

# Authenticity of Germolles' Mural Decoration and Painting Technique

## The Input of Imaging Techniques



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Develop an optimised and adapted use of **spectral**  
and **spatial techniques** for the documentation of  
Cultural Heritage

## **Re-examination** of unique medieval wall paintings

- **Rediscovered** in the 1940s
- **Restored** in the 1990s
- **But not documented**

On the basis of existing **medieval records**





One of the few princely residences of the end of the  
14th. c. still surviving in France





**Margaret of  
Flanders**

Lille, Musée de l'Hospice  
Comtesse, 16<sup>th</sup> century



**Philip the Bold**

Vienne, Hofburg, 16<sup>th</sup> c.

Best preserved residence of the **Dukes of Burgundy**  
**(1380-1400)**





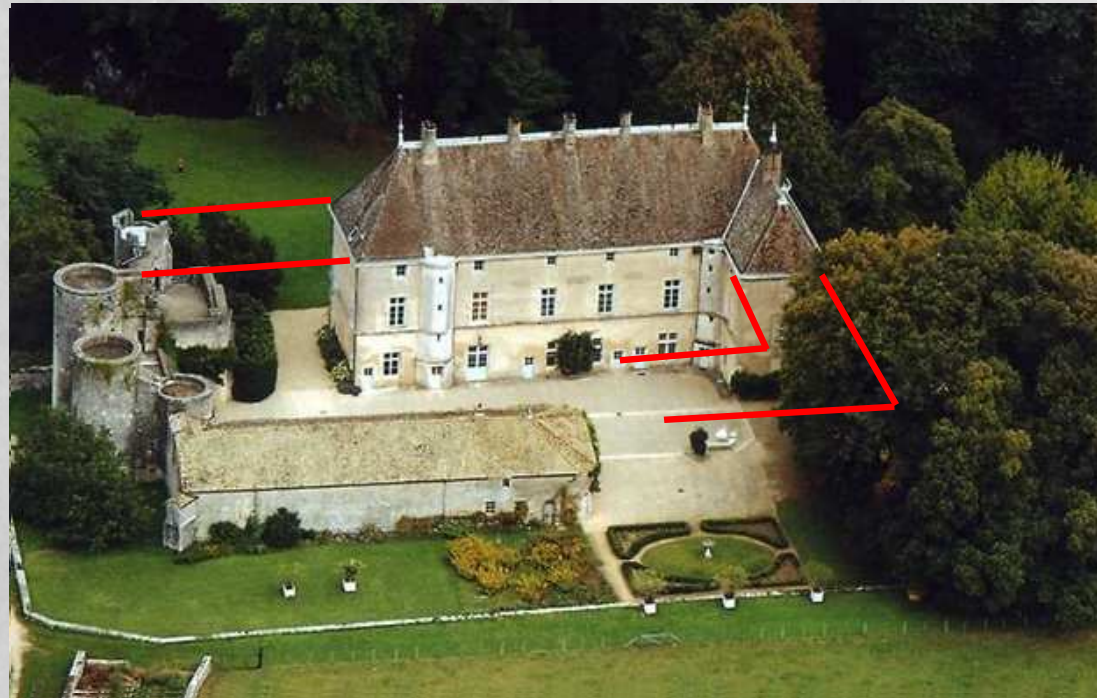




Private but listed  
10 000 visitors / year



# Ducal Palace of Germolles





# Germolles' mural decoration

## Jean de Beaumetz workshop





# Germolles' mural decoration

## Jean de Beaumetz workshop



**Margaret of Bavaria**



**Philip the Bold**



**Margaret of Flanders**

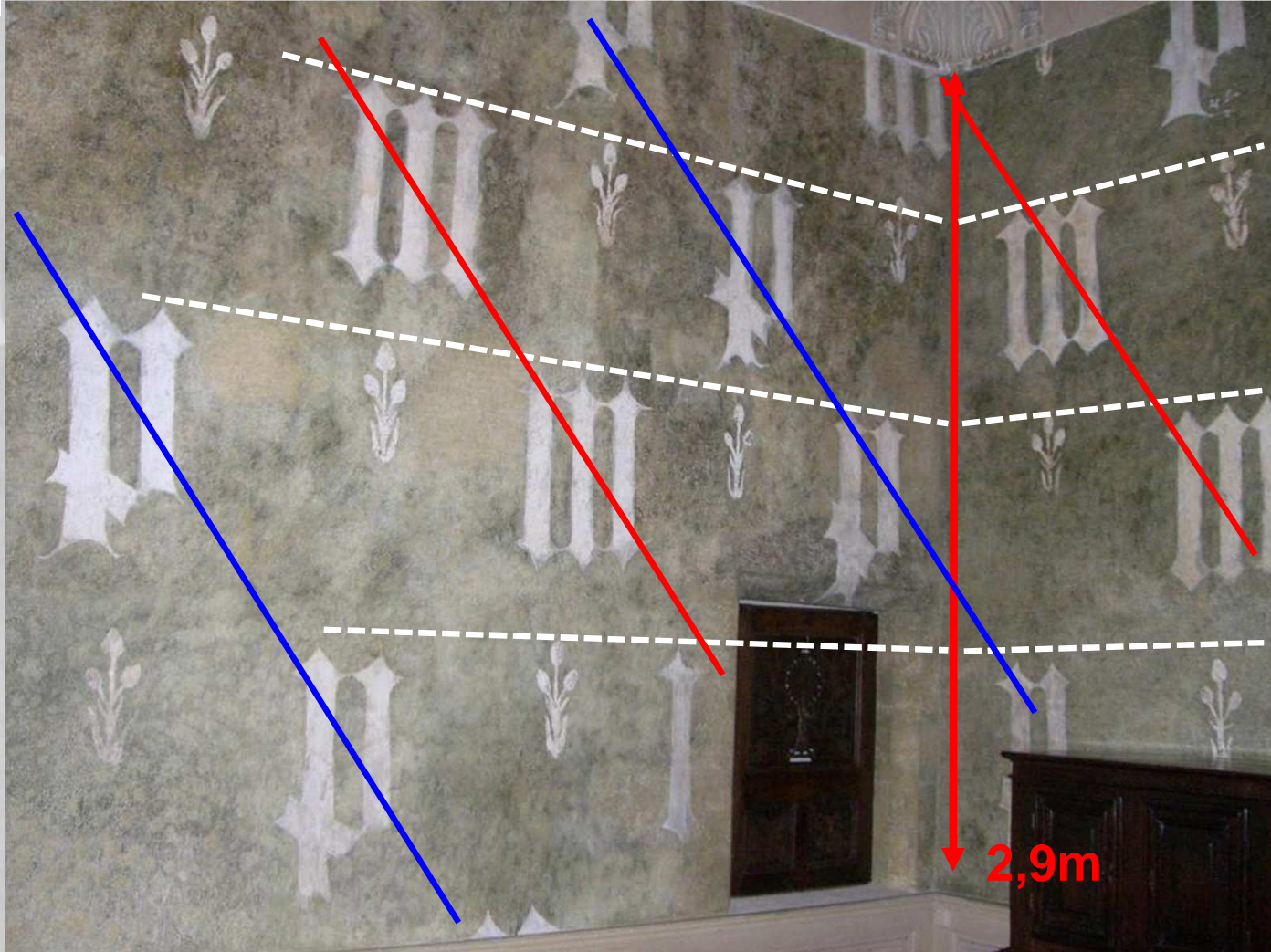






**Dressing-room of Margaret of Bavaria (Countess of Nevers)**





A thoughtful  
distribution  
of **symbols**

**Dressing-room of Margaret of Bavaria (Countess of Nevers)**



# Historical facts



Before 1940

- **Aged** (14<sup>th</sup> to 18<sup>th</sup> c.)
- **Keyed** (beginning of the 19<sup>th</sup> c.)
- **Application of a new plaster**



# Historical facts



- **Aged** (14<sup>th</sup> to 18<sup>th</sup> c.)
- **Keyed** (beginning of the 19<sup>th</sup> c.)
- **Application of a new plaster**
- **Rediscovered** around 1940



# Historical facts



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- **Cleaned** in the 1970s
- **First restoration** in the 1980s



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- **De-restoration**, end of the 1980s



# Historical facts



©I. Takahashi



©I. Takahashi

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©I. Takahashi

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- **De-restoration**, end of the 1980s
- **Re-restoration**, beginning of the 1990s
- **Consolidation (Paraloid B72)**

©I. Takahashi



# Goals

- **Objective 1: Distinguishing** original material from restoration work and **conservation condition**
- **Objective 2: Rediscovery** of the original materials
- **Objective 3: Analysis** of original materials
- **Objective 4: Understanding** the painting techniques used
- **Objective 5: Interconnection** between data and their management
- **Objective 6: 3D virtual representation** of the original decoration



# Recording techniques

From non invasive to slightly invasive approach

## Distinguishing original material from restoration work



UV observation with  
**mobile hand-held high  
intensity UV lamp:  
STSM1**



# Recording techniques

From non invasive to slightly invasive approach

## Distinguishing original material from restoration work



VIS, UV and IR  
photographs (**technical  
photography**) at macro  
levels: STSM1

**Acq:** Digital camera CANON  
EOS 5D Mark II. Illumination:  
Halogen Lowel V (500W) lights  
(for VIS and IR light) and UV  
light: Hg vapour lamps with  
DUG11 filters (to block parasitic  
light)



# Rediscovery of the original materials

## Micro-technical photography: STSM1

Dino-lite digital microscope  
pro AM413T-FVW with  
visible and UV light sources





# Rediscovery of the original materials



## Structured Light Imaging

**Acq.:** 3D SMART SCAN scanner  
using the OPTOCAT software

**Proc.:** OPTOCAT software



# Rediscovery of the original materials

## Highlight-Reflectance Transformation Imaging: STSM4

**Acq.:** Nikon D 7100 digital camera equipped with a variable focal (DX-VR, AF-S 18-140) and used with maximum magnification (140 mm), at a working distance of approximately 25cm.  
**Illumination:** torch equipped with a LED of a power of white light (XM L2)

**Proc.:** RTIbuilder and RTIViewer softwares





# Rediscovery of the original materials



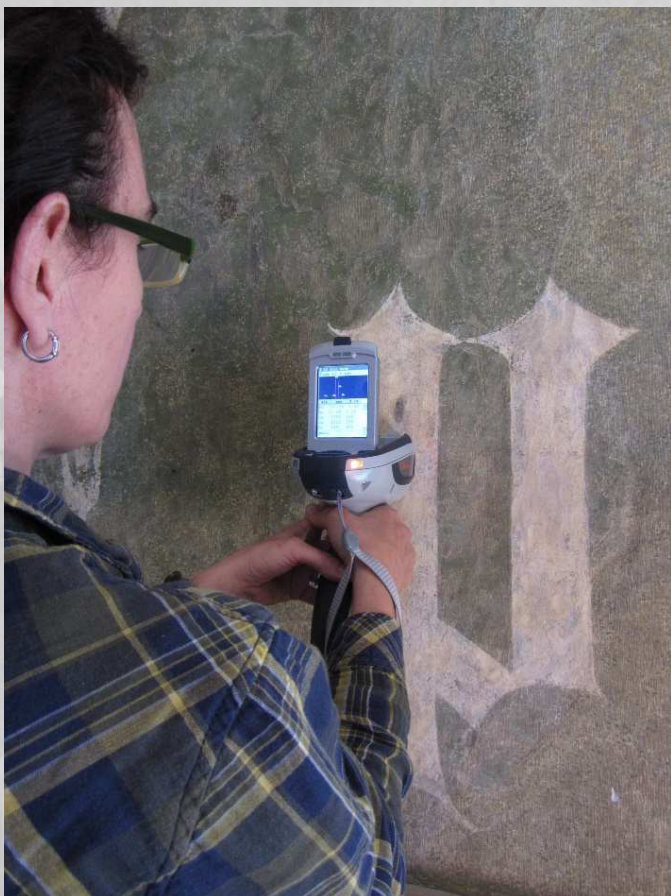
## Hyperspectral imaging

**Proc.:** CCD camera (HS-XX-V10E), developed by SPECIM and providing a 1600 x 840 pixel resolution, a spectral resolution of 2.8 nm and a wavelength range between 400 to 1000 nm. Illumination: two halogen lamps oriented to 45°

**Acq.:** ENVI 5.2 + IDL software



# Analysis of original materials



Non invasive:  
**XRF: STSM2**



# Analysis of original materials

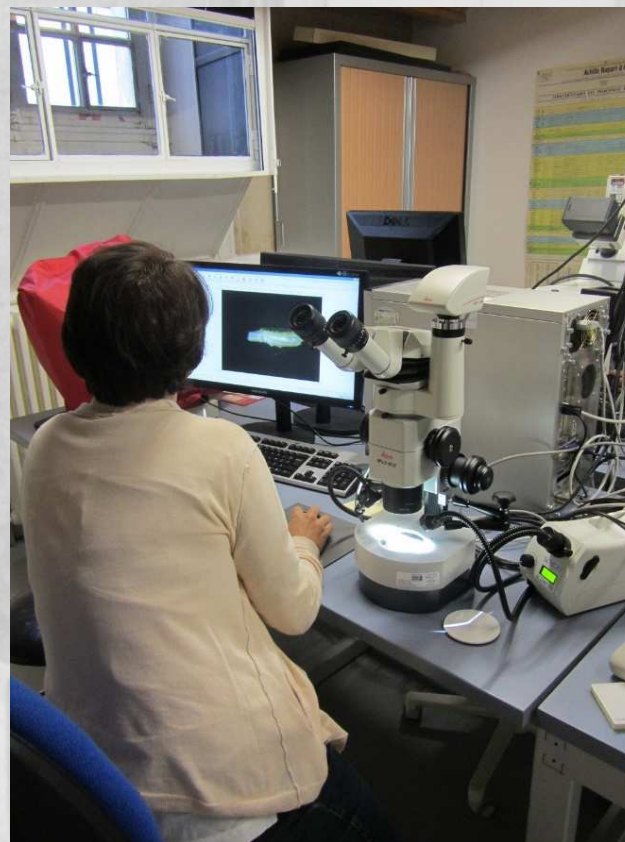
Micro-destructive:  
**LIBS**





## Analysis of original materials

Sampling of a detached fragment from a thistle

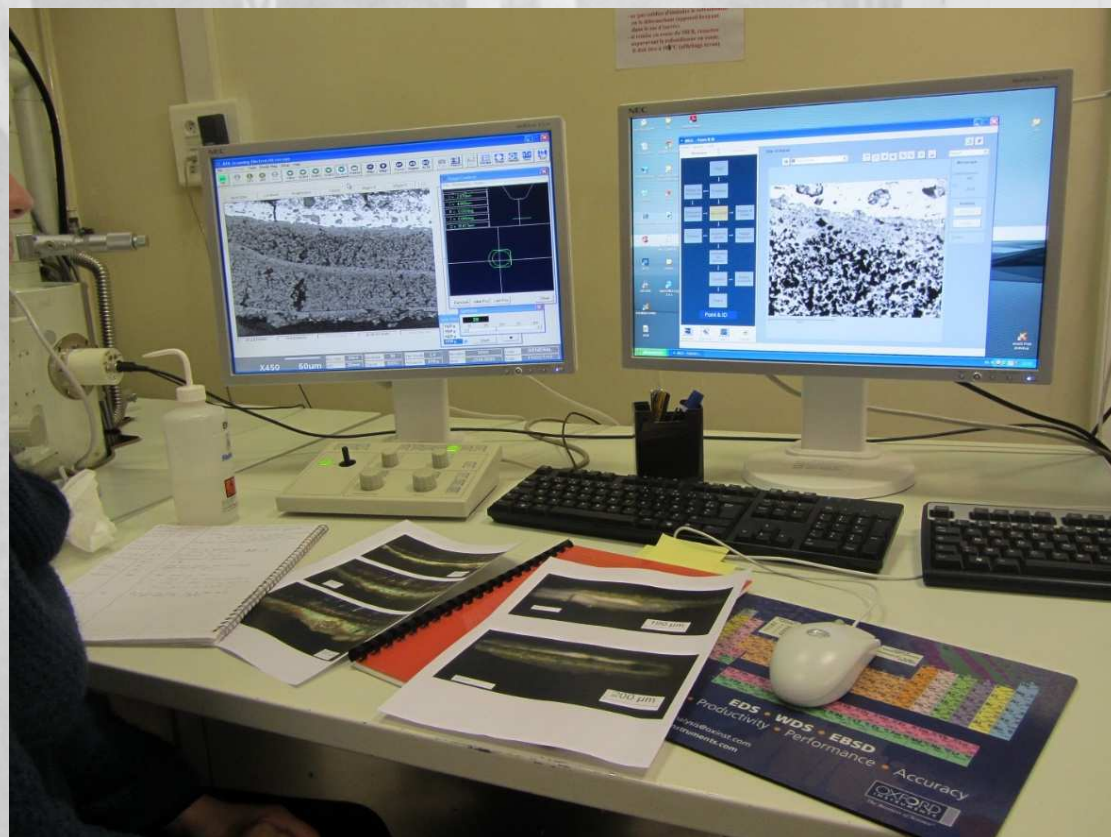


**Observation of a  
cross-section under  
microscope**



# Analysis of original materials

Sampling of a detached fragment from a thistle



**SEM-EDS**



# Analysis of original materials

## Sampling of a detached fragment from a thistle



**FTIR**



## Conservation condition



**VIS photographs at  
micro level: STSM4**



# Conservation condition



**Spectrocolorimetry:  
STSM2**

**Proc.: Minolta CM-  
700d handheld  
spectrophotometer**



# Conservation condition

## IR thermography: STSM5

**Acq.:** Thermocamera testo 890 equipped with IR-FPA (focal-plane array) detector. IRT can be passive or active using an air convector. Images collected with camera IRsoft (Testo) software

**Proc.:** IRsoft (Testo) software + LabView® platform as a programming system



# Interconnection between data and their management



## Photogrammetry

**Acq.:** Canon EOS 6D digital camera equipped with a 16-35 mm stabilized zoom lens set at 16 mm

**Proc.:** PhotoScan (Captair) or processing chain Tapioca / Tapas / MicMac (MAP).



# Constraints

- Size of the room
- Daylight changes (shutters had to be closed)
- Visits (not interrupted)
- Availability of techniques & experts
- Work progress bringing new needs

# Results

## Distinguishing original material from restoration work



## Technical photography



# Results

## Distinguishing original material from restoration work

### Technical photography





# Results

## Distinguishing original material from restoration work



## Technical photography



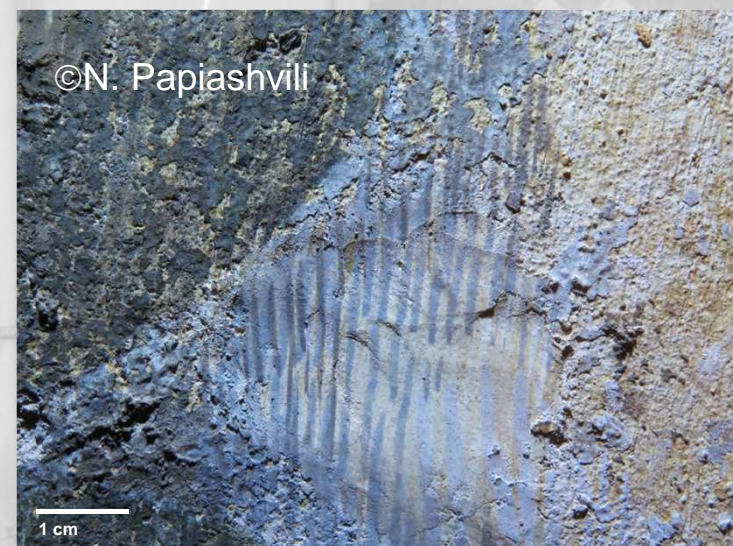


# Results

## Distinguishing original material from restoration work



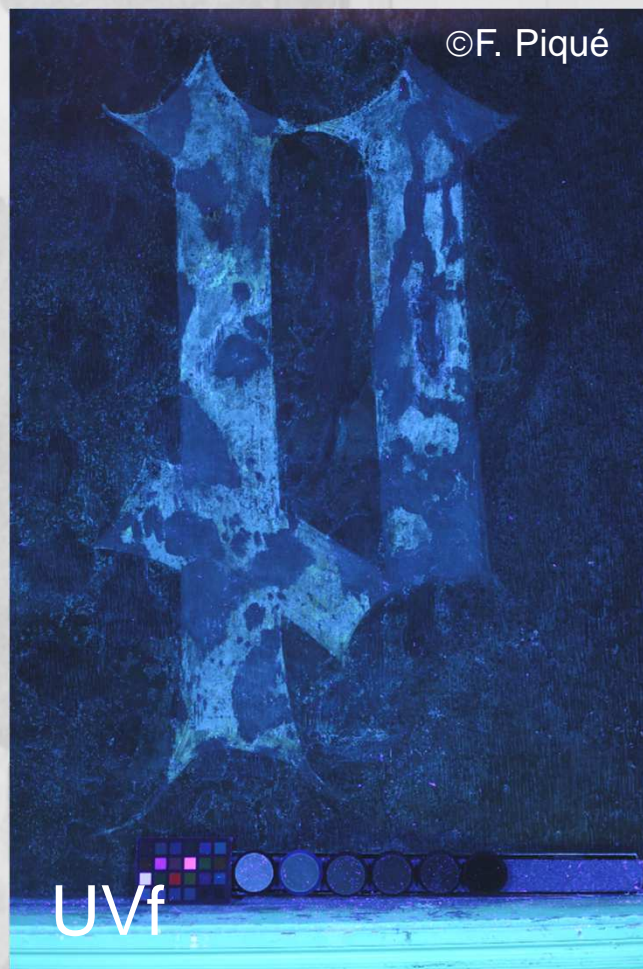
## Technical photography





# Results

## Distinguishing original material from restoration work



## Technical photography





# Results

## Distinguishing original material from restoration work



## Technical photography

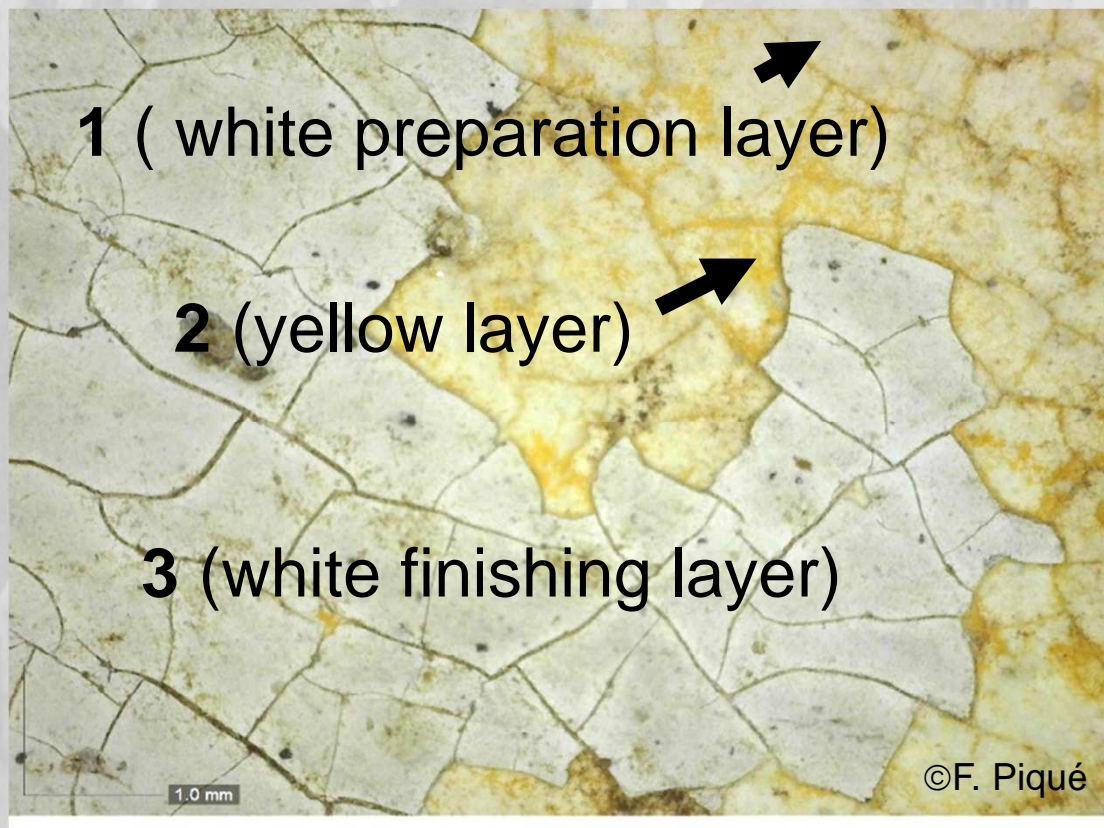




# Results

## Rediscovery and analysis of the original materials

### $\mu$ -technical photography



### Letters “M” & “P”

### XRF & LIBS



Pb

Fe, Al, Si (ochre)

Ca (lime)





©F. Piqué



# Similarity of letters “M” ? **Stencilling**



©F. Piqué



# Letters “P” look similar but...





# Technical photography



Letters «P»  
embellished



VIS



© F. Piqué

© H. Takahashi



1982





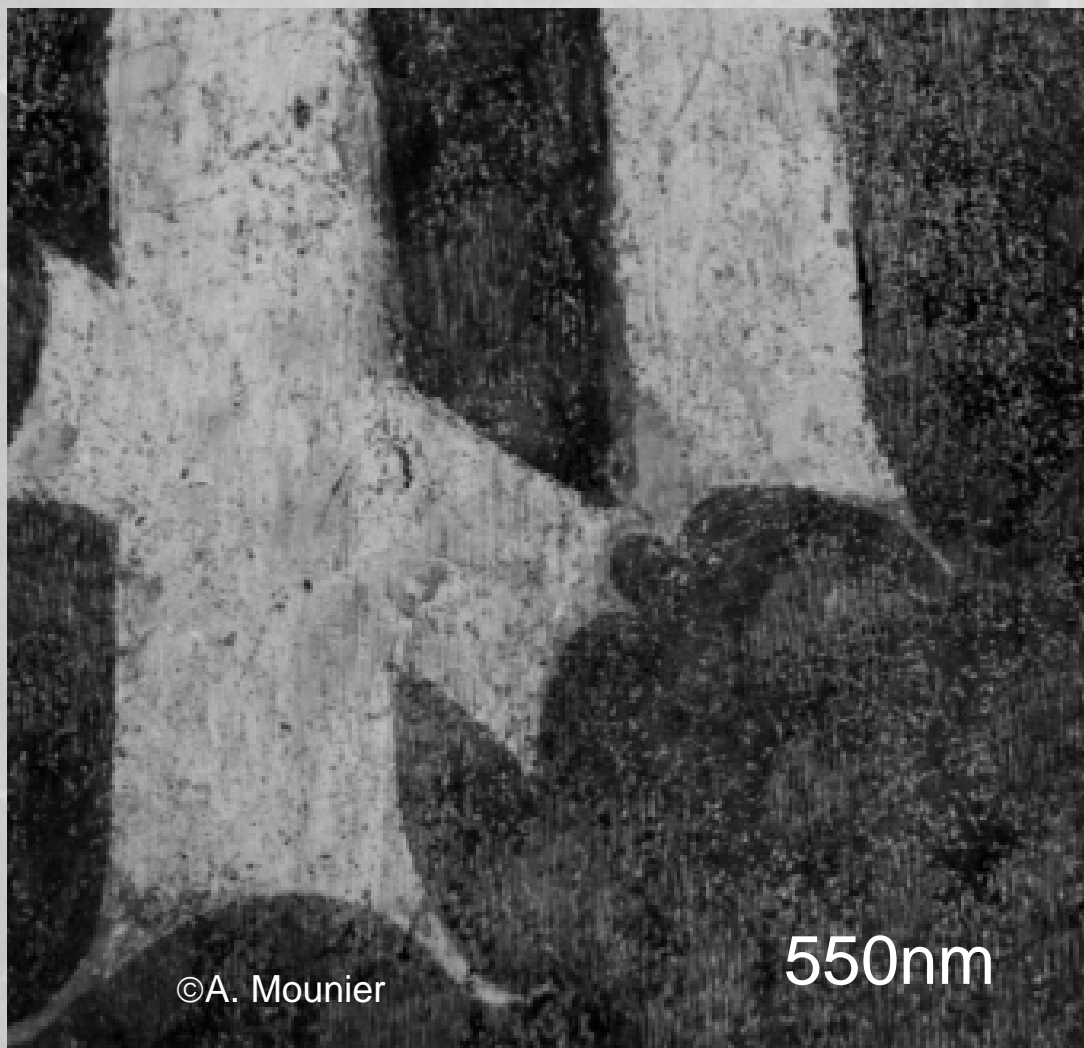
© F. Piqué



# Hyperspectral imaging



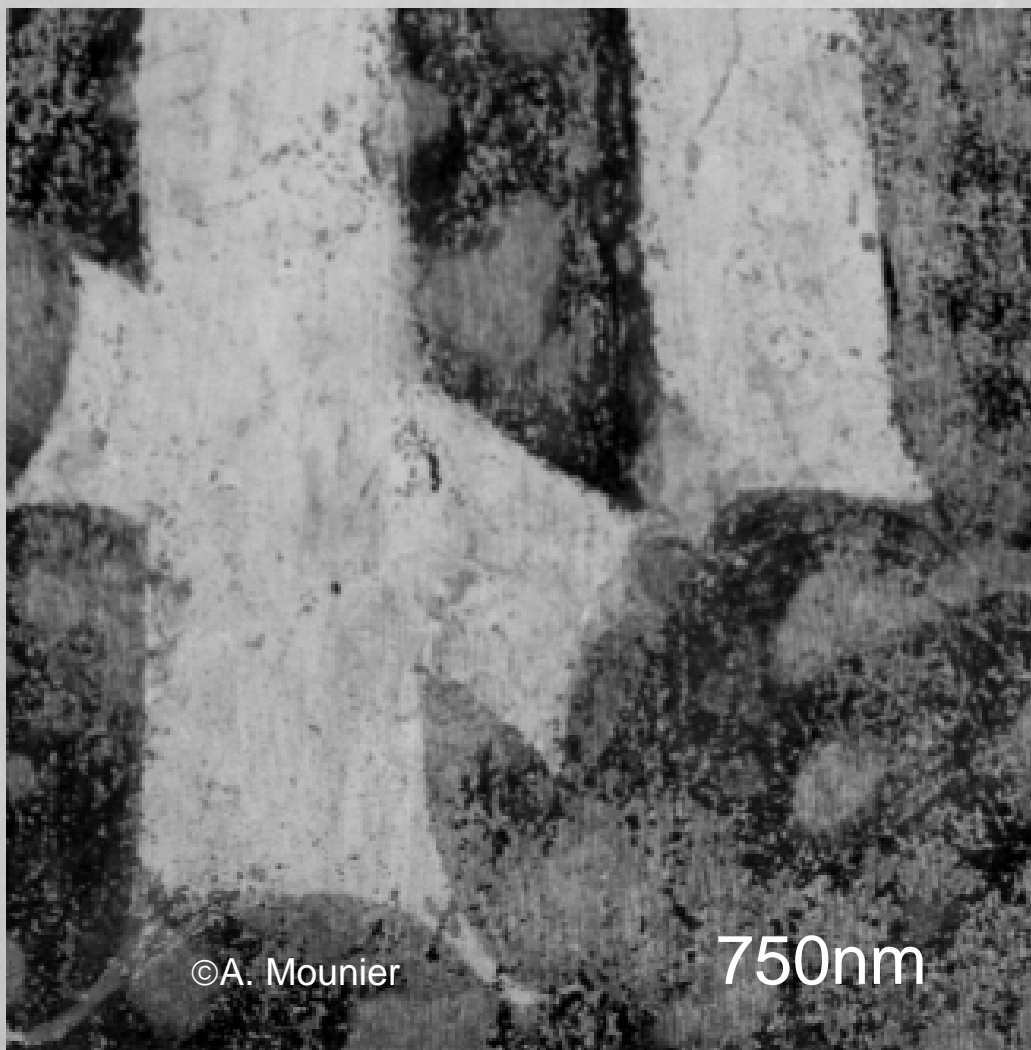




©A. Mounier

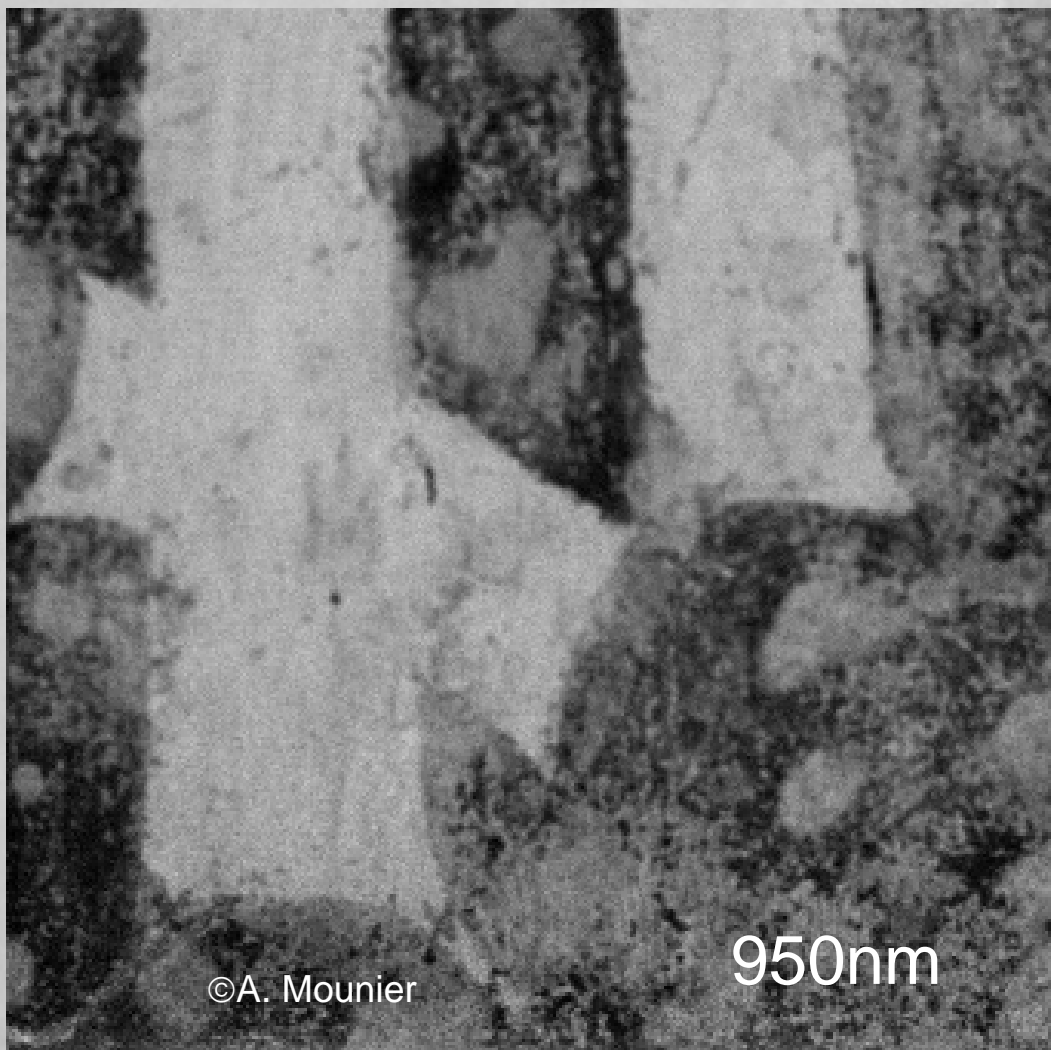
550nm





©A. Mounier

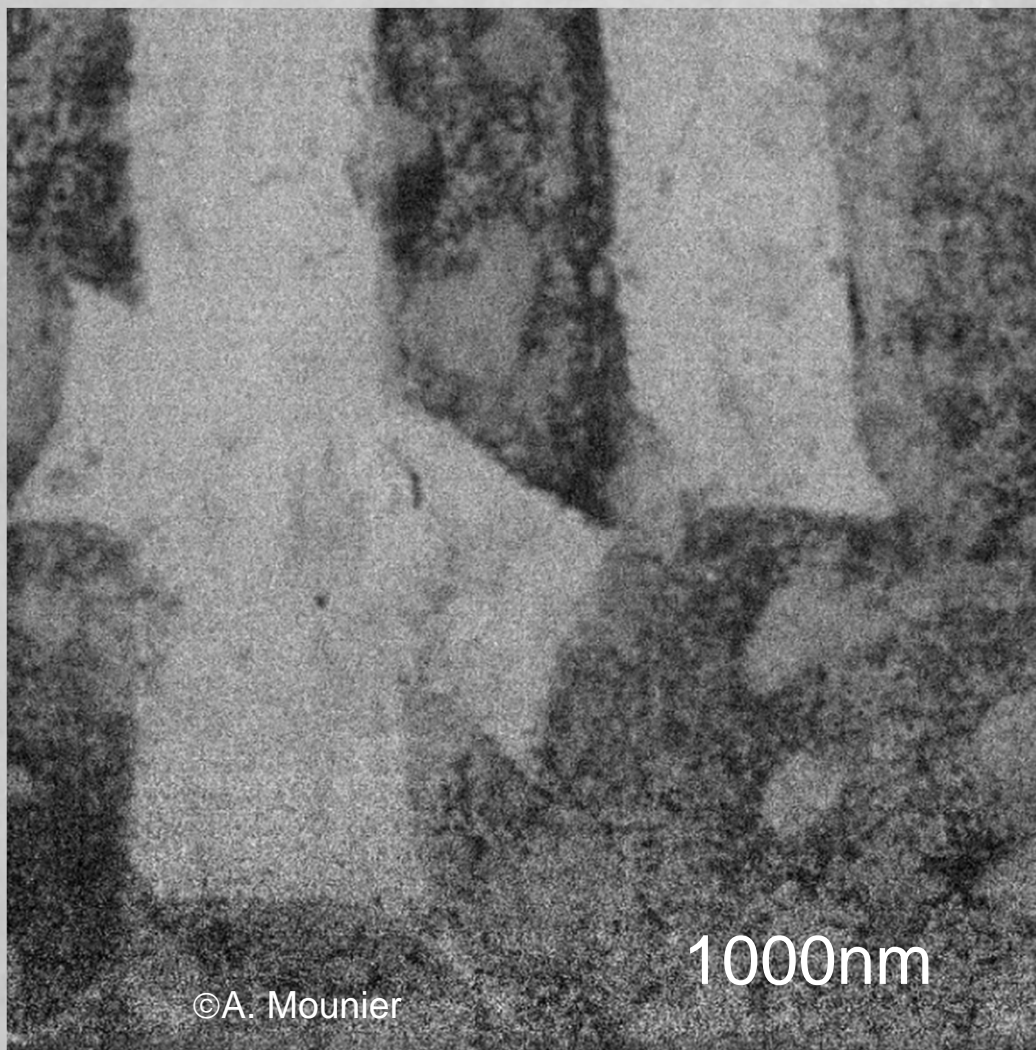
750nm

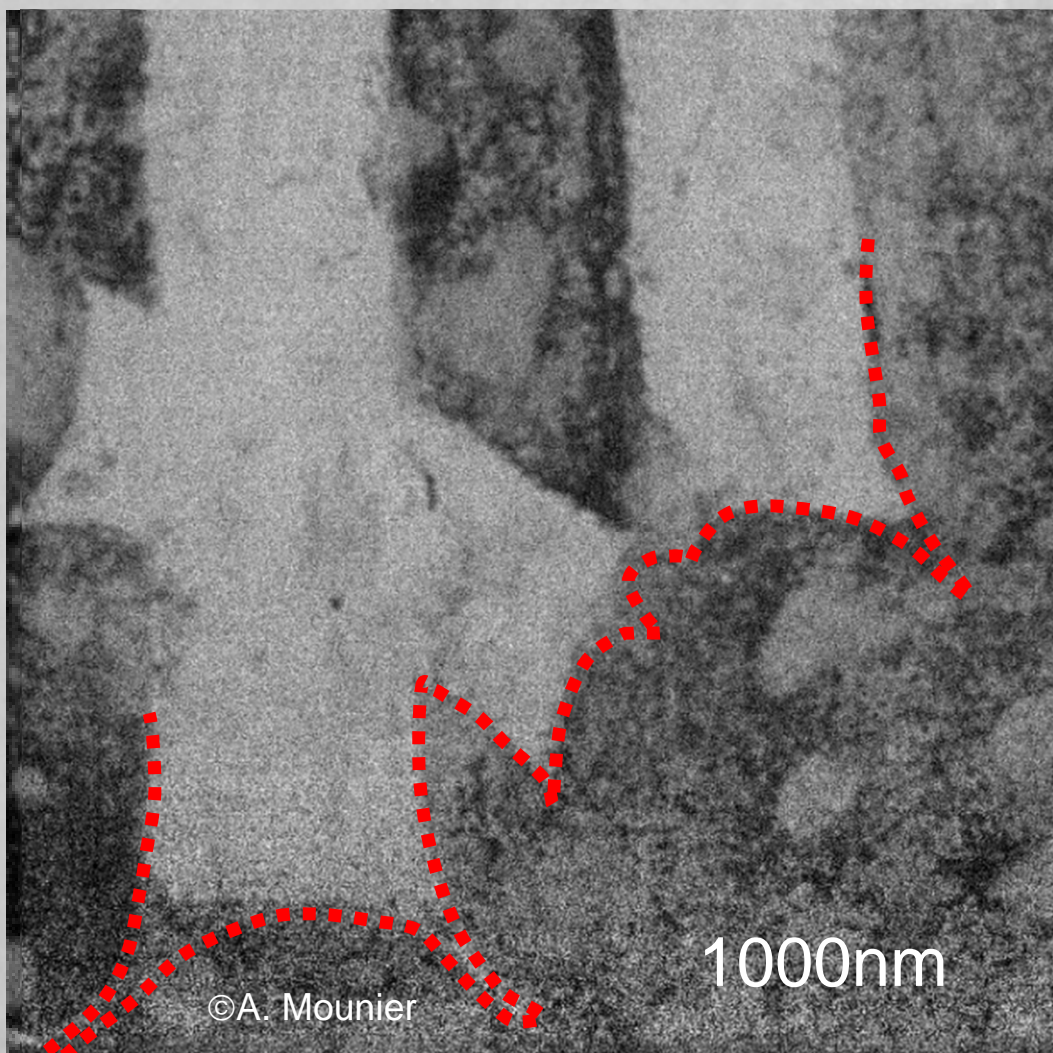


©A. Mounier

950nm









# Technical photography

©F. Piqué



Letters «P»  
embellished



Individualised



# Technical photography



©N. Papiashvili

SEM

Unexpected  
metallic  
decoration  
on the  
thistles?



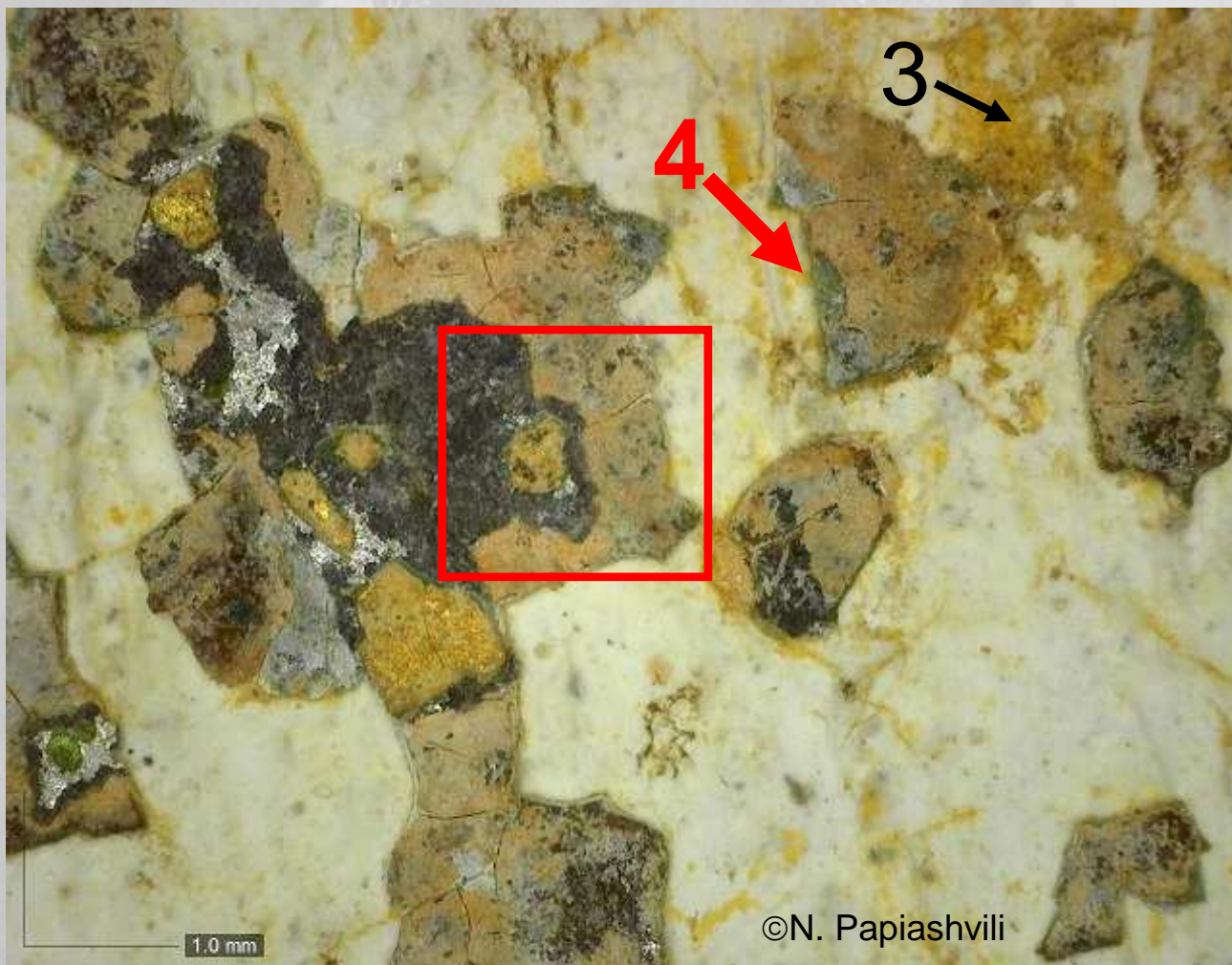


# $\mu$ -Technical photography

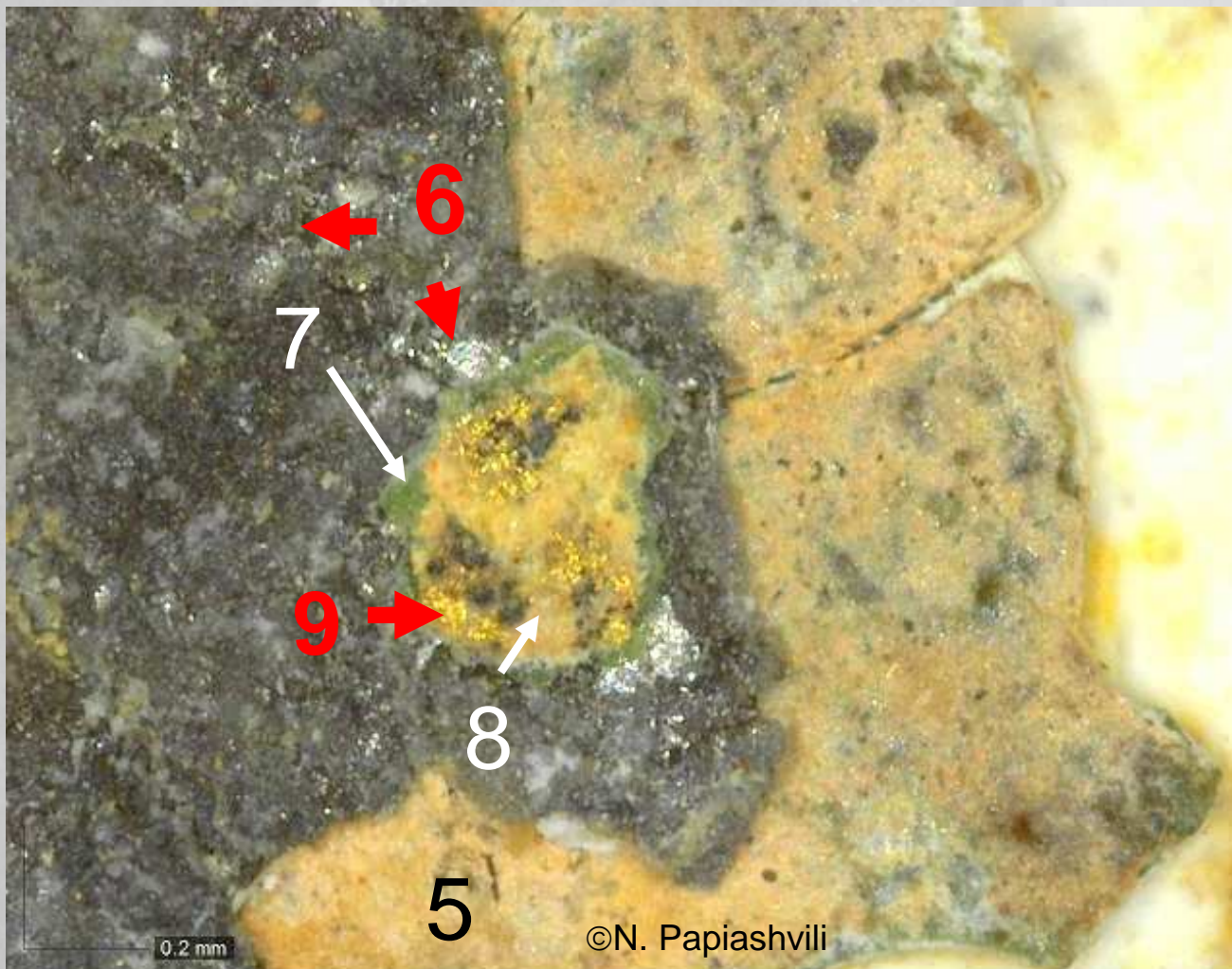


©N. Papiashvili



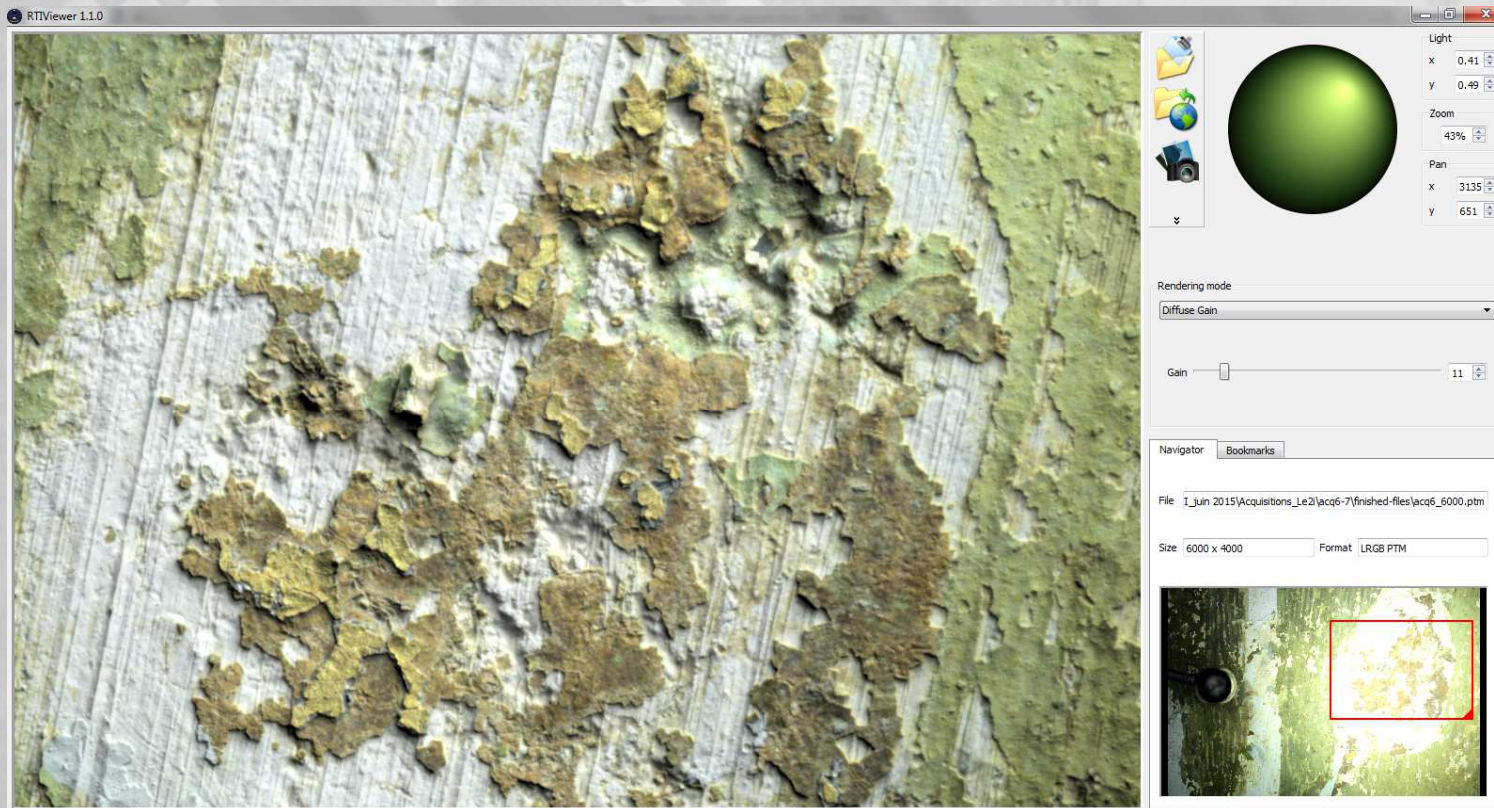








# Highlight - Reflectance Transformation Imaging



LIBS



Ba,Zn,Ti (repainting)

Au

Al,Fe,Si

Cu

Sn

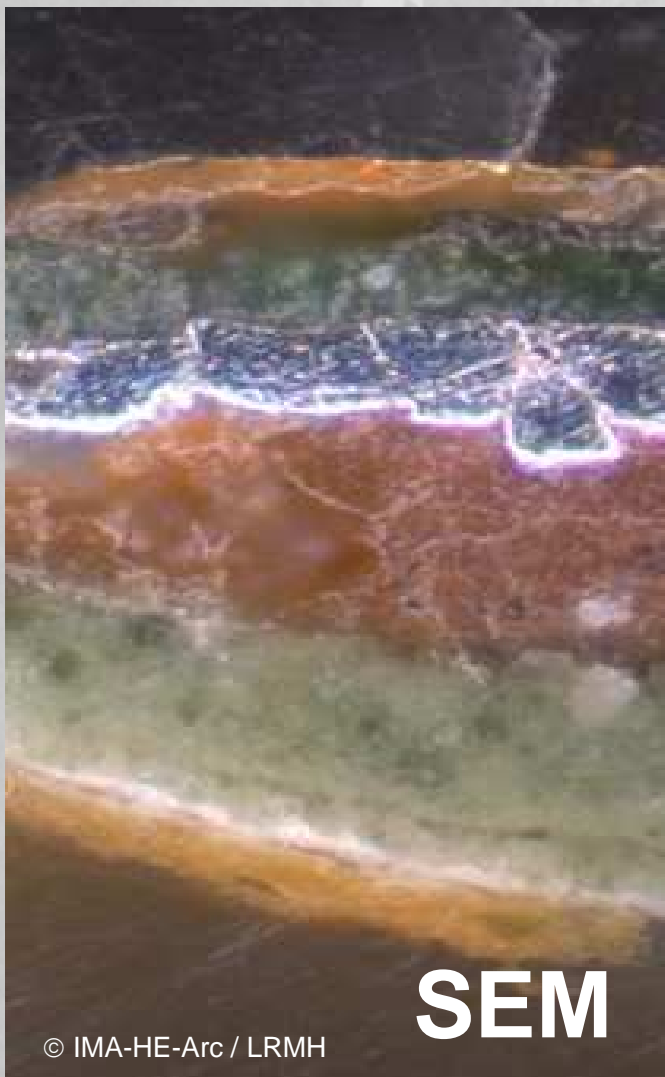
Al,Fe,Si

Cu,Pb (background)

Al,Fe,Si (ochre)

Ca (support)





Ba,Zn,Ti (repainting)

Au

Al,Fe,Si

Cu

Sn

Al,Fe,Si

Cu,Pb (background)

Al,Fe,Si (ochre)

Ca (support)



Ba,Zn,Ti (repainting)

**Au**

**Al,Fe,Si**

**Cu**

**Sn**

**Al,Fe,Si**

Cu,Pb (background)

Al,Fe,Si (ochre)

Ca (support)



# Technical photography

2014/10/03 13:57:01 Unit: mm Magnification: 50x No Calibration

Sn

Glaze

Au

1.0 mm

©F. Piqué

	Germolles	Rouvres	Argilly chapel	Champmol abbey
<b>Gold foils</b>	2 400	2 400	61 841	66 850
<b>Gilded tin foils</b>	720	348	288	1 524
<b>Green tin foils</b>	1 908	60	17	1 524
<b>White tin foils (unprepared)</b>	540	492	612	840
<b>Bresin (lb)</b>	1 ¼			
<b>Vermillion (lb)</b>	8	4	86	59
<b>Lead red (mine) (lb)</b>	59	6	158	110
<b>Indigo (lb)</b>	1		10	7
<b>Blanc de Pouille (CaCO<sub>3</sub>) (lb)</b>	60	6	6	10
<b>Ochre – berry (lb)</b>	120		68	46
<b>Linseed and walnut oils (pints)</b>	18		238	190
<b>Varnish (lb)</b>	89	22	72	82
<b>Paper (quires)</b>	9	4 ½		3

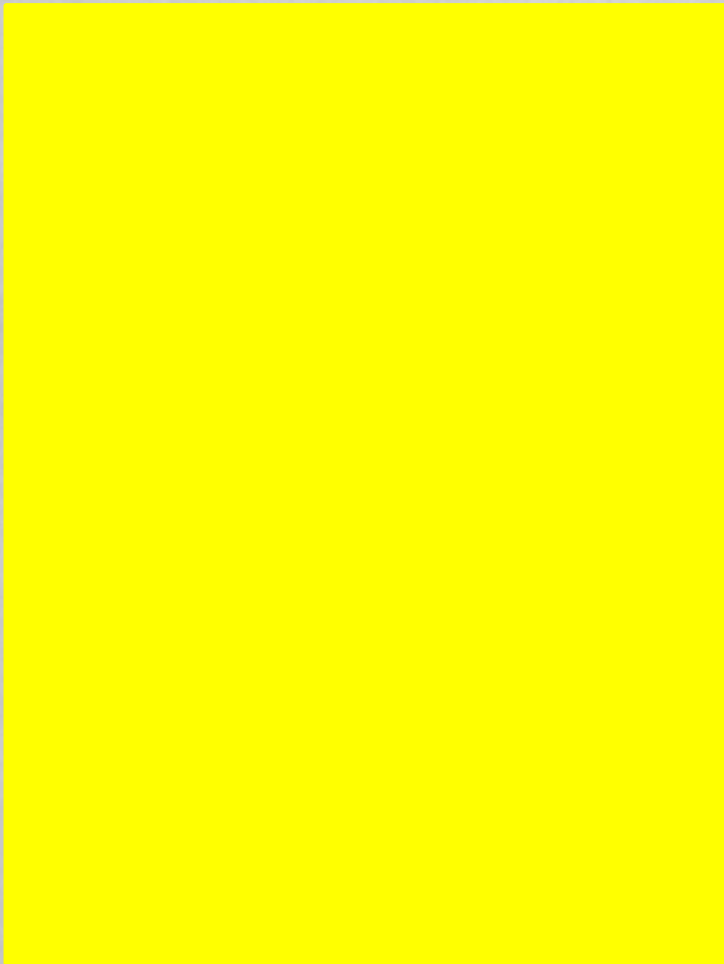
Validation by  
medieval  
records

Painters' materials in the ducal accounts 1375 – 1416 for four major ducal sites (from Nash "Pour couleurs et autres choses prise de lui ...: The Supply, Acquisition, Cost and Employment of Painters' Materials at the Burgundian Court, c.1375–1419", in Trade in Artists' Materials, (2010), pp. 98-182))

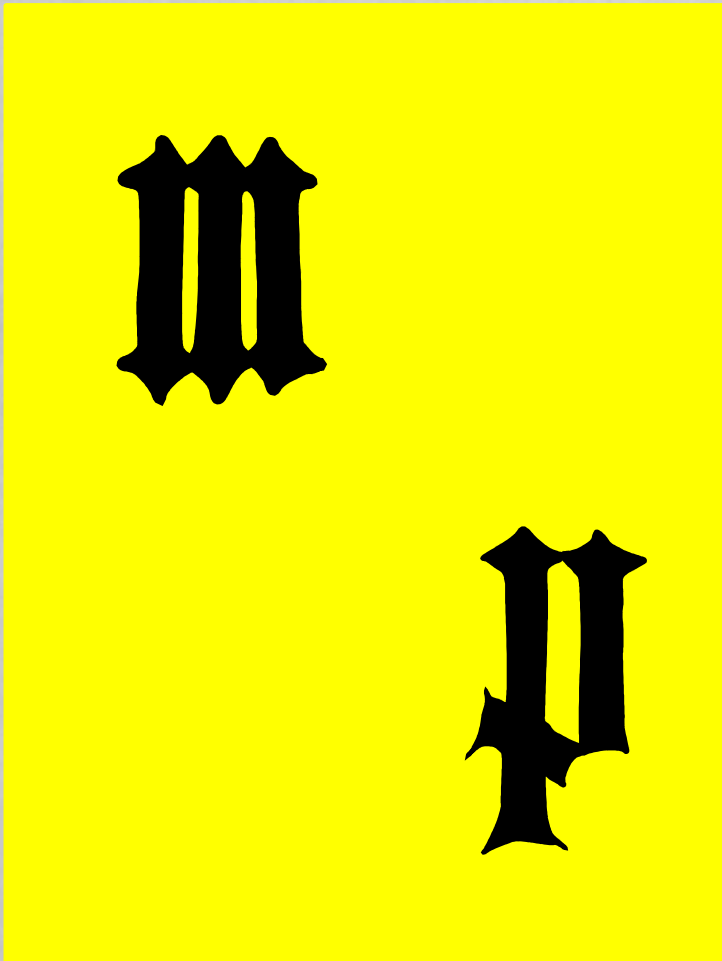


# Understanding the painting techniques used

1. Application of a uniform **yellow ochre** layer



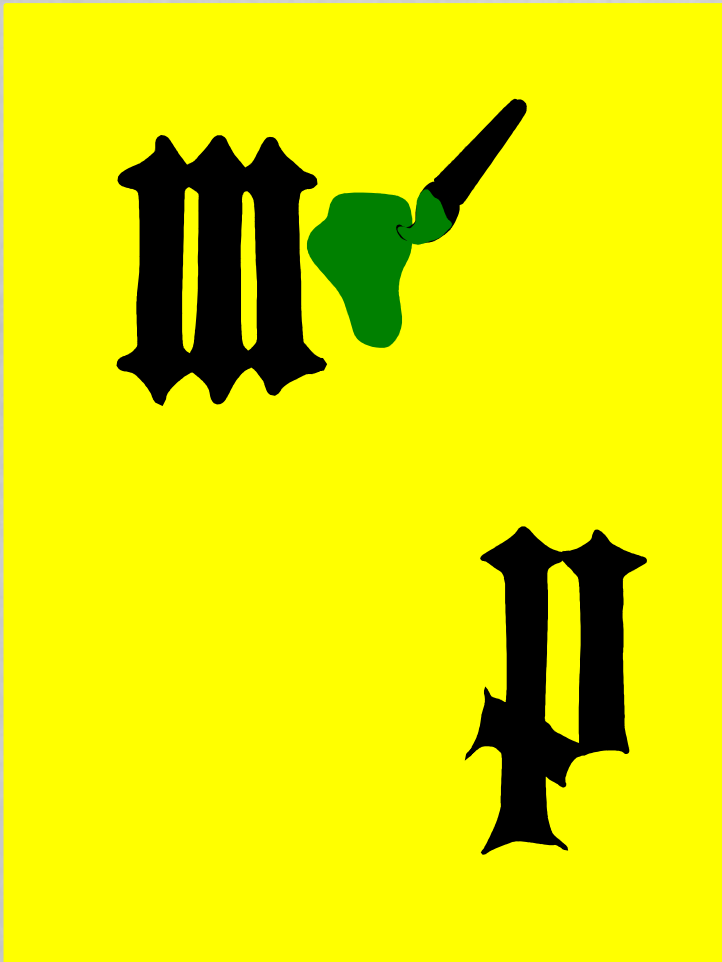
# Understanding the painting techniques used



1. Application of a uniform **yellow ochre** layer
2. **Use** of stencilling patterns for the “M” and the “P”,

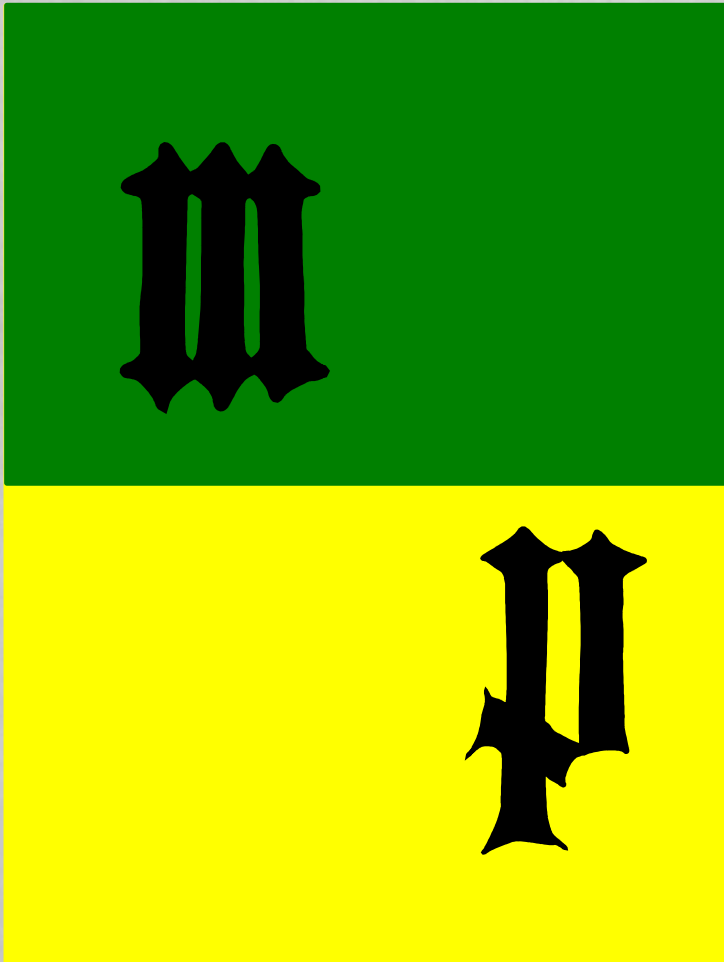


# Understanding the painting techniques used



1. Application of a uniform **yellow ochre** layer
2. **Use** of stencilling patterns for the “M” and the “P”,
3. Application of the **green background**,

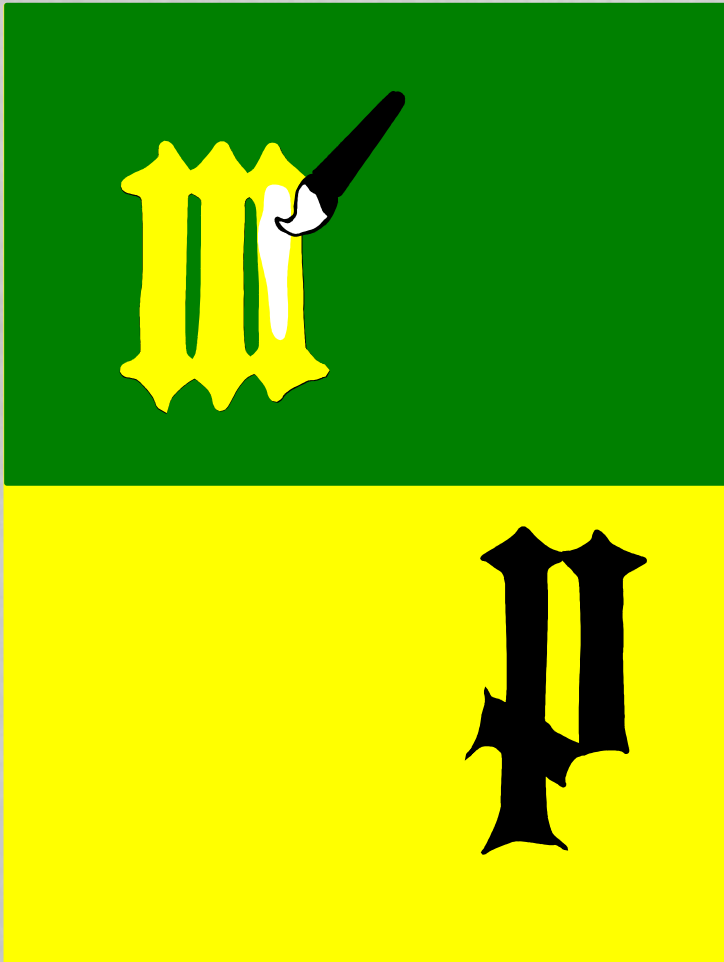
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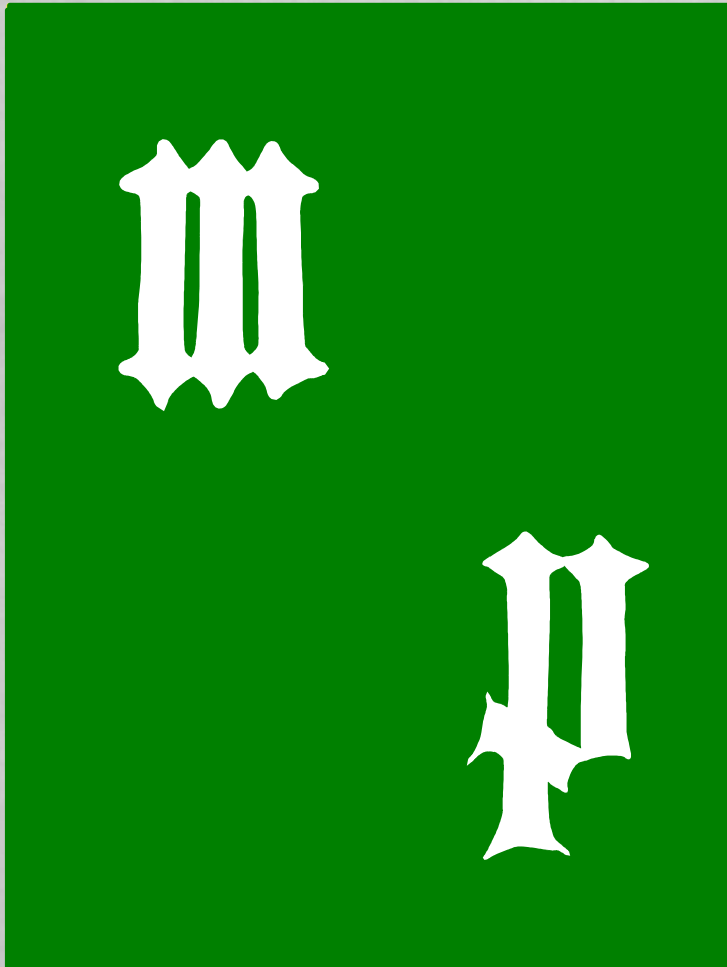


# Understanding the painting techniques used



1. Application of a uniform **yellow ochre** layer
2. **Use** of stencilling patterns for the “M” and the “P”,
3. Application of the **green background**,
4. **Painting of the letters** with lead white

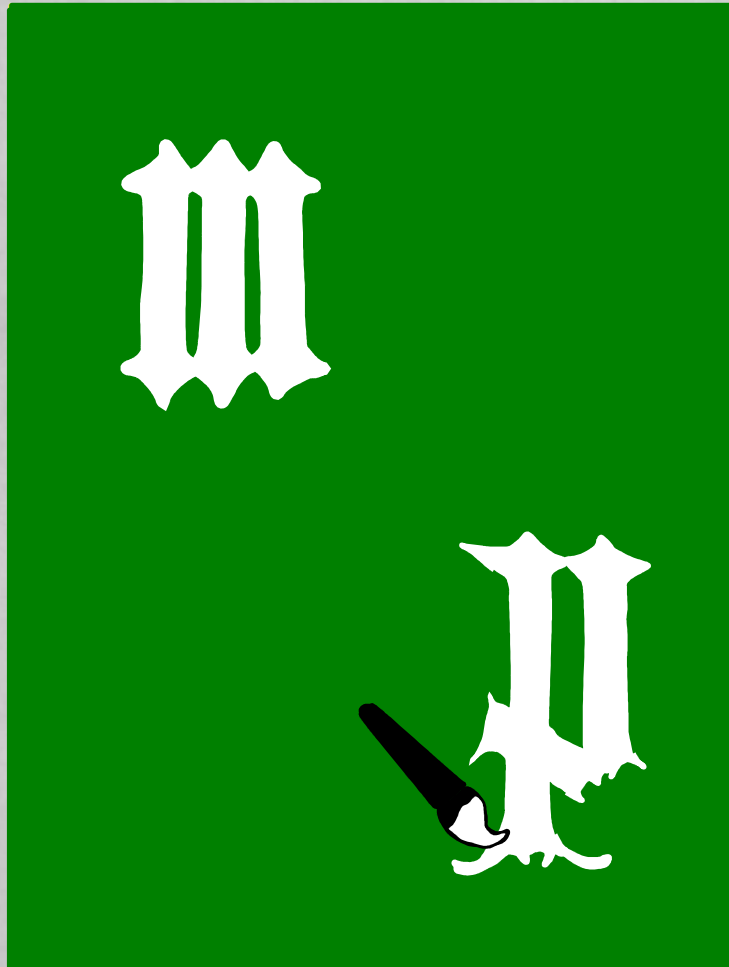
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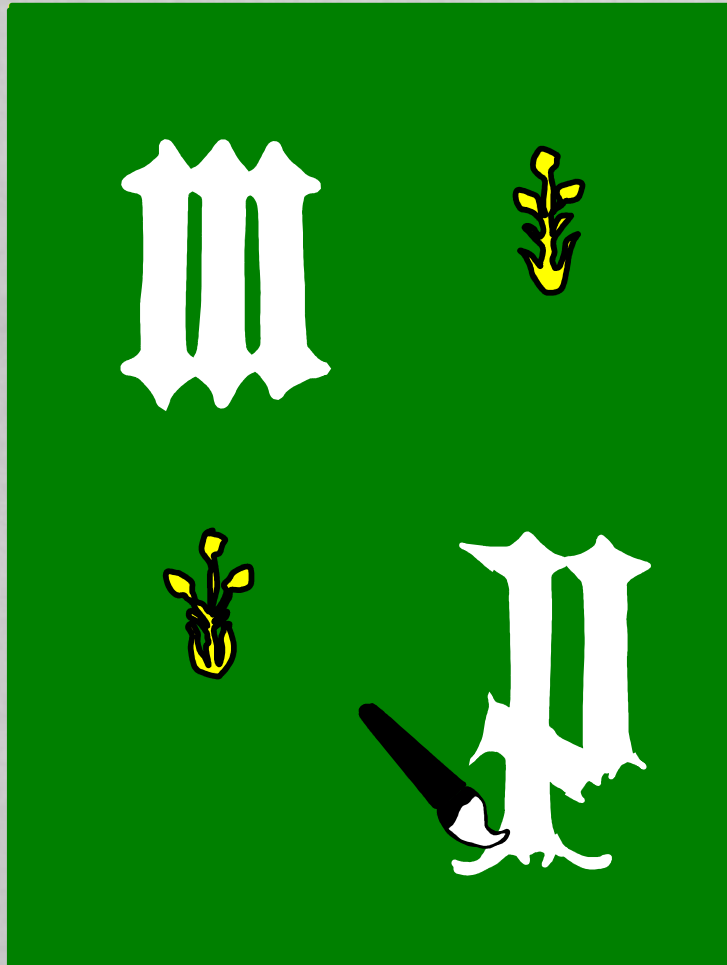


# Understanding the painting techniques used



1. Application of a uniform **yellow ochre** layer
2. **Use** of stencilling patterns for the “M” and the “P”,
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5. Addition of **arabesques** at the extremities of the «P»

# Understanding the painting techniques used



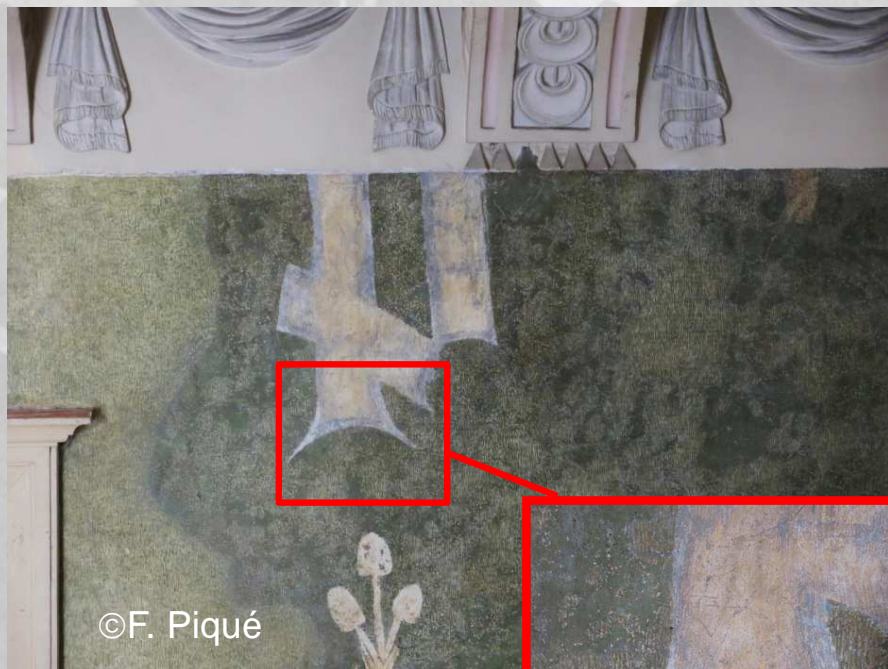
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2. **Use** of stencilling patterns for the “M” and the “P”,
3. Application of the **green background**,
4. **Painting of the letters** with lead white
5. Addition of **arabesques** at the extremities of the «P»
6. Application of **the metallic thistles**



# Results

## Conservation condition

### Technical photography



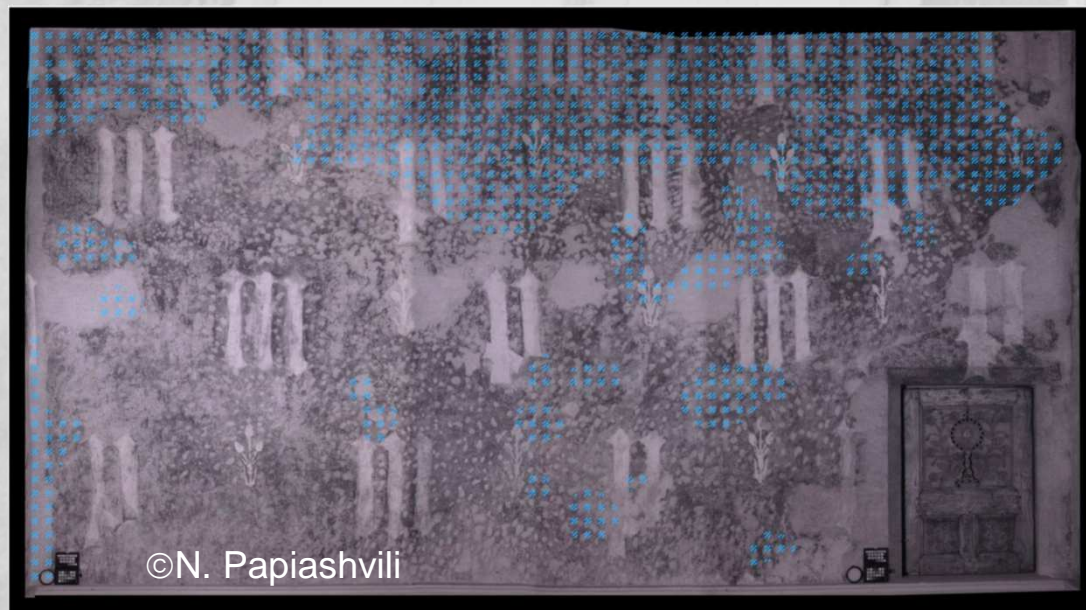
A shadow effect?



Physical  
stability?



# Finger tapping analysis



Detached zone identified on West wall



# IR thermography

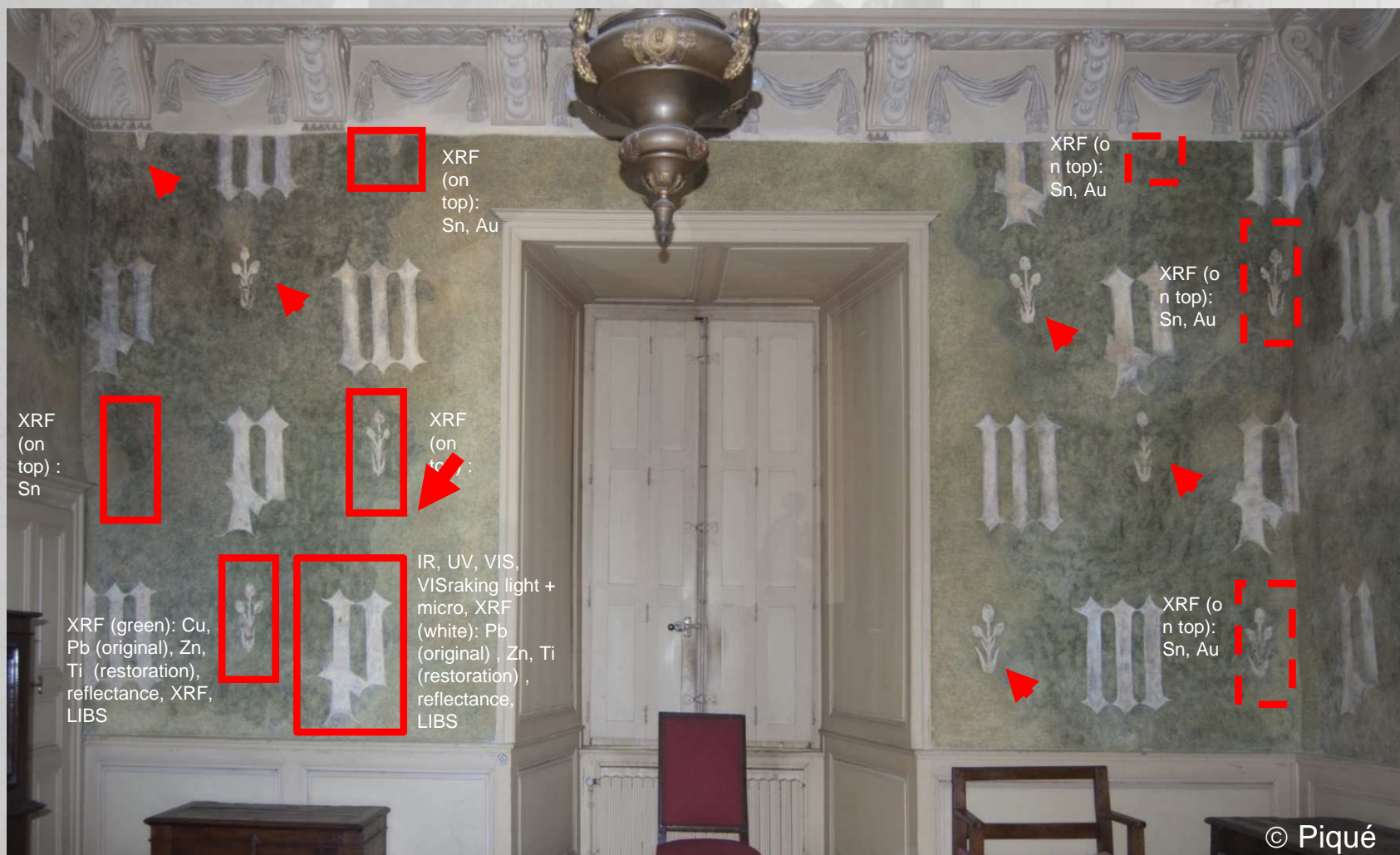


©C. Tedeschi, M. Cucchi

**Similar  
results: the  
upper part  
next to the  
moulding  
is very  
fragile**

# Results

## Data management

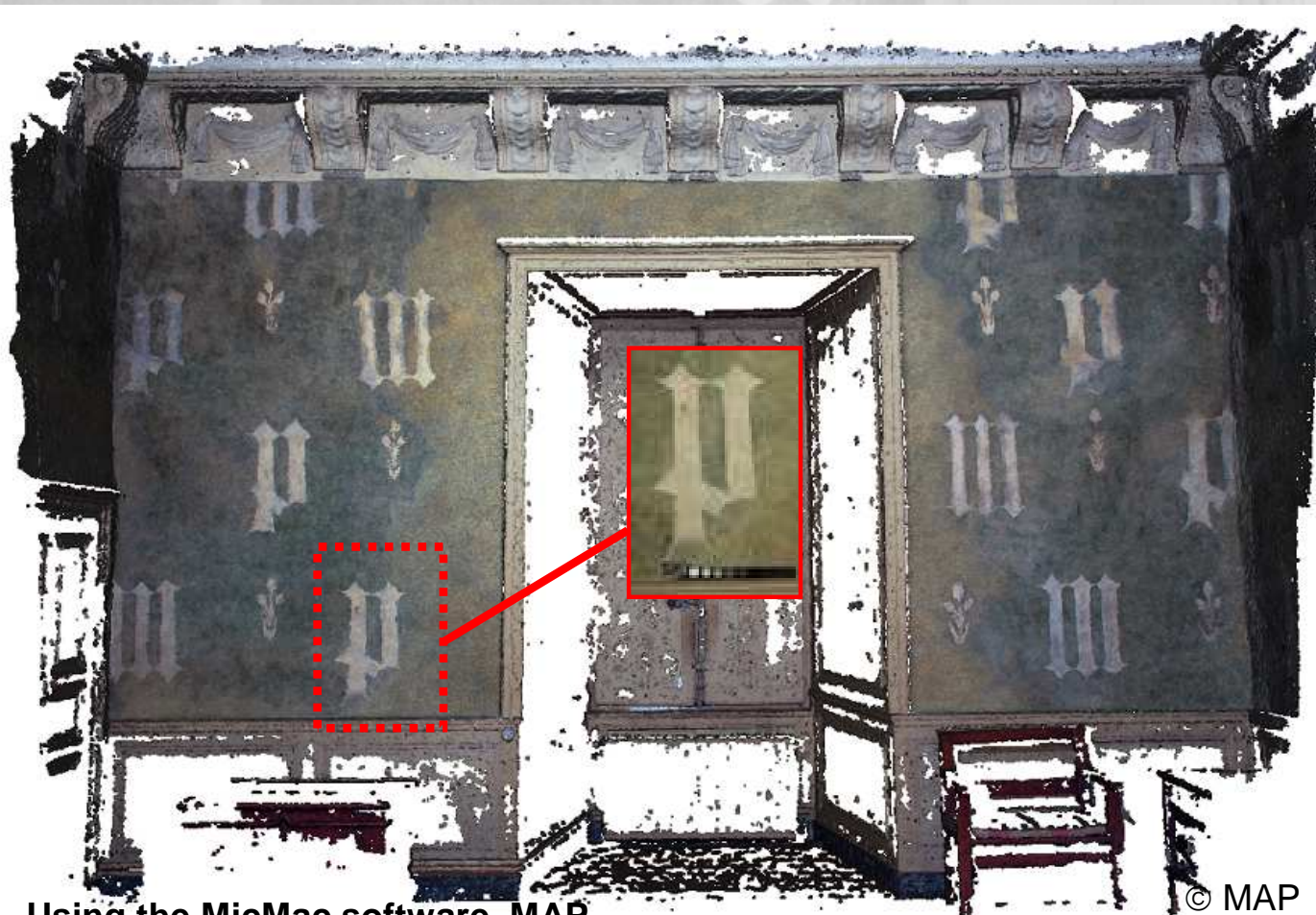




# Results

## Data management

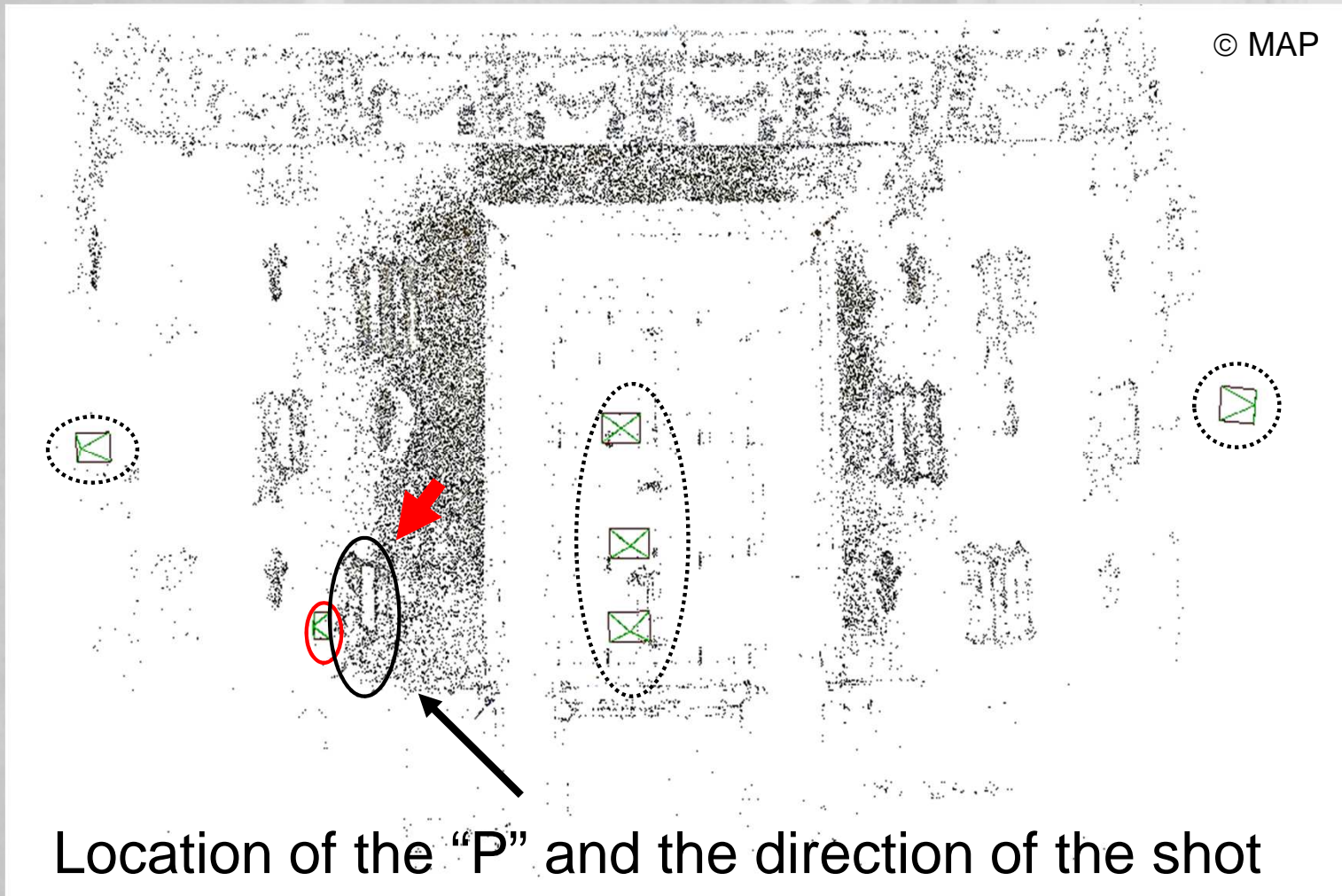
Data  
alignement



Using the MicMac software, MAP

# Results

## Data management



Data  
alignement



# Results

## Data management

i3mainz - TiledImageViewer



### Vector Layer

Layer	Active	Color	Alpha	Stipple	LineWidth
0	<input type="radio"/>				3
1	<input type="radio"/>				3
2	<input checked="" type="radio"/>				3
3	<input type="radio"/>				1
4	<input type="radio"/>				1

### Loaded Images

Image Name	Close	Active	Alpha
visualization_difference-map	Close	<input type="radio"/>	
registered_per_dn_s_1_irfc	Close	<input type="radio"/>	
registered_per_dn_s_1_rr	Close	<input type="radio"/>	
registered_per_dn_s_1_uvfc	Close	<input checked="" type="radio"/>	
registered_per_dn_s_1_uvfc	Close	<input type="radio"/>	
registered_per_dn_s_1_uvr	Close	<input type="radio"/>	

### Processing

- ☒ None  
☐ Phong Shading  
☐ Sobel Filtering  
☐ Laplace Filtering

### Settings

**Spatial Image analysis and  
Viewing Tool, i3Mainz**

©S. Wefers

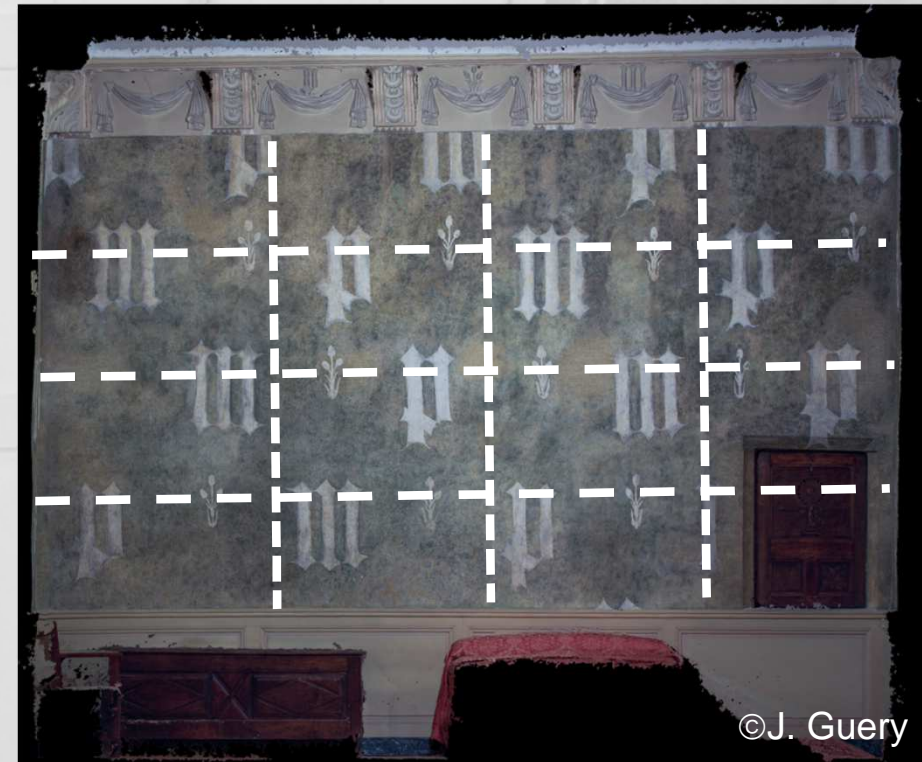
# Results

## 3D virtual representation of the original decoration

### Possibilities of augmented reality

Recording of a wall in its  
current condition

- SDK:  **kudan**  
AUGMENTED REALITY
- Data imported in **Unity3D**



©J. Guery

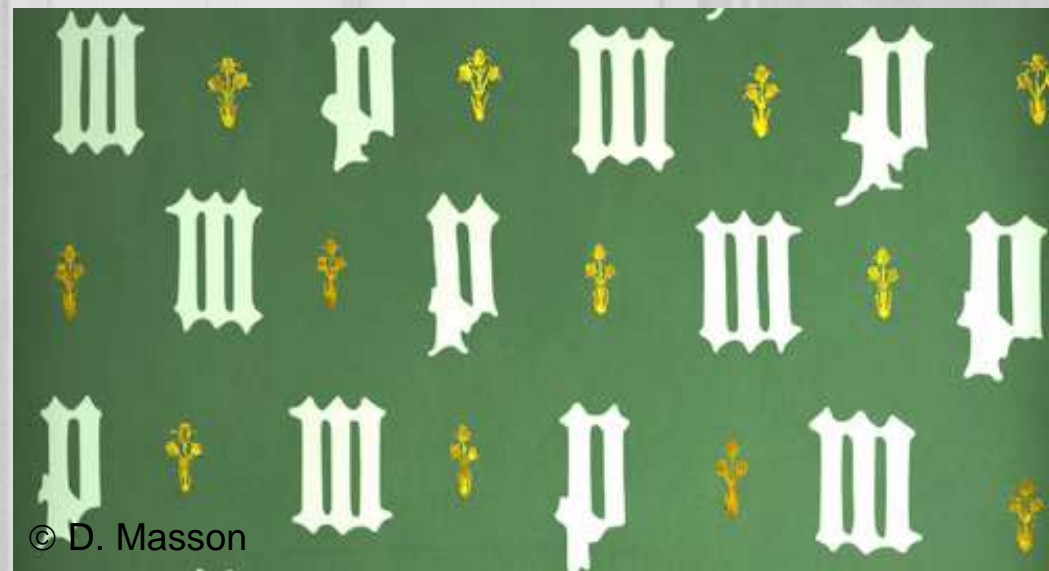


# Matching with a wall recreated from scientific data



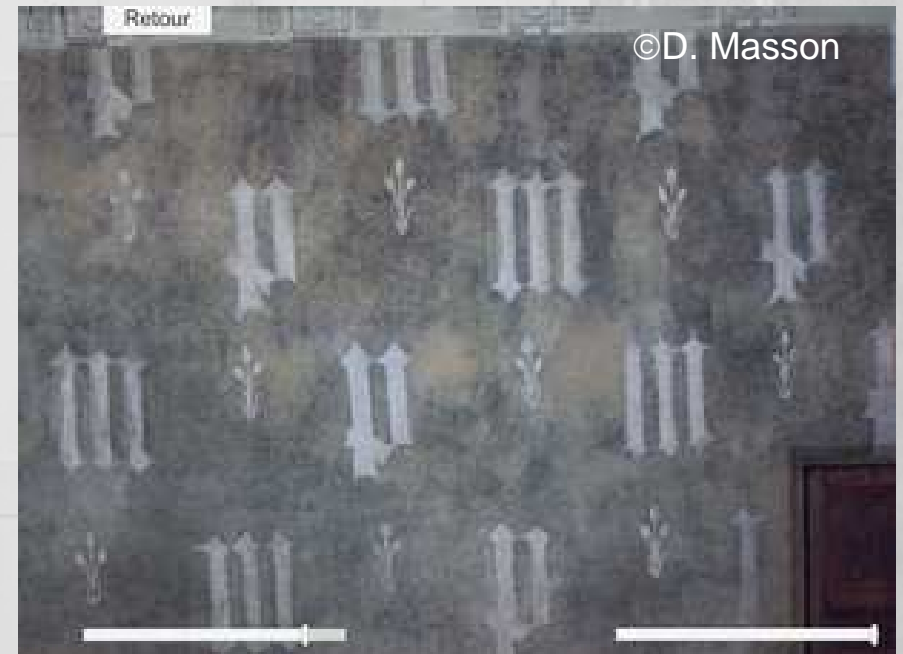
© D. Masson

Simulation of a  
thistle from analysis



© D. Masson

# Matching with a wall recreated from scientific data



**Non-invasive experience with a tablet**



# Matching with a wall recreated from scientific data

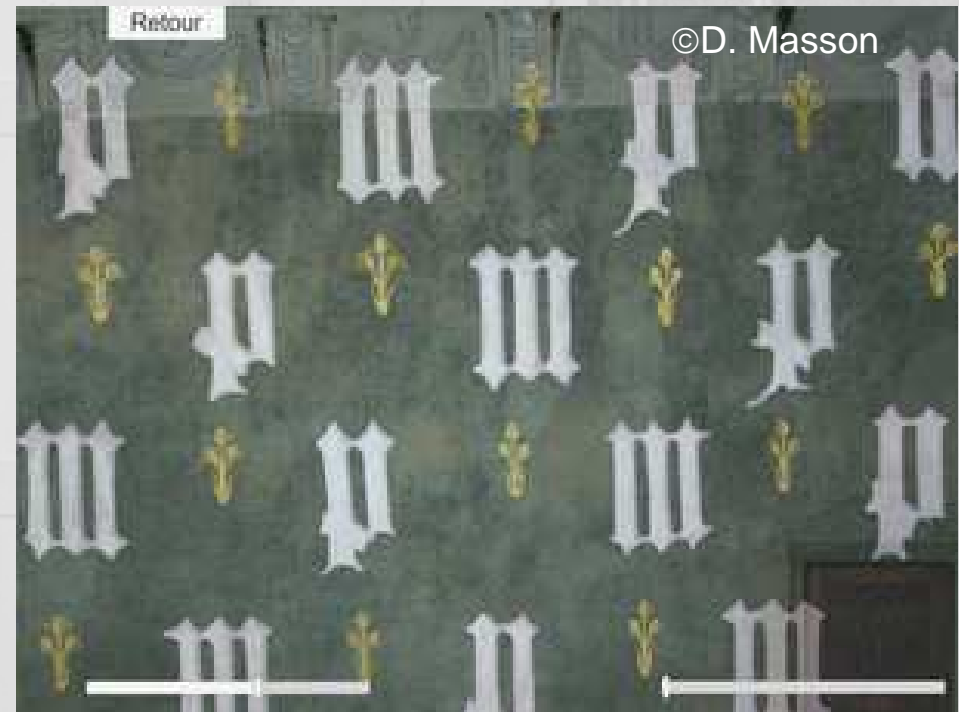


**Non-invasive experience with a tablet**

# Matching with a wall recreated from scientific data

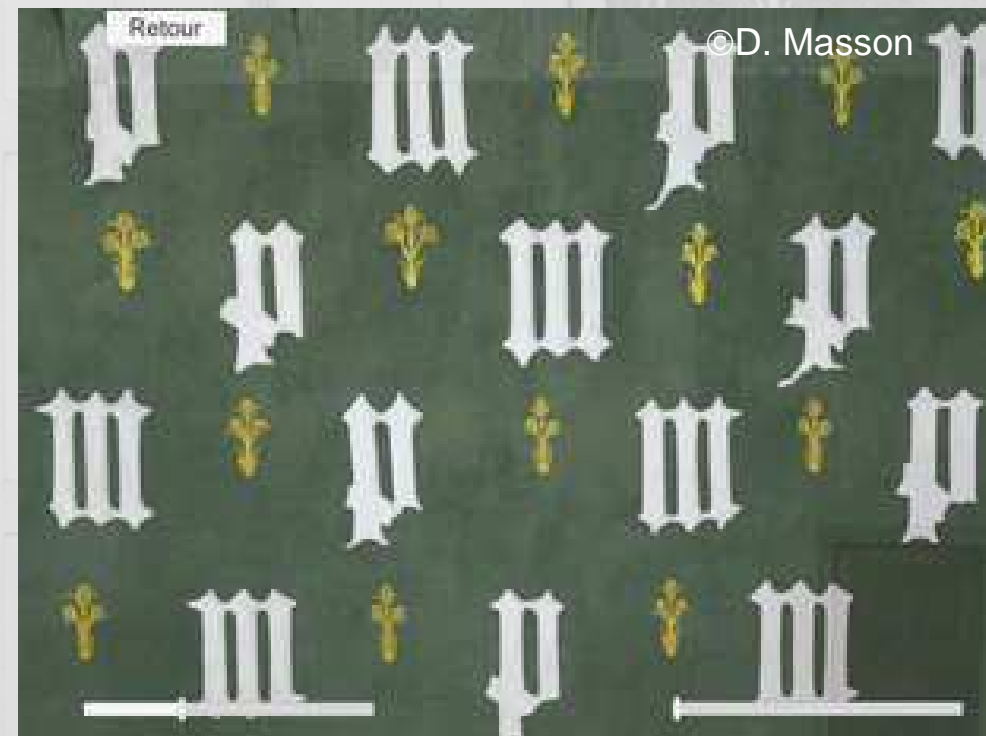


**Non-invasive experience with a tablet**





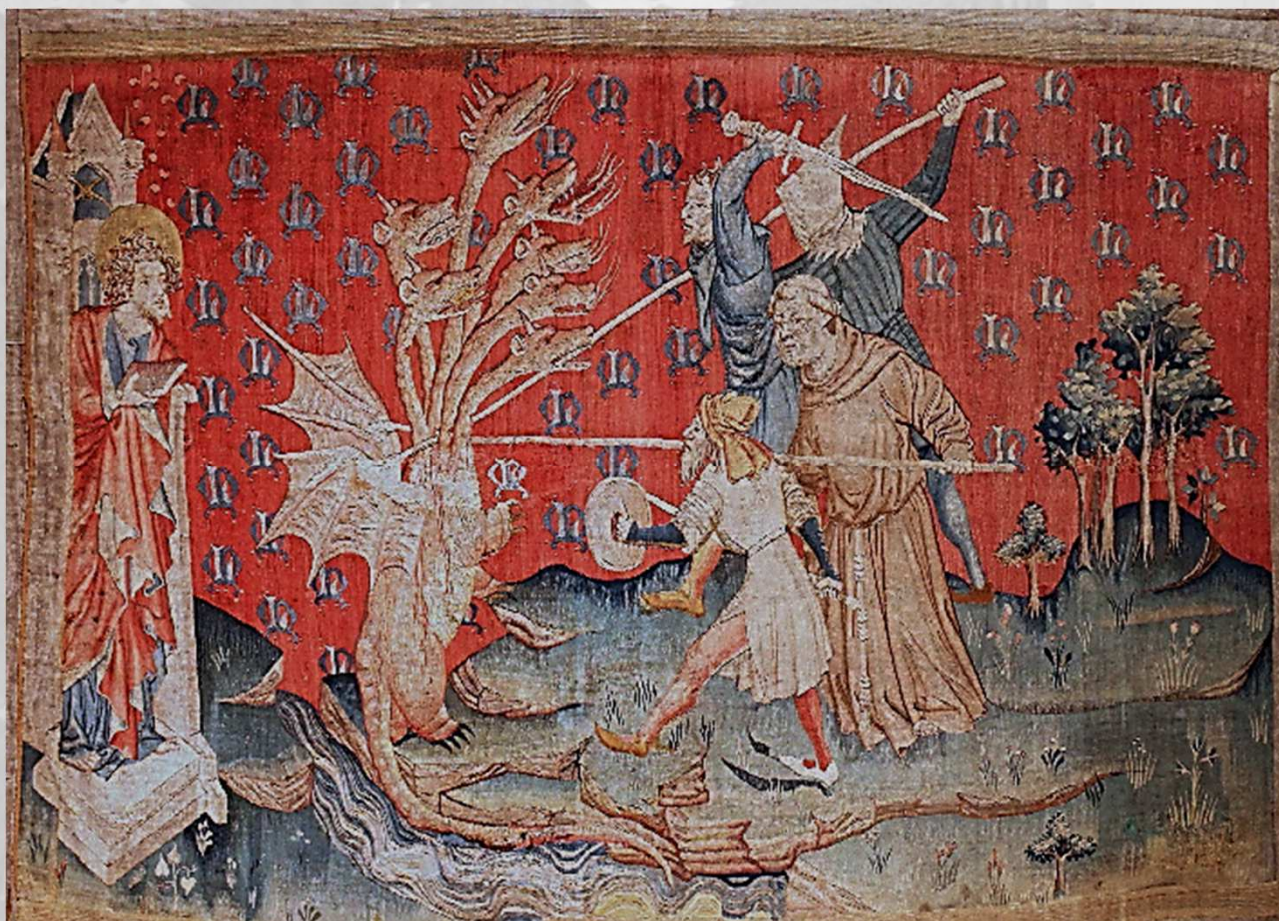
# Matching with a wall recreated from scientific data



**Non-invasive experience with a tablet**



# Tapestries of **Louis I d'Anjou**

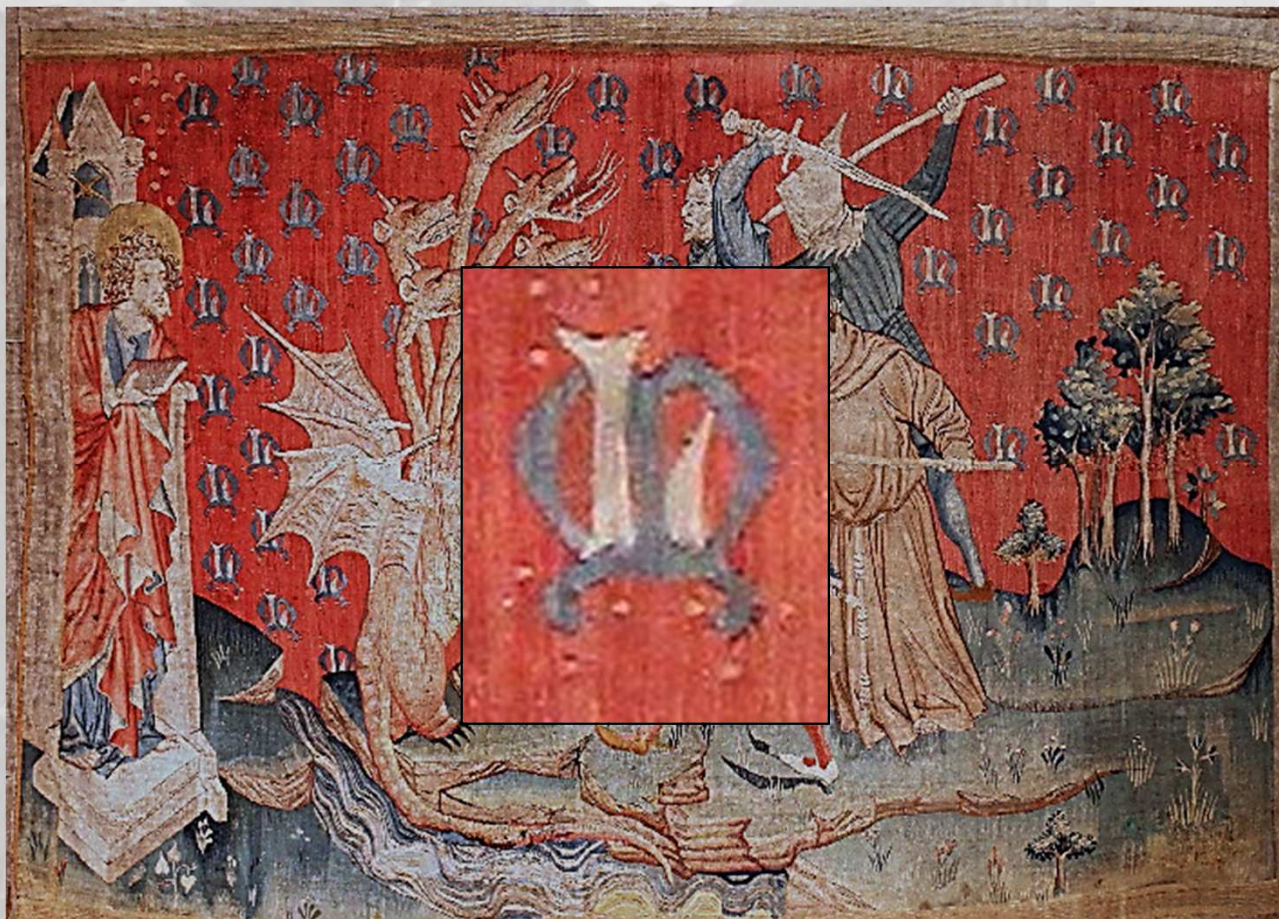


**Tenture de l'Apocalypse ,  
3<sup>rd</sup> piece, scene 39 : The  
dragon fighting God  
servants, 1380-1382, wool,  
© Angers, musée des  
tapisseries**

[architecture.relig.free.fr](http://architecture.relig.free.fr)



# Tapestries of **Louis I d'Anjou**

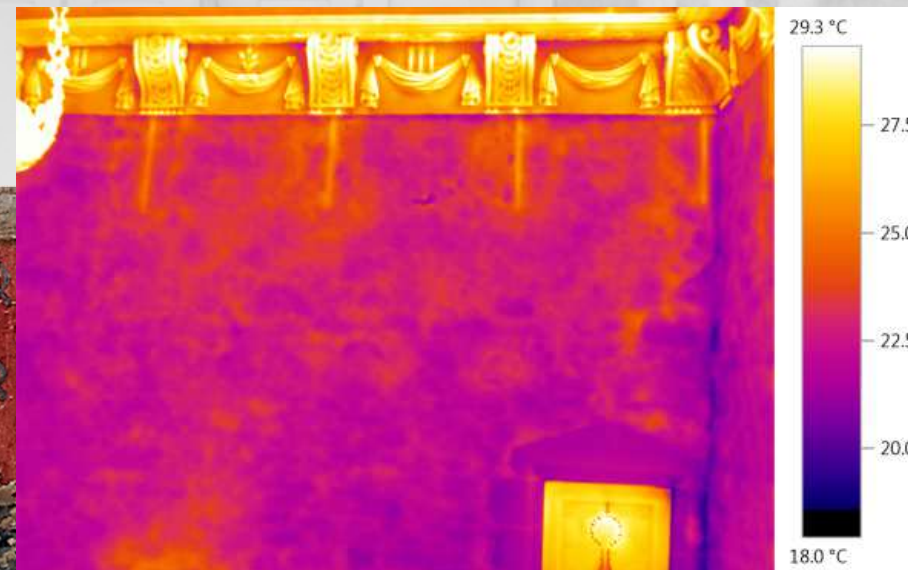
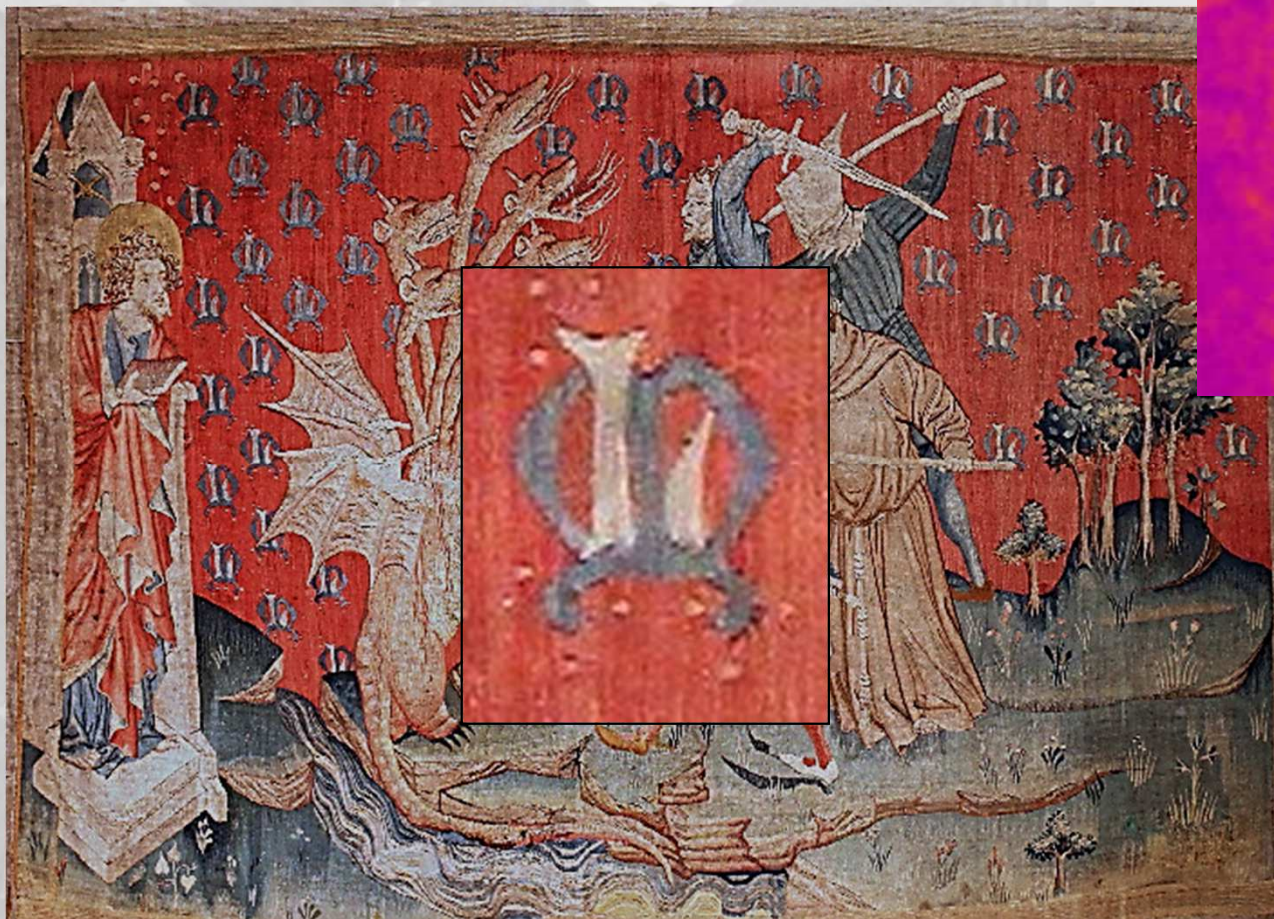


**Tenture de l'Apocalypse ,  
3<sup>rd</sup> piece, scene 39 : The  
dragon fighting God  
servants, 1380-1382, wool,  
© Angers, musée des  
tapisseries**

[architecture.relig.free.fr](http://architecture.relig.free.fr)



# Tapestries of **Louis I d'Anjou**

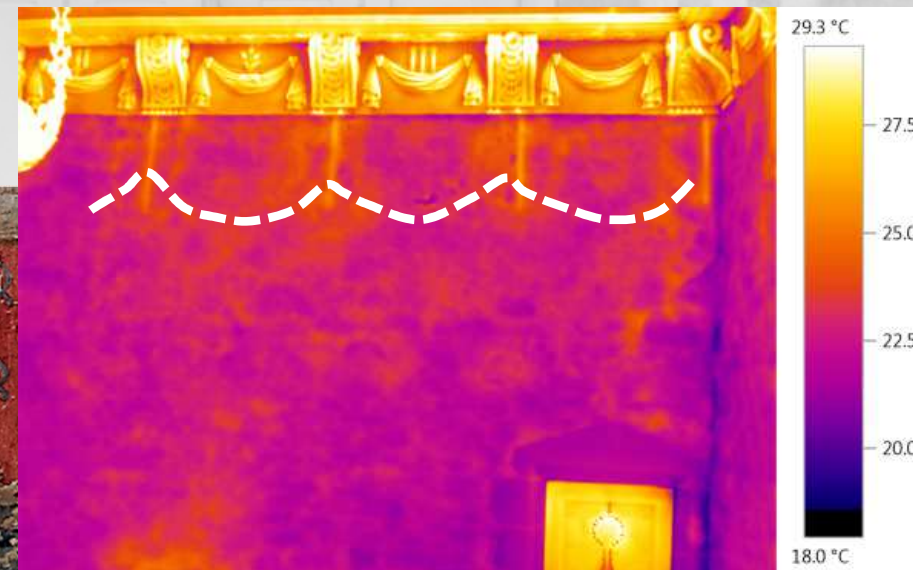
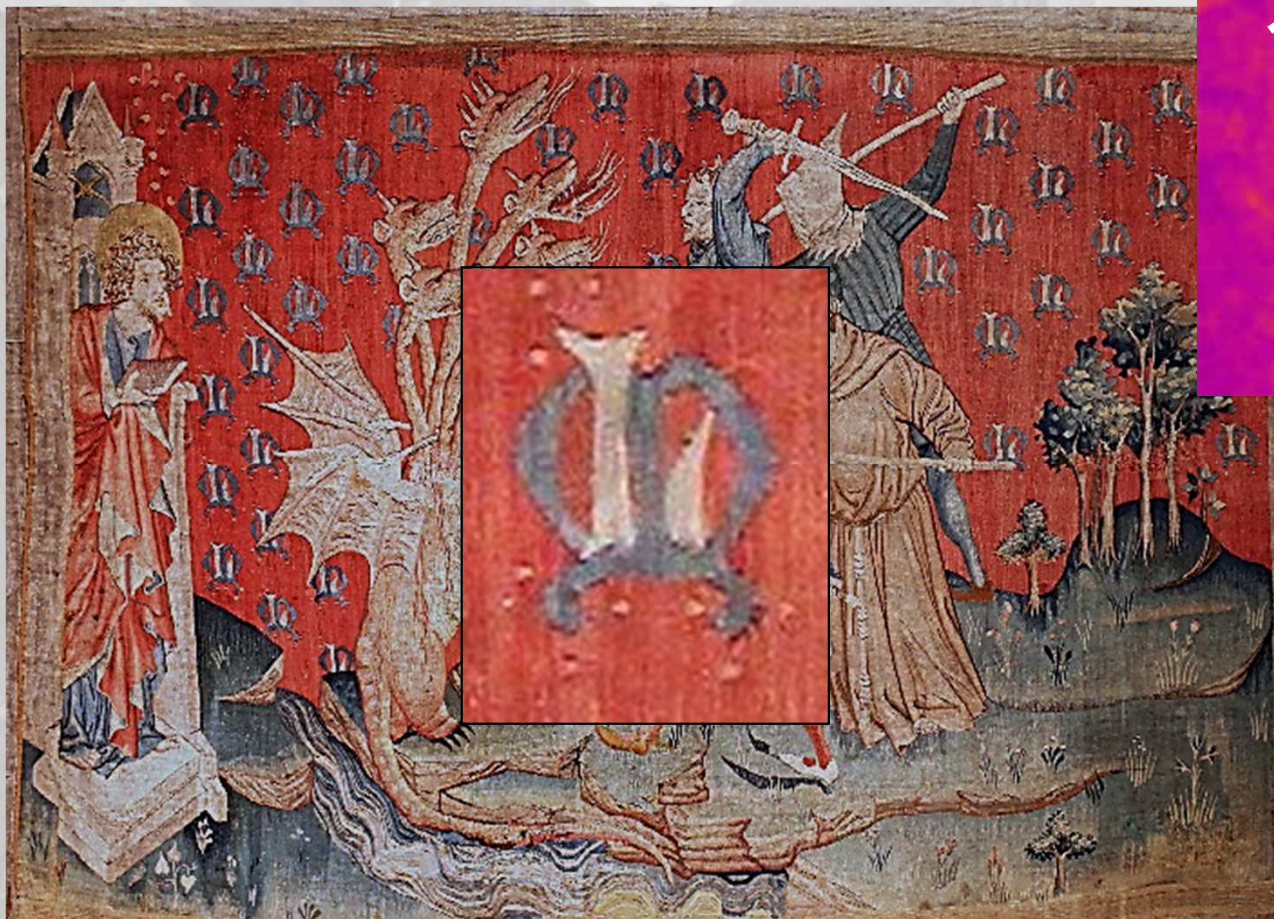


**Tenture de l'Apocalypse ,  
3<sup>rd</sup> piece, scene 39 : The  
dragon fighting God  
servants, 1380-1382, wool,  
© Angers, musée des  
tapisseries**

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# Tapestries of **Louis I d'Anjou**



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# Limitations and sources of error

- **Level of knowledge of the coordinator** on the techniques, data size, softwares
- **Limitations of the equipment:** SLI and H-RTI
- **Storage of raw data** and their management



# Benefits

## Recording techniques used versus traditional techniques

- Favouring a **non invasive documentation approach**
- Favouring a **global approach towards a local one**
- Allowing the **data management** using precise basemaps
- Giving tools to the managers to **disseminate the information** gained towards **the public**
- Enabling further **multidisciplinary research**

# Primary tasks and sub-tasks addressed

- **PT4:** Germolles' wall paintings are a **typical application** to implement optimal processing chains, from data capture up to the final results, guided by all the interdisciplinary expertise available to COSCH
  - **Compare results** between different spatial (**WG2**) and spectral (**WG1**) techniques on a similar problematic;
  - **Assess** the approach and the results obtained according to the surface characteristics (**WG4**).



- **PT5:** Establishment of the **conceptual** and **practical frameworks** for **multisensory data acquisition**, its implementation and evaluation



Kick-off meeting at Germolles, January 2015

- **PT5:** Establishment of the **conceptual** and **practical frameworks** for **multisensory data acquisition**, its implementation and evaluation

Final meeting at IRPA,  
Brussels, July 2016





- **PT6**: Development of recommendations for solution providers as well as end users

## Training school on 3 easy accessible imaging techniques

### Photogrammetry



### Technical photography



### H-RTI



# Acknowledgements







# Thank you for your attention