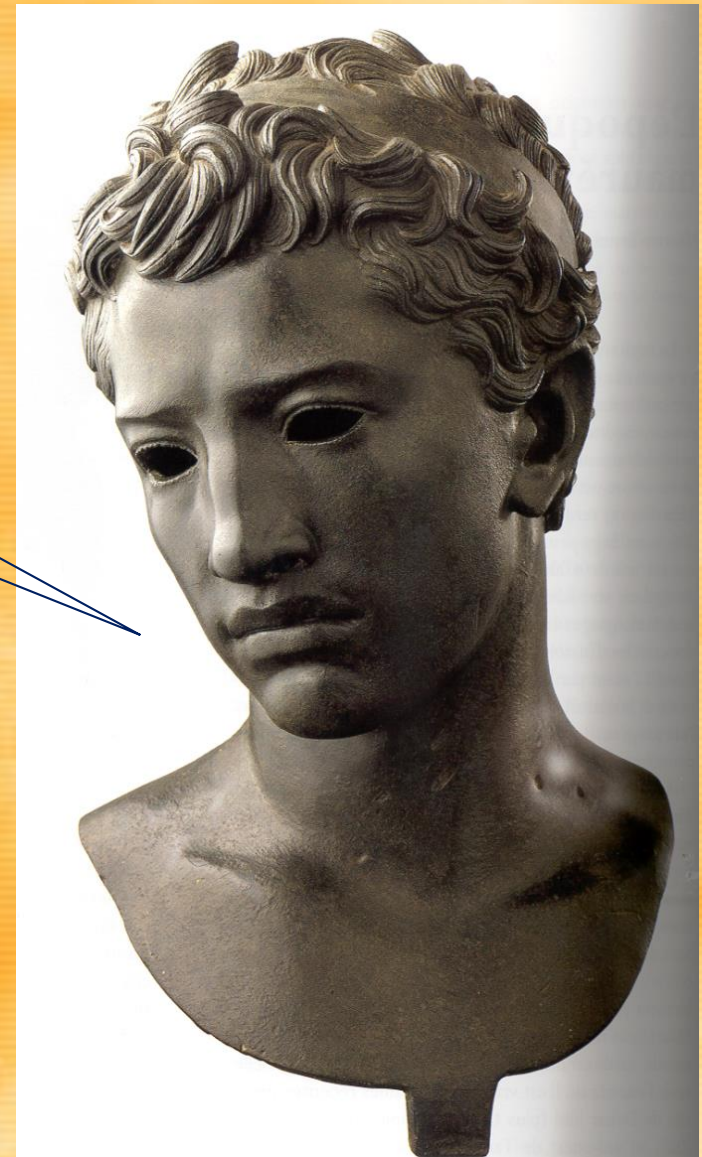


*Borj Bab Marrakech-
Essaouira*

Other planned studies



Thank you for
your attention



*Juba II King of Morocco -
(25b.J.-C.-23a.J.-C)*