Characterization of Cultural Heritage using a Micro-beam

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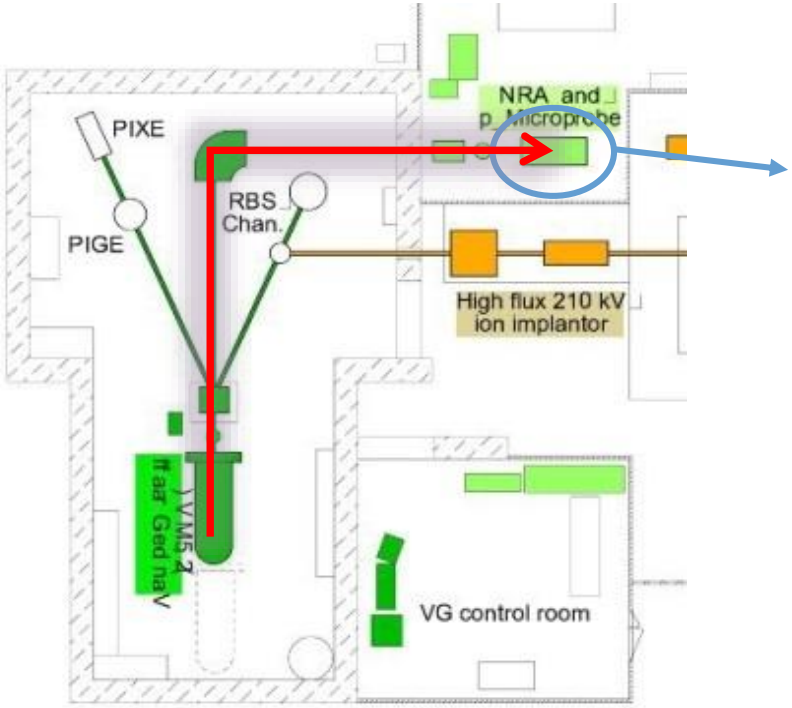
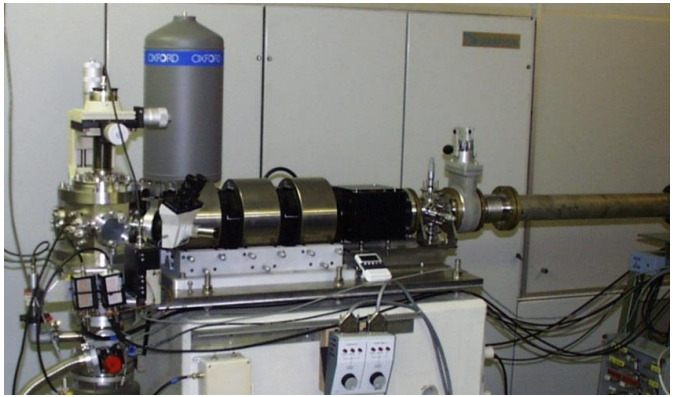
Outline

- Ion beam laboratory @ Lisbon
  - External beam
- Applications
  - Manufacturing techniques
  - The importance of impurities
    - Metals
    - Iron gall inks
- Final remarks

Ion beam laboratory @ Lisbon

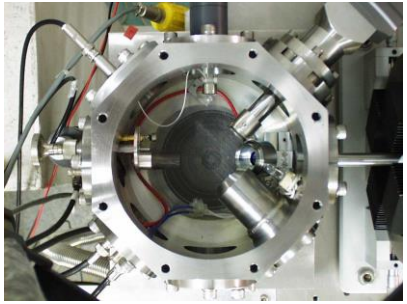


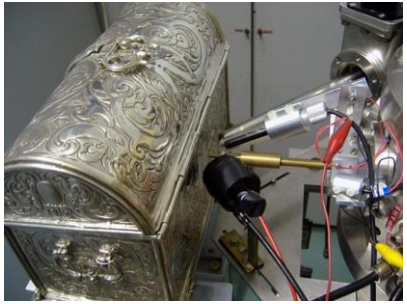


Ion beam laboratory @ Lisbon

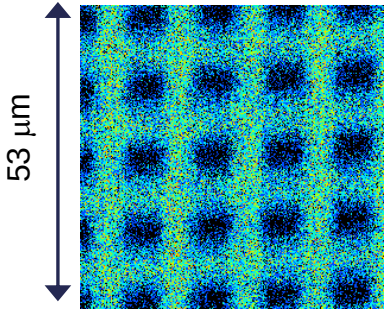
The nuclear microprobe allow us:

- Focus the beam
- Beam scanning
- Work under vacuum or atmosphere conditions

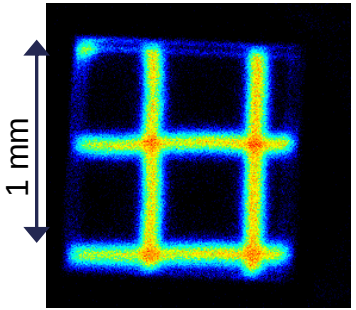




Vacuum:
- Energy: 2MeV
- 100 pA
- Resolution: 3x4 μm^2



Cu grid: 2000 mesh



Cu grid: 50 mesh

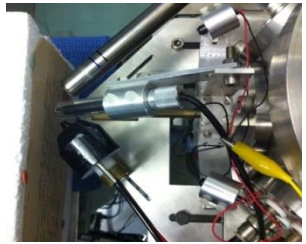
External
- Energy: 1.9MeV
- 1 nA
- Resolution: 65x65 μm^2

Applications

Glass: private collection

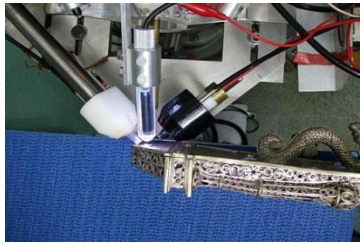
Glass: Amadora Archaeology Museum

Metals, Évora Museum

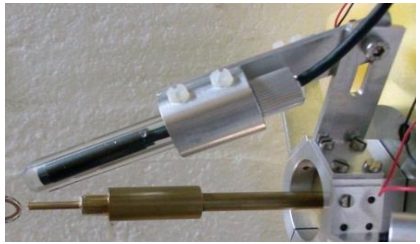


Iron-gall inks, paper
Private Collection

Tiles, Sta Clara-a-Velha, Alcobaça…



Metals, National Fine Arts Museum



Jewellery: Private Collection

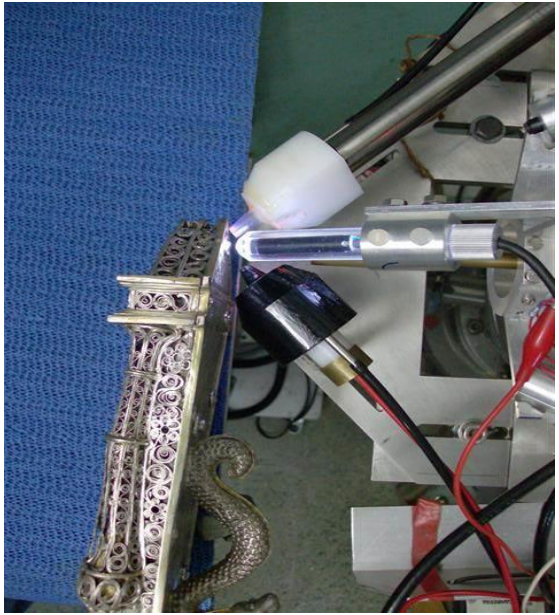
Metals: Anastácio Gonçalves Museum

Pigments, Private collection

Ceramics

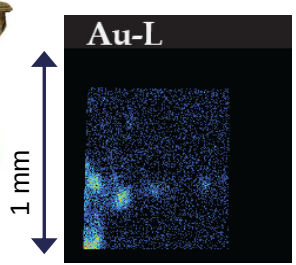
Assessing manufacturing, golden surfaces

Ciborium, CMAG 1180
Silver with partially gilded areas.
Portuguese origin
XVI century.

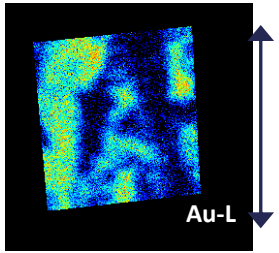


Pax, MNAA
Silver with golden areas.
Indo-Portuguese origin
XVI century.

Assessing manufacturing, golden surfaces

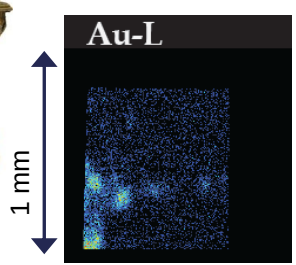


Both silver objects have golden surfaces



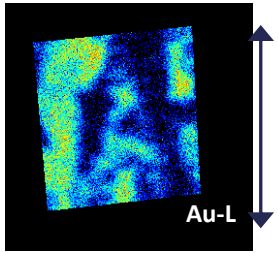
V. Corregidor et at., /10.1016/j.nimb.2011.04.070

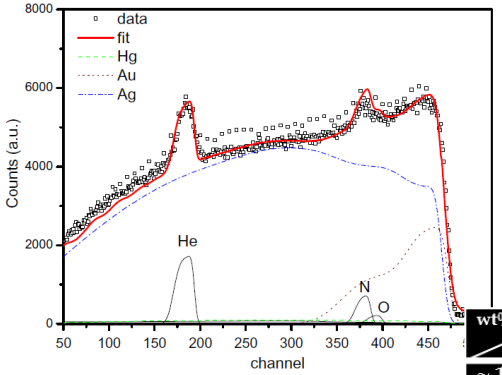
Assessing manufacturing, golden surfaces



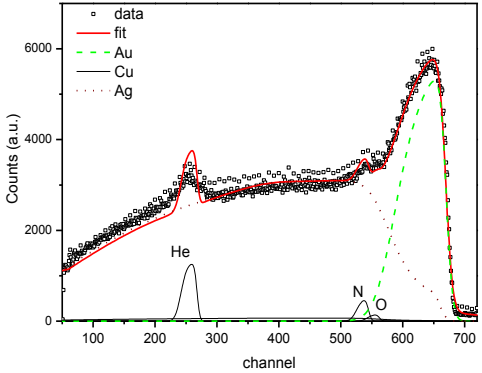
Both silver objects have golden surfaces

The RBS spectra show different gold content and depth distribution





wt% / thick.	Cu	Ag	Au	Hg
~ 1 µm	0.3	67.6	31.2	0.7
~1.5 µm	1.3	80.9	16.3	1.0
-	2.5	95.7	-	1.4



wt% / thick.	Cu	Ag	Au
~466 nm	1,4	24,3	74,3
~356 nm	2,0	35,5	62,5
~270 nm	2,5	43,9	53,6
-	5,4	94,6	0,0

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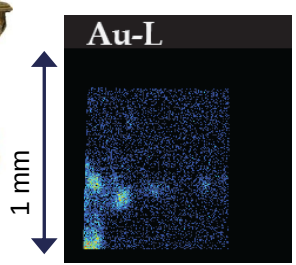
Assessing manufacturing, golden surfaces



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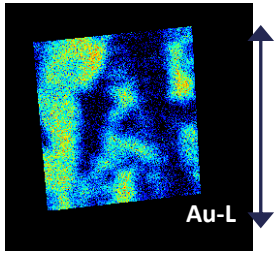

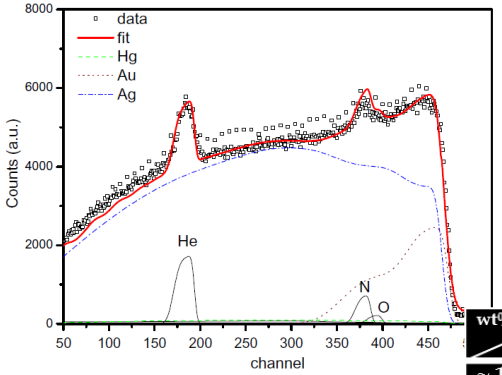

IBA allows to identify manufacturing techniques

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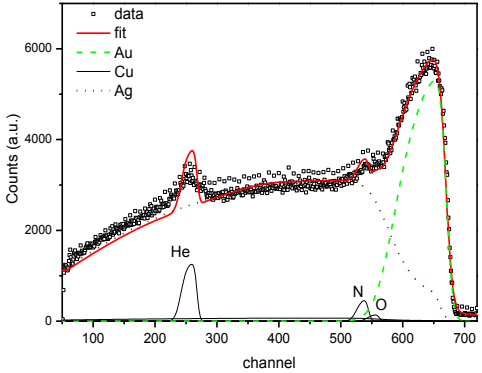

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Assessing manufacturing, golden surfaces

Both silver objects have golden surfaces

The RBS spectra show different gold contents and depth distribution

Mercury Fire Gilding method

IBA allows to identify manufacturing techniques

	Ag	Au	Hg
	67.6	31.2	0.7
~1.5 µm	1.3	80.9	16.3	1.0
[redacted]	2.5	95.7	–	1.4

Au leaf method

Au
74,3
62,5
53,6
0,0

V. Corregidor et at., /10.1016/j.nimb.2011.04.070

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  - The importance of impurities
    - Metals
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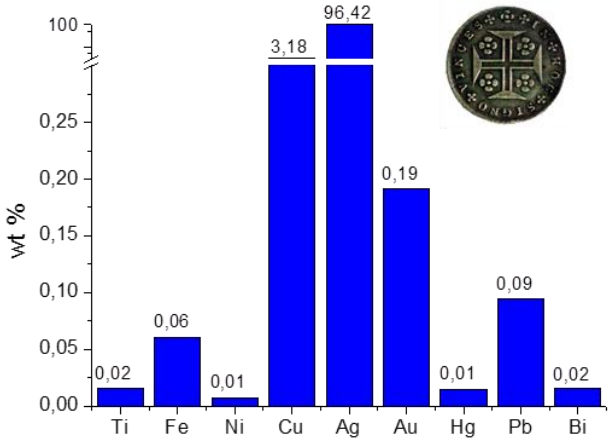
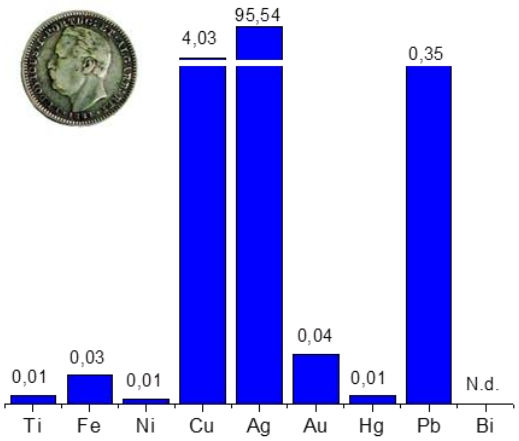
The importance of the impurities

Portuguese Silver coins:

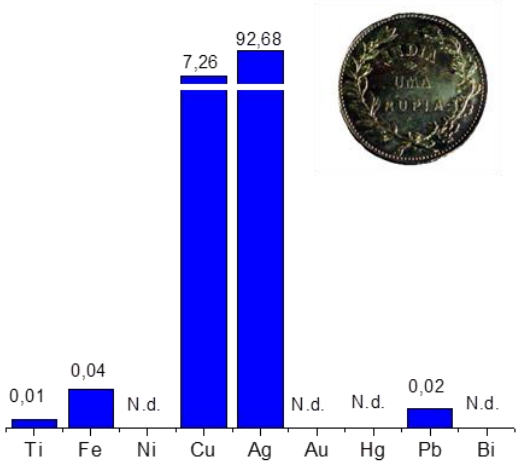
- Ag e Cu as main constituents.
- Along time, the control of impurities have been improved: extraction method and purification of the raw material.
- Trace elements: Ag origin, date, …



6 vinténs – D. João VI (1816-1826)



1/2 Rupia 1881



1 Rupia 1912

PRIVATE COLLECTION

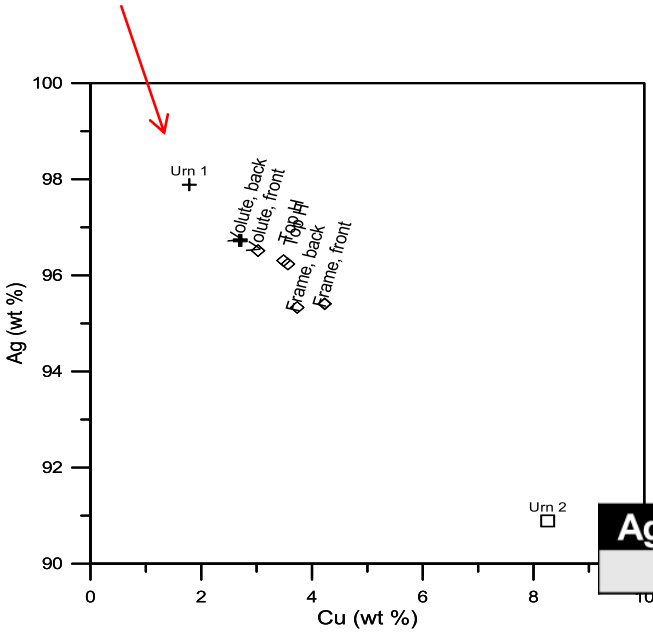
The importance of the impurities

Oratory, MNAA
Silver with golden areas.
Indo-Portuguese origin
XVI century.

The importance of the impurities

Oratory, MNAA
Silver with golden areas.
Indo-Portuguese origin
XVI century.

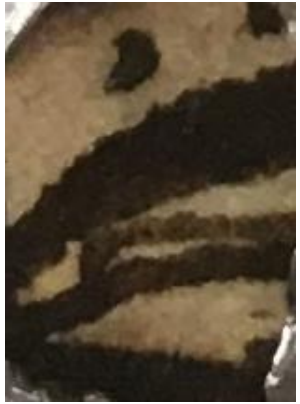
Ag (wt %)	Cu (wt %)	Impurities
89,9	9,2	Fe, Pb, Au, Bi, **Zn, Ni**

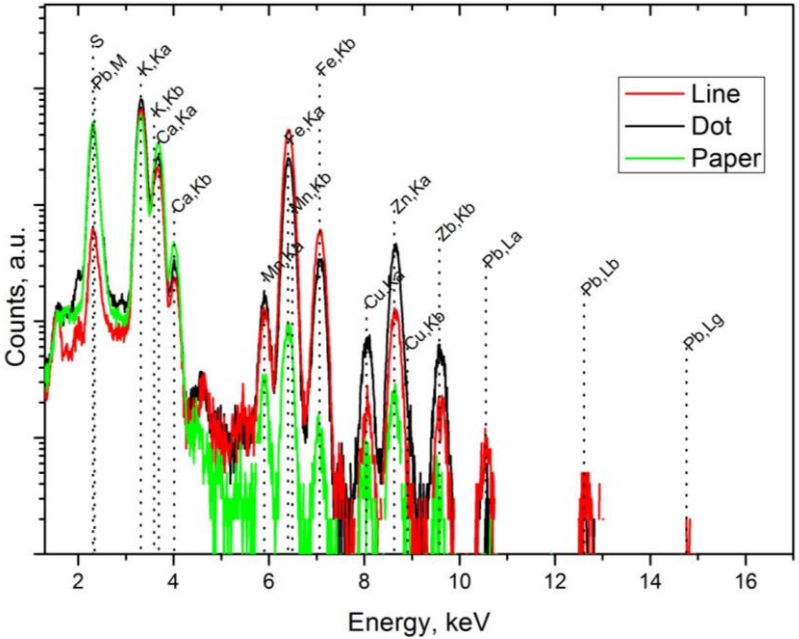


Ag (wt %)	Cu (wt %)	Impurities
97,6	1,9	Fe, Pb, Au, Bi

mnaa
Museu Nacional de Arte Antiga

The importance of the impurities: Iron gall inks





Protons
2MeV

PIXE confirms that ink is iron-gall ink.
Ink: Fe and S as main elements and Cu, Zn, Pb, Mn as minor, depending on the ink
Paper: besides cellulose, Ca, K. Also it is possible detect Fe, Cu, Mn due to ink migration

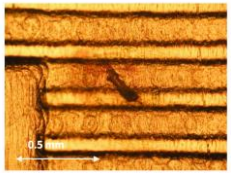
Final remarks

- Ion beam techniques allow to:
  - obtain compositional distribution without sampling,
  - characterize a wide range of materials,
  - determine production techniques
- From the impurities
  - provenance
  - Difference between similar items

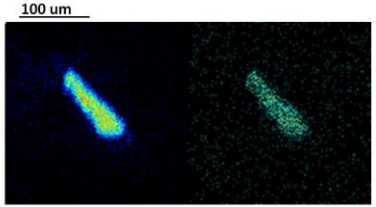
Elemental depth distribution – 3D imaging

INCM - 2006
Finishing: FDC

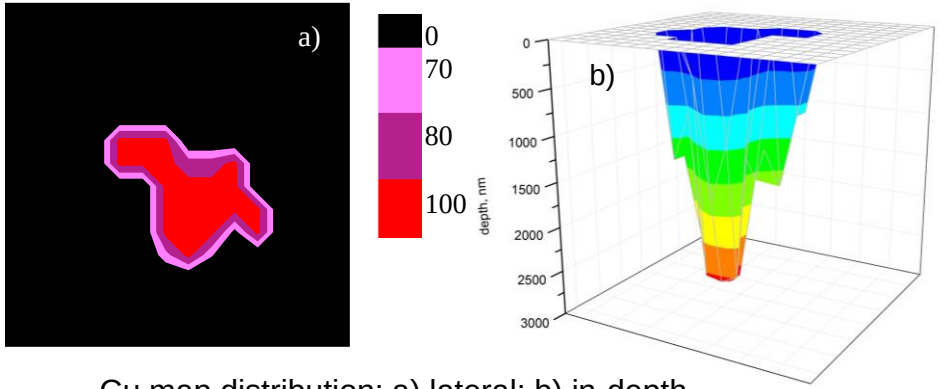
Poster 122



Gold coin with a defect, with high content of Cu and Zn



neural networks



Cu map distribution: a) lateral; b) in-depth

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