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

Margaret of Flanders
Lille, Musée de l'Hospice Comtesse, 16th century

Philip the Bold
Vienne, Hofburg, 16th c.
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

Philip the Bold
Margaret of Flanders
Margaret of Bavaria
Dressing-room of Margaret of Bavaria (Countess of Nevers)
A thoughtful distribution of symbols

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

2.9m
Historical facts

- **Aged** (14\(^{th}\) to 18\(^{th}\) c.)
- **Keyed** (beginning of the 19\(^{th}\) c.)
- **Application of a new plaster**
Historical facts

• Aged (14\textsuperscript{th} to 18\textsuperscript{th} c.)
• Keyed (beginning of the 19\textsuperscript{th} c.)
• Application of a new plaster
• Rediscovered around 1940

Around 1940
Historical facts

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

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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 approximatively 25cm. Illumination: torch equipped with a LED of a power of white light (XML2)

**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

©F. Piqué

©F. Piqué

©N. Papiashvili

Normal VIS

UVf
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

μ-technical photography

1 (white preparation layer)
2 (yellow layer)
3 (white finishing layer)

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

© F. Piqué
Hyperspectral imaging

© A. Mounier

RGB

© A. Mounier
Technical photography

Letters «P» embellished

Individualised
Technical photography

Unexpected metallic decoration on the thistles?

©N. Papiashvili
µ-Technical photography

©N. Papiashvili
Highlight - Reflectance Transformation Imaging
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)
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))

<table>
<thead>
<tr>
<th>Material</th>
<th>Germolles</th>
<th>Rouvres</th>
<th>Argilly chapel</th>
<th>Champmol abbey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold foils</td>
<td>2 400</td>
<td>2 400</td>
<td>61 841</td>
<td>66 850</td>
</tr>
<tr>
<td>Gilded tin foils</td>
<td>720</td>
<td>348</td>
<td>288</td>
<td>1 524</td>
</tr>
<tr>
<td>Green tin foils</td>
<td>1 908</td>
<td>60</td>
<td>17</td>
<td>1 524</td>
</tr>
<tr>
<td>White tin foils (unprepared)</td>
<td>540</td>
<td>492</td>
<td>612</td>
<td>840</td>
</tr>
<tr>
<td>Bresin (lb)</td>
<td>1 ¼</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vermillion (lb)</td>
<td>8</td>
<td>4</td>
<td>86</td>
<td>59</td>
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<tr>
<td>Lead red (mine) (lb)</td>
<td>59</td>
<td>6</td>
<td>158</td>
<td>110</td>
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<tr>
<td>Indigo (lb)</td>
<td>1</td>
<td></td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Blanc de Pouille (CaCO₃) (lb)</td>
<td>60</td>
<td>6</td>
<td>6</td>
<td>10</td>
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<tr>
<td>Ochre – berry (lb)</td>
<td>120</td>
<td></td>
<td>68</td>
<td>46</td>
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<tr>
<td>Linseed and walnut oils (pints)</td>
<td>18</td>
<td></td>
<td>238</td>
<td>190</td>
</tr>
<tr>
<td>Varnish (lb)</td>
<td>89</td>
<td>22</td>
<td>72</td>
<td>82</td>
</tr>
<tr>
<td>Paper (quires)</td>
<td>9</td>
<td>4 ½</td>
<td>72</td>
<td>82</td>
</tr>
</tbody>
</table>

Validation by medieval records
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”,

![Stencilling Patterns](image)
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**, 
Understanding the painting techniques used

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

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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
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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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
5. Addition of **arabesques** at the extremities of 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,
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?

©F. Piqué

©N. Papiashvili
Finger tapping analysis

Detached zone identified on West wall

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© Piqué
IR thermography

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

©C. Tedeschi, M. Cucchi
Results

Data management
Results
Data management

Using the MicMac software, MAP

Data alignement
Results
Data management

Location of the “P” and the direction of the shot

© MAP
Results

Data management

Using the MicMac software, MAP Data alignment

Location of the “P” and the direction of the shot

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

- Data imported in Unity3D
Matching with a wall recreated from scientific data

Simulation of a thistle from analysis

© D. Masson

© D. Masson
Matching with a wall recreated from scientific data

Non-invasive experience with a tablet
Matching with a wall recreated from scientific data

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Tapestries of **Louis I d’Anjou**

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

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

©G. Lugano
- **PT6**: Development of recommendations for solution providers as well as end users

**Training school on**

3 easy accessible imaging techniques

**Photogrammetry**  
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**Technical photography**  
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**H-RTI**  
©J-M. Vallet

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COSCH Final Conference, Mainz 10-11/10/2016
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Thank you for your attention