



Mobile Raman instrumentation and its application in art and archaeology

Peter Vandenameele
Ghent University

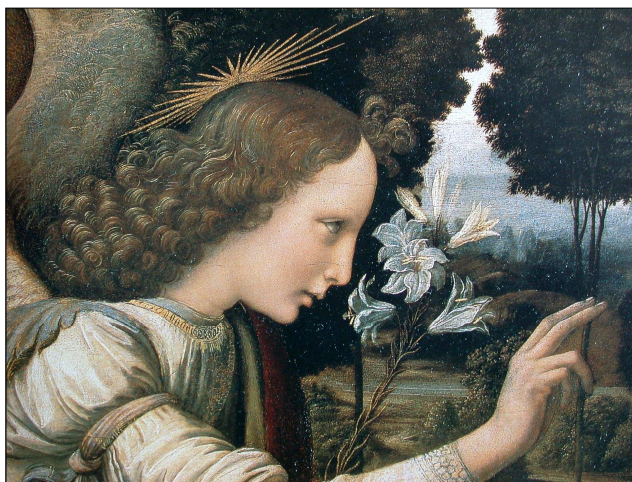
Department of Archaeology
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B-9000 Ghent (Belgium)

Peter.Vandenameele@UGent.be



Archaeometry and Art Analysis

- Fundamental interest in materials and techniques



Annunciation (fragment), Leonardo da Vinci, 1470, Galleria degli Uffizi, Firenze



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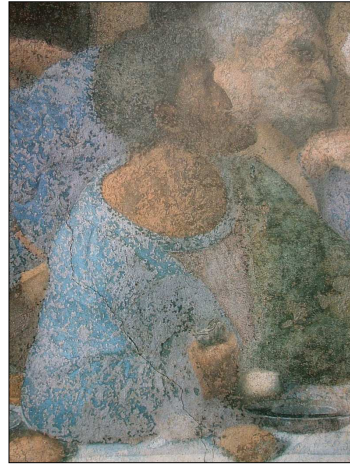
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Archaeometry and Art Analysis

- Fundamental interest in materials and techniques
- Questions during conservation



*Last supper (fragment), Leonardo da Vinci,
1494 - Santa Maria delle Grazie, Milaan*

Archaeometry and Art Analysis

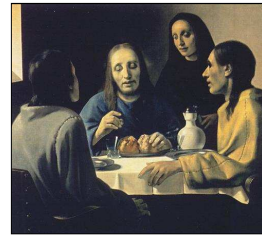
- Fundamental interest in materials and techniques
- Questions during conservation



*The vision of Saint Helena, Paolo Veronese,
1560-1565*

Archaeometry and Art Analysis

- Fundamental interest in materials and techniques
- Questions during conservation
- Detection of falsifications



*Christ in Emmaus
Han Van Meegeren, 1937
(Museum Boymans)
fake Vermeer*

Archaeometry and Art Analysis

- Fundamental interest in materials and techniques
- Questions during conservation
- Detection of falsifications

**Portrait of Martin Luther,
1520-1530, Hans Holbein**

**Pruissian Blue, $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
Invented beginning of the 18th century**



Archaeometry and Art Analysis

- Fundamental interest in materials and techniques
- Questions during conservation
- Detection of falsifications



**Portrait of
Alexander Mornauer
1464-1488,
anonymous**



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Art analysis: how?



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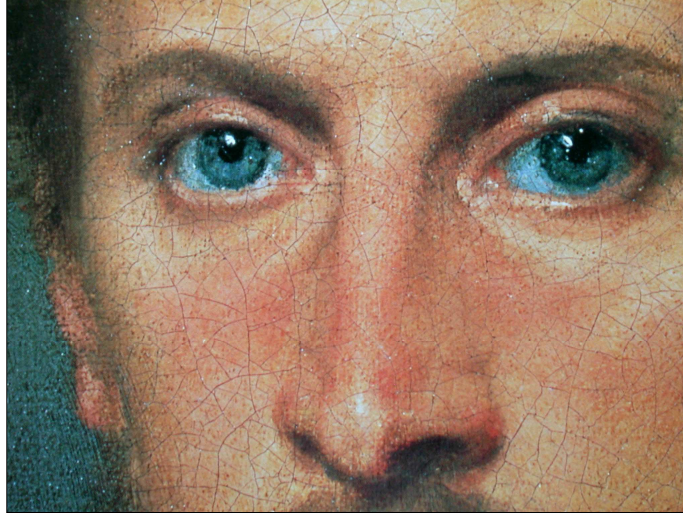


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Art analysis: how?



Tiziano Vecellio, *Man with blue-green eyes (detail)*, 1545, Galleria Palatina, Firenze



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Visual light

Visual light



Infra-red

Ultra-violet

X-rays

Gamma-rays

$$750 \text{ nm} > \lambda > 400 \text{ nm}$$

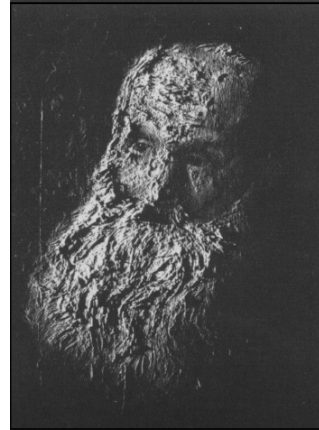
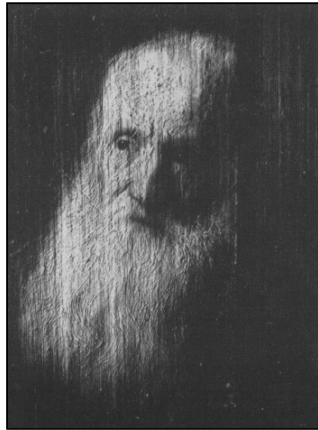


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Ranking light



Portrait of an old man, Jan Lievensz (1604-1674), Herzog Anton Ulrich Museum, Braunschweig

Infra-red

Visual light

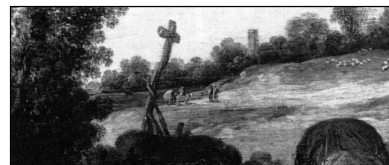
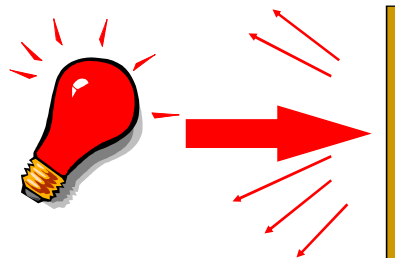
Infra-red

Ultra-violet

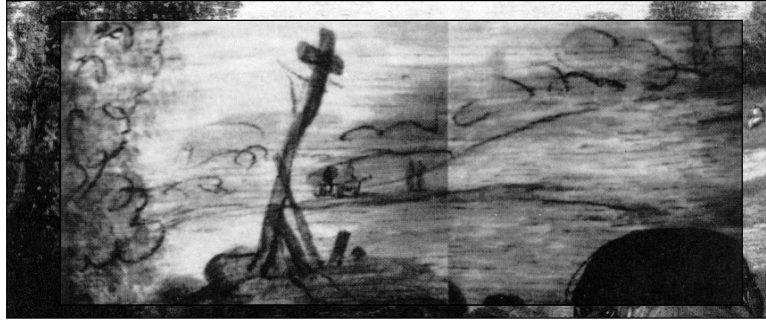
X-rays

Gamma-rays

$1900 \text{ nm} > \lambda > 750 \text{ nm}$



Infra-red reflectography



Infra-red reflectography



Anonimous manuscript, 1460 Eine Galerie des Unsichtbaren, R. Fuchs et al.
Spektrum der Wissenschaft, juni 1995

Ultra-violet

Visual light

Infra-red

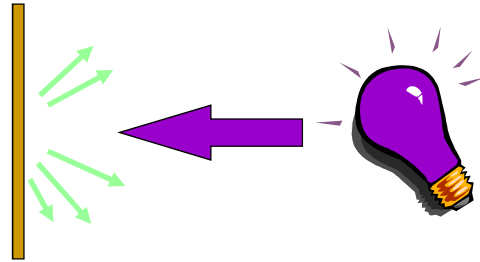
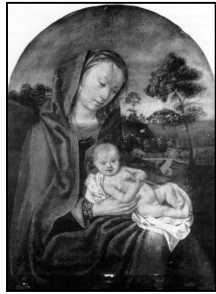


Ultra-violet

X-rays

Gamma-rays

$$400 \text{ nm} > \lambda > 320 \text{ nm}$$



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Ultra-violet



Gita Govind, Rajput School, India, ca. 1730, Detroit Institute of Arts



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X-rays

Visual light

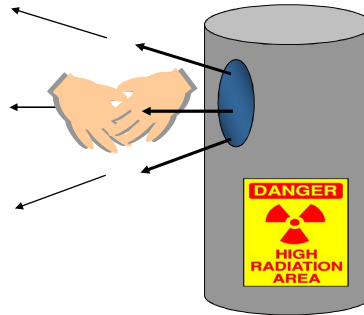
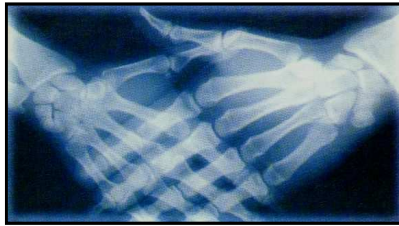
Infra-red



Ultra-violet

X-rays

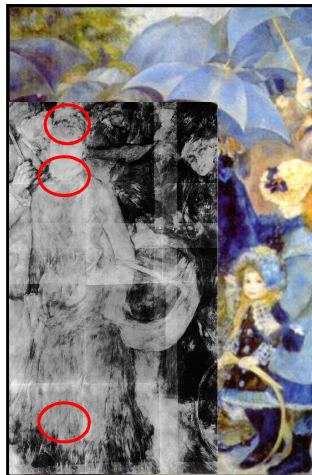
Gamma-rays



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X-rays



Les parapluies
P.A. Renoir, 1881-'86
National Gallery, London

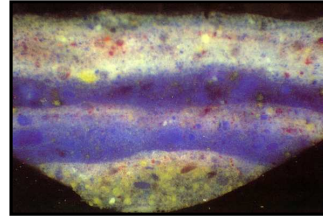
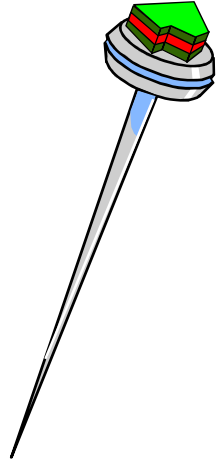


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If looking is not sufficient: analysis



Sampling:

ca. 0,1 mm diameter
Often during restoration

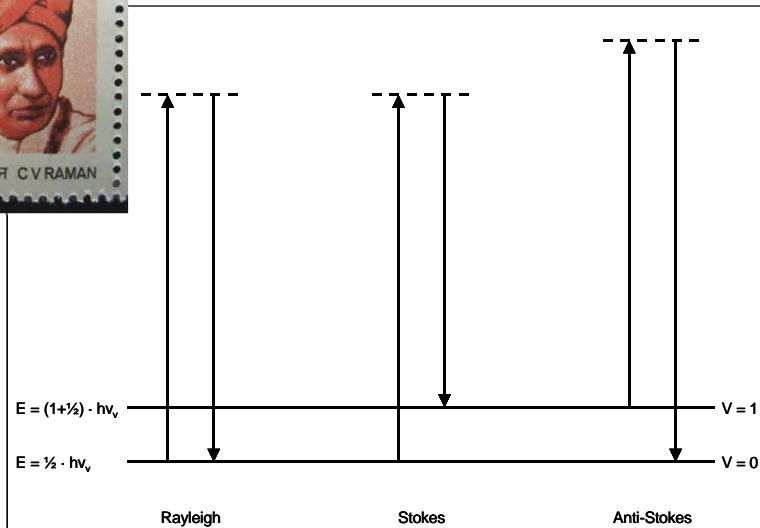
Sampling



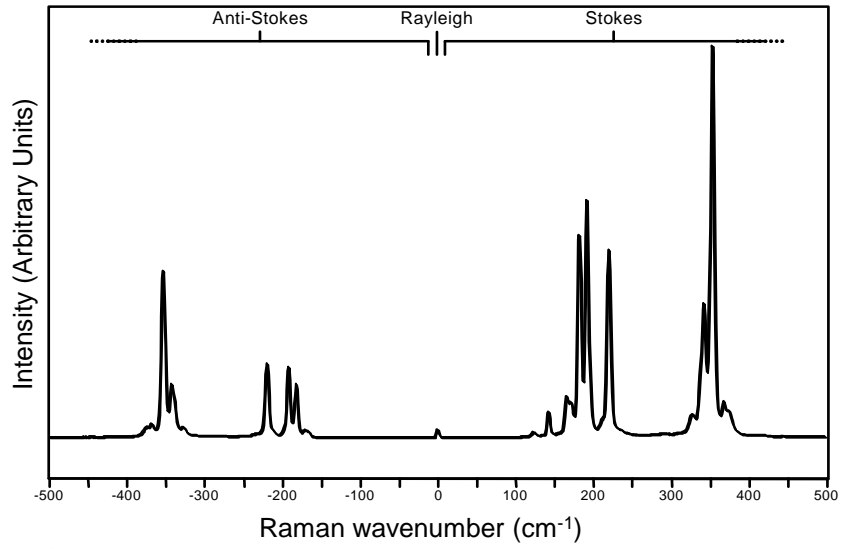
Sampling



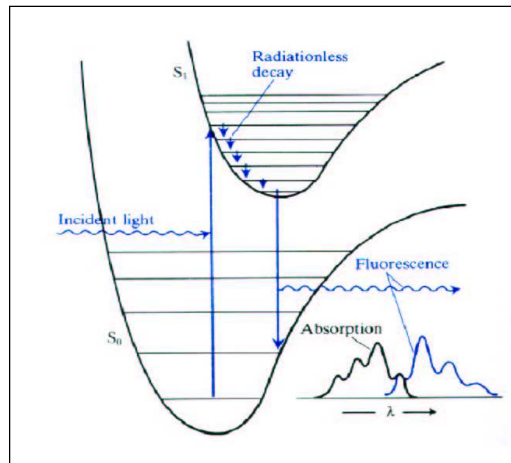
Raman Spectroscopy



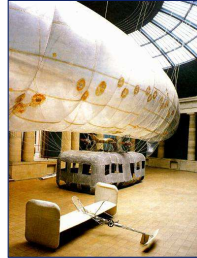
Raman Spectroscopy



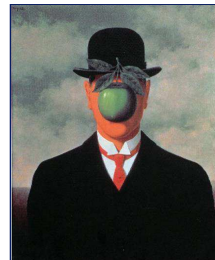
Raman Spectroscopy



Raman Spectroscopy in Archaeometry



Antique and modern art
Inorganic and organic
Fingerprinting and
spectral interpretation
Micro-samples and
direct analysis



Raman Spectroscopy in Archaeometry

P. Vandenabeele
et al. Chem. Rev.
107/3 (2007), 675.

	Minerals
Pigments	Textile fibres
Corrosion products	Paper and parchment
Biomaterials	Varnishes
	Jewels
Glass and glazes	Binding media
	Ceramics

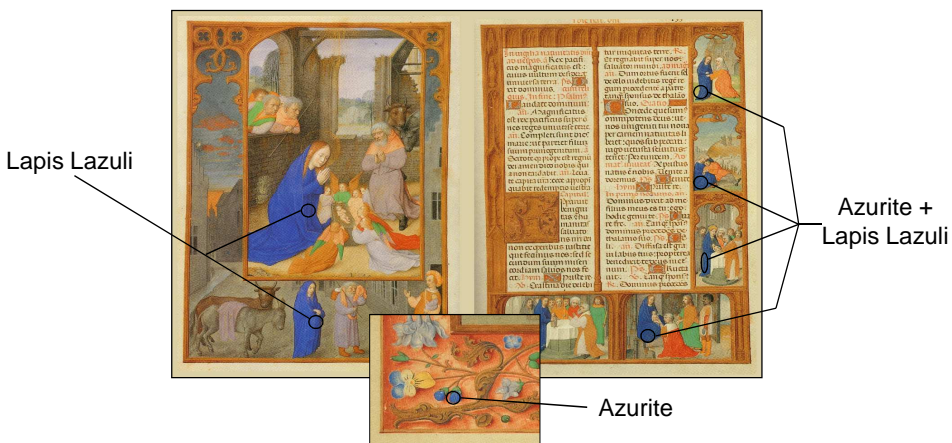
Breviarium Mayer van den Bergh



Flanders, ca. 1500
Ghent - Bruges School
Different miniaturists

P. Vandenebeele, et al, *Analyst*, 124 (1999), 169-172.

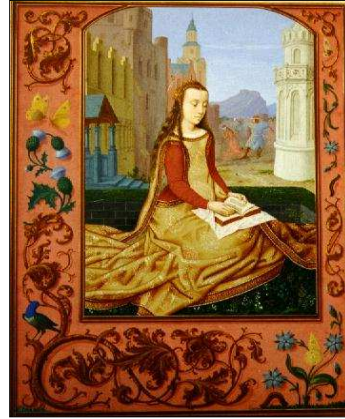
Breviarium Mayer van den Bergh



Dating of a manuscript

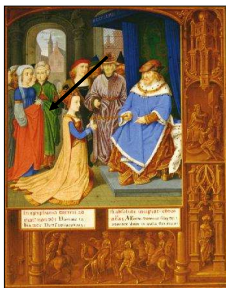


Salomon
Anonimous, Castle of Gaasbeek, Lennik(B)

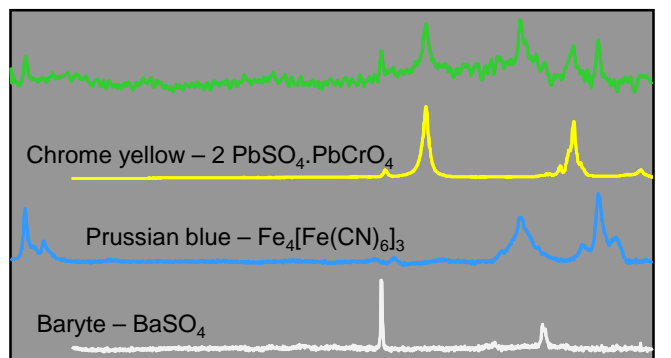


St. Barbara
Anonimous, Castle of Gaasbeek, Lennik(B)

Dating of a manuscript

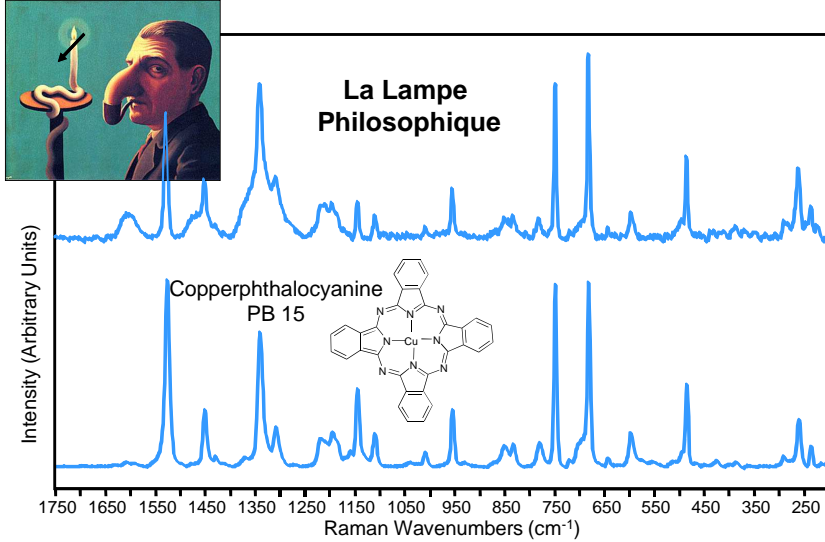


Intensity (relative)



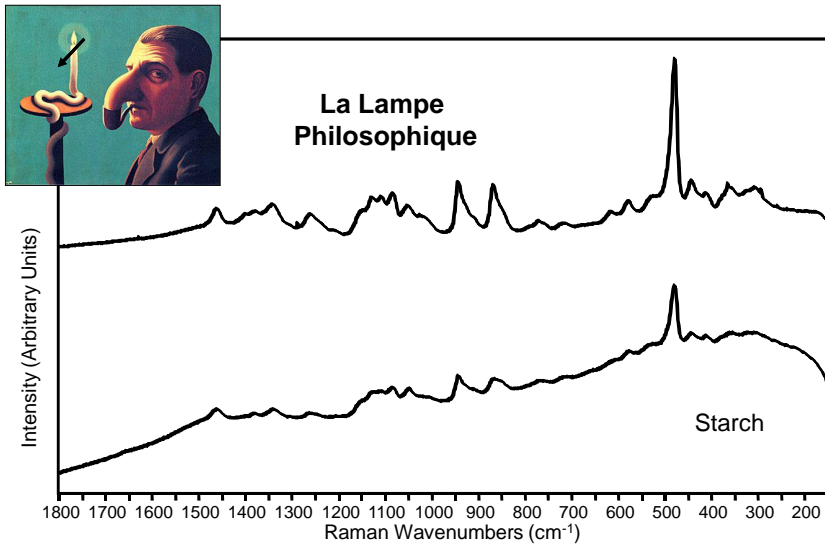
Raman wavenumber(cm^{-1})

René Magritte: La Lampe Philosophique (1936, C.R. 399)



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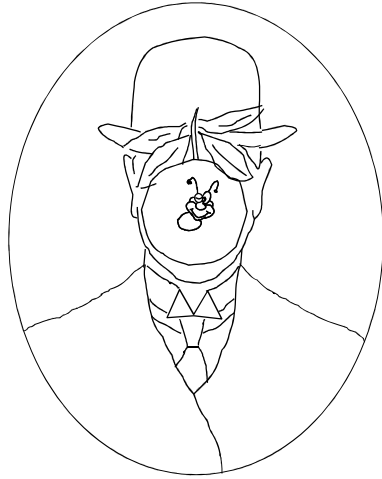
René Magritte: La Lampe Philosophique (1936, C.R. 399)



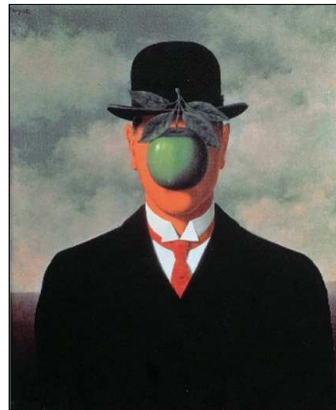
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René Magritte



La Grande Guerre
1964, CR: 1000



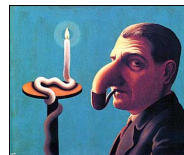
« Study for: La Grande Guerre »



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René Magritte



« Study for: La Grande Guerre »

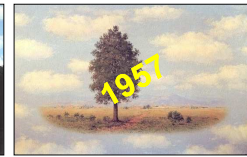
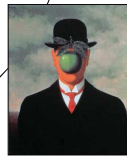


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René Magritte



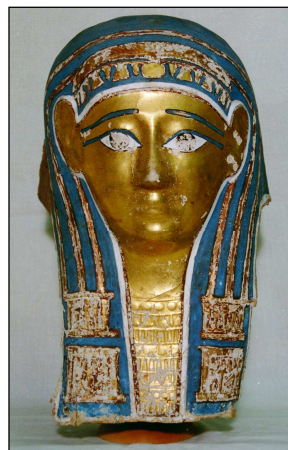
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Egyptian Burial Masks

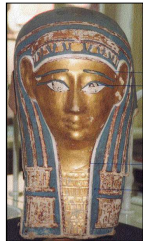


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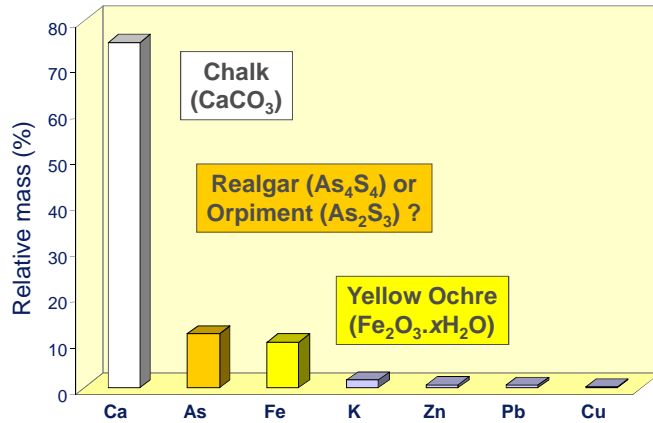
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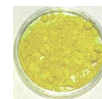
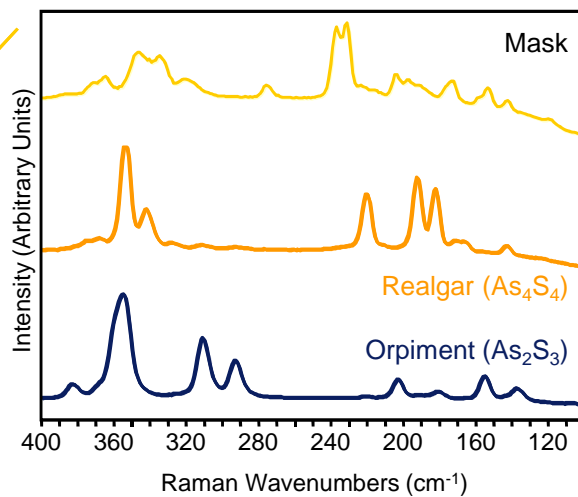
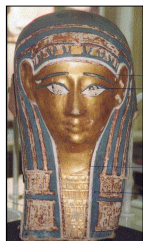
Egyptian Burial Masks



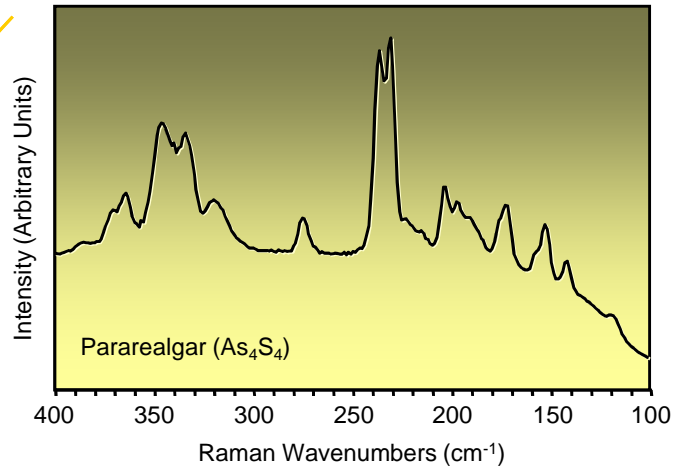
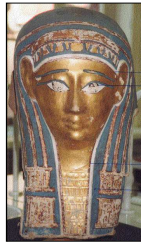
Elemental analysis of a beige sample (TXRF)



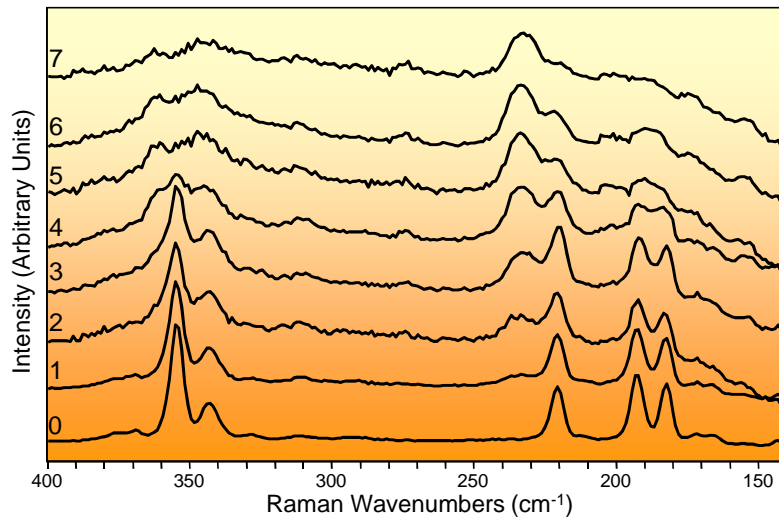
Egyptian Burial Masks

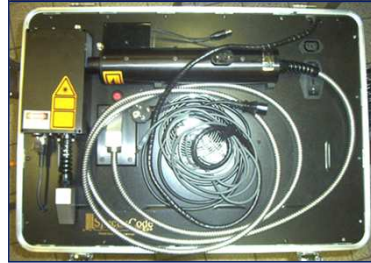
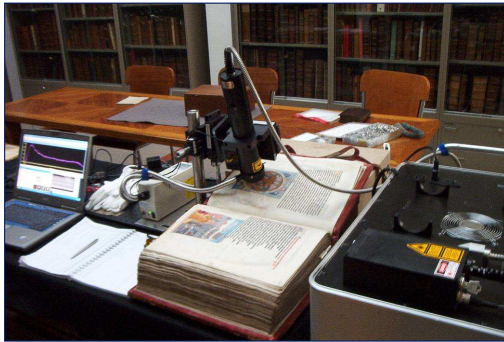


Egyptian Burial Masks



Egyptian Burial Masks





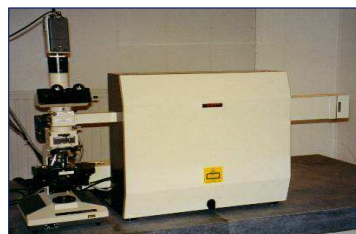
P. Vandennebe et al., *Analytical and Bioanalytical Chemistry*, 379/1 (2004), 137-142

Fibre optics probe head with colour camera and different objective lenses
 785 nm diode laser - spectral range 80-2500 cm^{-1}
 Laptop (USB) controlled through home-made software
 Different positioning equipments

Raman Instrumentation in Archaeometry

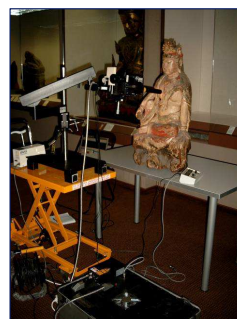
Laboratory equipment

- Micro-analysis (down to 1 μm)
- Samples or direct analysis
- Often different lasers available

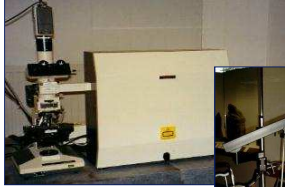


Mobile equipment

- Fibre-optics based
- Positioning equipment
- *In situ* analysis



Mobile Raman Spectroscopy



Transportable



Mobile



Portable



Handheld

Palm

P. Vandebaele et al., *Analytical and Bioanalytical Chemistry*, 379/1 (2004), 137-142

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Mobile Raman Spectroscopy



D. Lauwers et al. *Spectrochimica acta A* 118 (2014), 294-301.

Dual laser mobile Raman system (785 and 532 nm)
 Different lenses: e.g. High N.A., Long W.D.
 2 probeheads, no simultaneous measurement
 Spectral range: 100-2200 cm^{-1} (785 nm) and 100-3100 cm^{-1} (532 nm)
 Battery operated, compact, 5m optical fibre

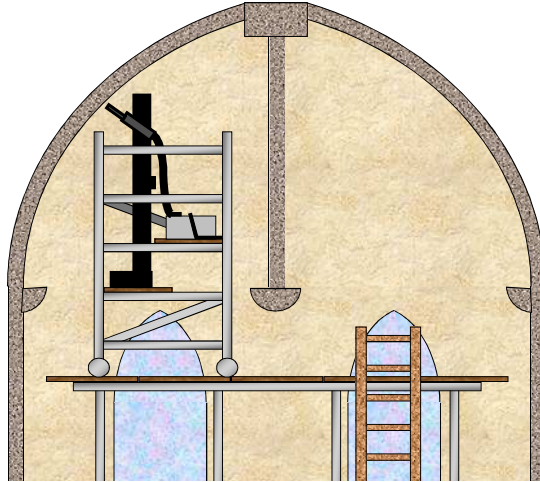


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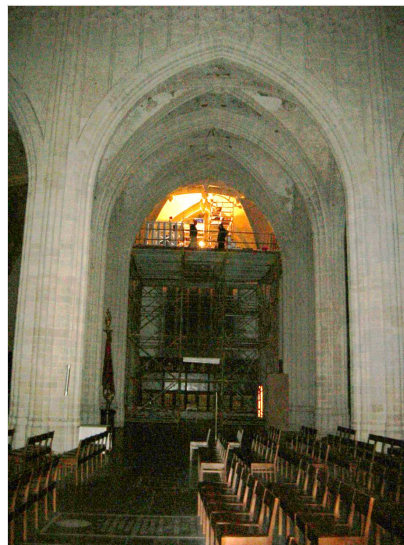
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Direct analysis of mediaeval wall paintings: Stability required: analysis on μm scale ?



Investigation of Mediaeval Wall Paintings: The Antwerp Cathedral (Work in progress)



Investigation of Mediaeval Wall Paintings: The Antwerp Cathedral (Work in progress)



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Investigation of Mediaeval Wall Paintings: The Antwerp Cathedral (Work in progress)

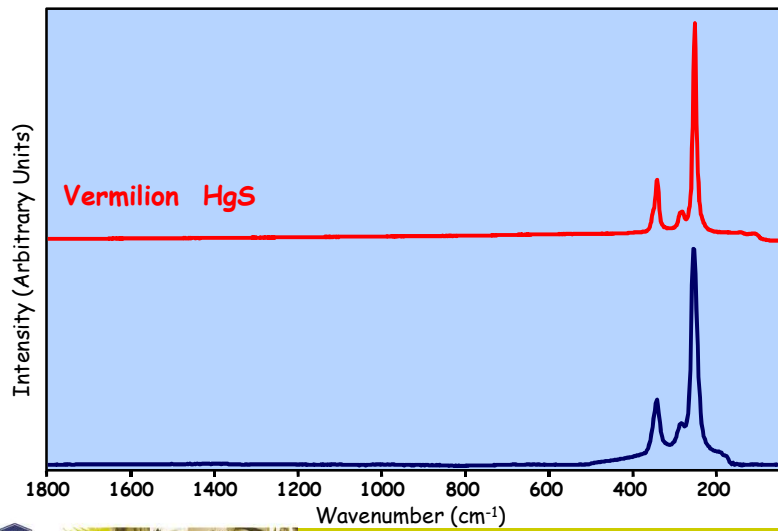


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Investigation of Mediaeval Wall Paintings: The Antwerp Cathedral (Work in progress)



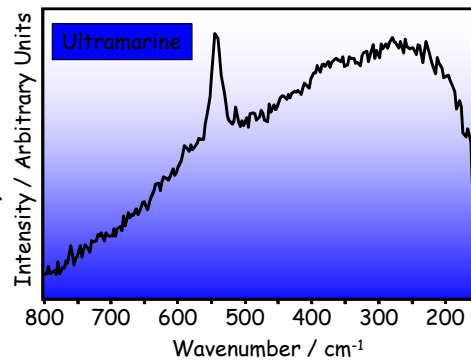
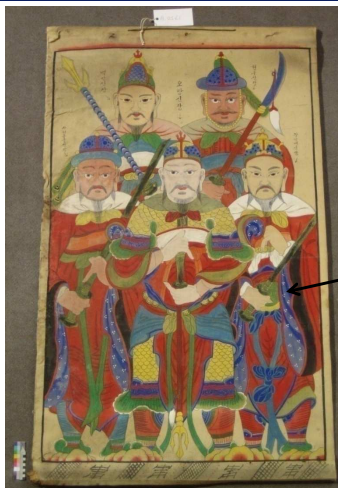
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Shaman paintings

P. Vandenabeele et al.
J. Raman Spectrosc.
39 (2008), 1030-1034.



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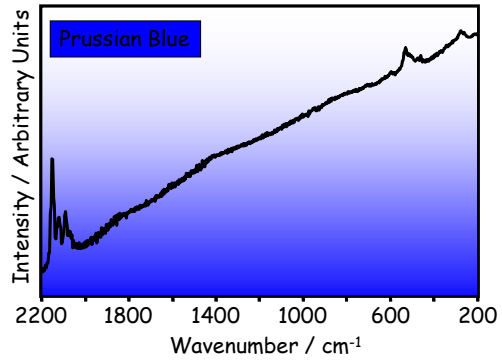
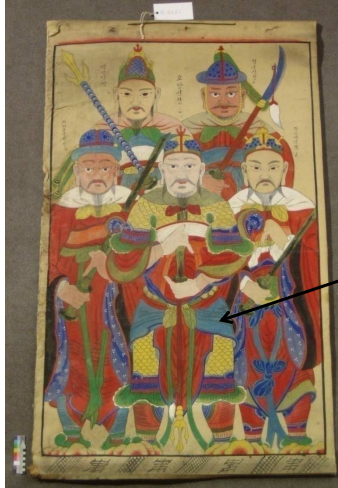
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Shaman paintings

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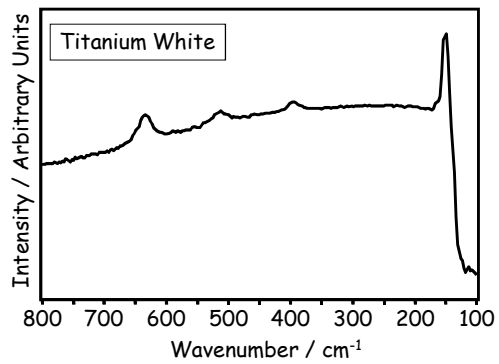
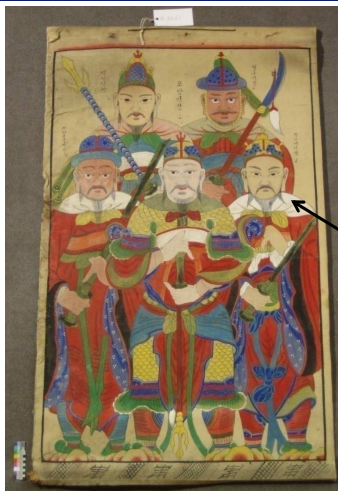
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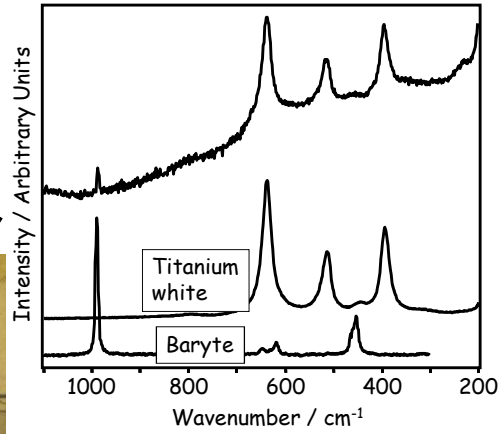
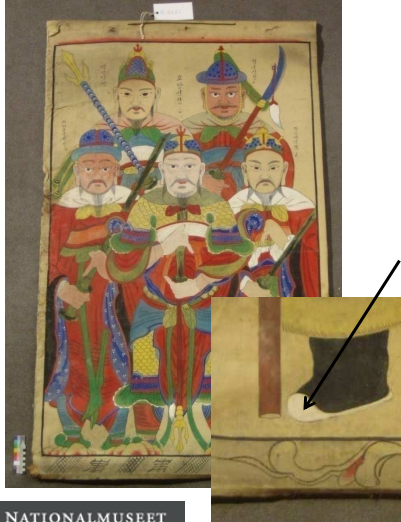
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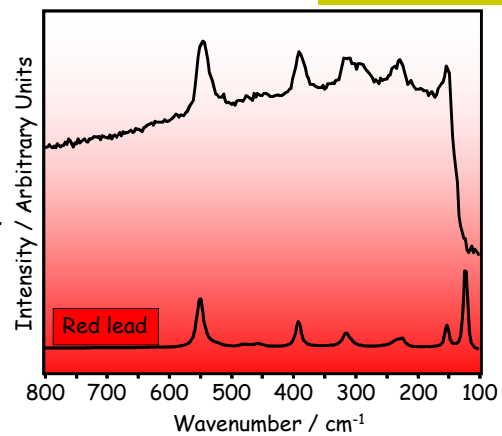
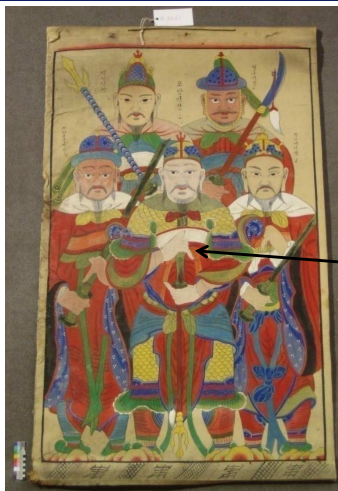


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Shaman paintings

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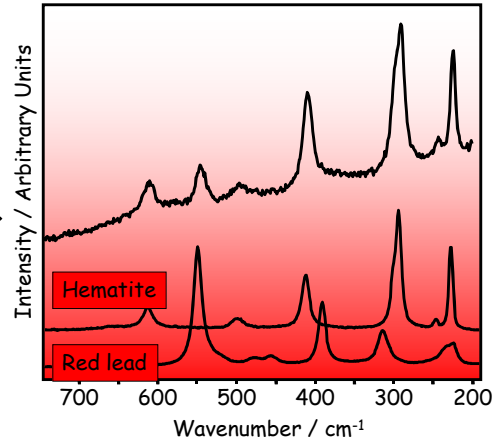
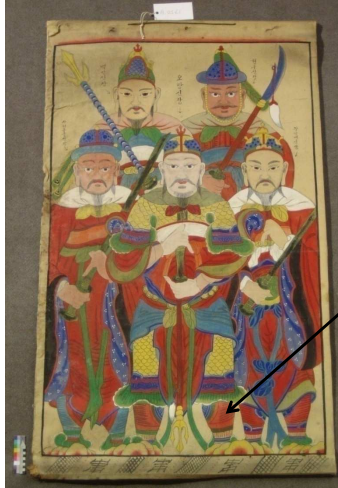
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39 (2008), 1030-1034.



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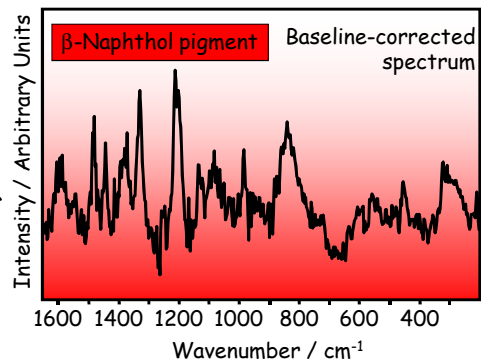
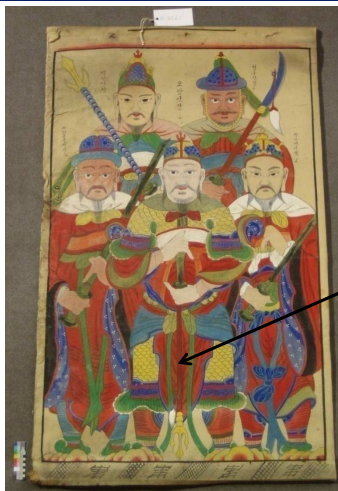
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Shaman paintings

P. Vandenabeele et al.
J. Raman Spectrosc.
39 (2008), 1030-1034.



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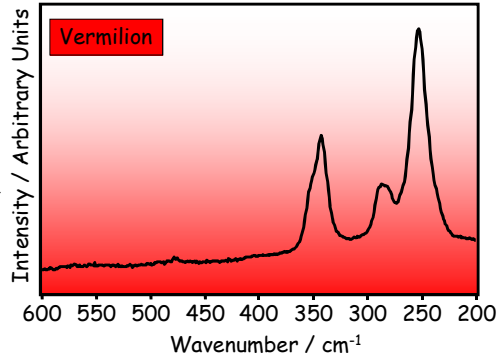
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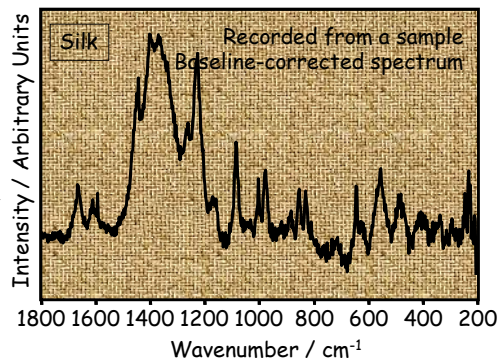
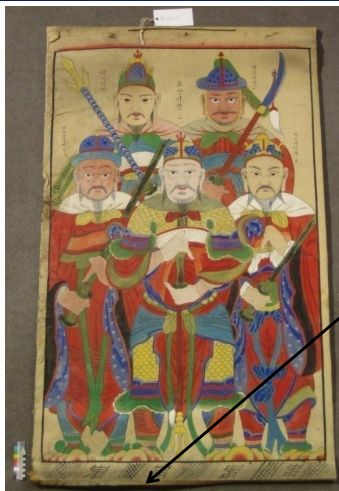
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Menna project

P. Vandenaabeele et al., Spectrochim. Acta A 73 (2009) 546-552



- Tomb of Menna (TT69)
- Theban Necropolis (Luxor)
- Private 18th Dynasty Chapel
- Reigns of Tuthmosis IV and Amenothep III (ca. 1419-1370 BC)
- "Overseer of the Fields"



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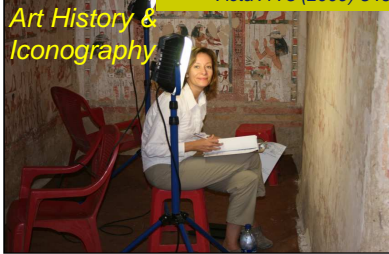
Menna project

P. Vandenaabee et al., *Spectrochim. Acta A 73 (2009) 546-552*

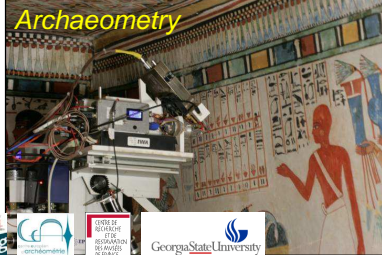
Archaeology



Art History & Iconography



Archaeometry



Conservation



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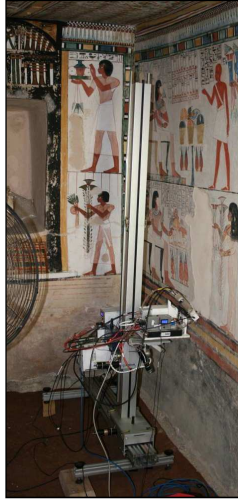


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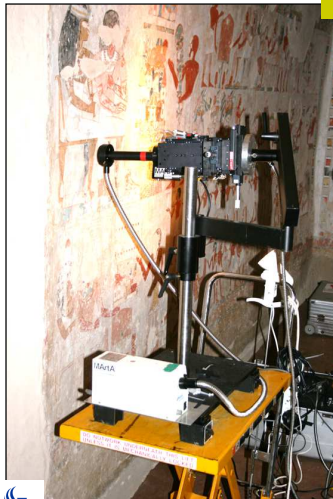
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Black:	Carbon black
White:	Gypsum & Calcite
Red:	Red ochre, Haematite, Realgar
Yellow:	Yellow ochre, Goethite, Orpiment
Green:	Egyptian green
Blue:	Egyptian blue



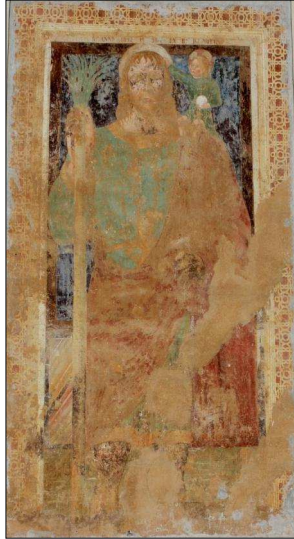
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Mobile Raman Spectroscopy



Wall Painting of S. Cristoforo
Church of Pianazzola (N. Italy)
Probably by Andrea Passeris di Torno (Como)
in 1495
Restored in 1892

Analysis with portable Raman spectroscopy

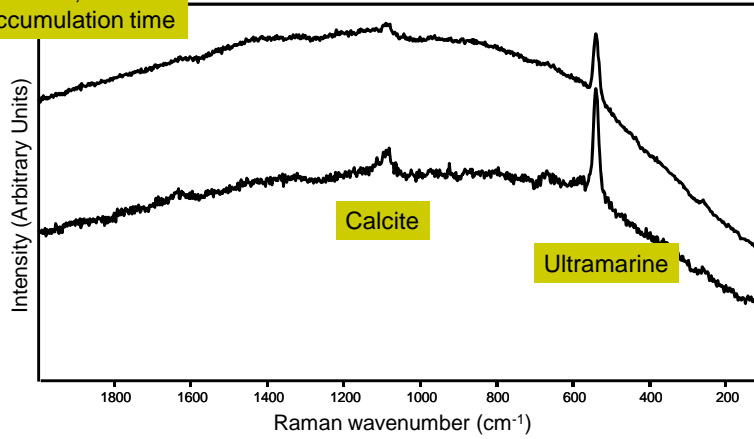
D. Lauwers *et al.*
Spectrochimica Acta A
(2014)

Mobile Raman Spectroscopy



Mobile Raman Spectroscopy

532 nm laser,
10s accumulation time

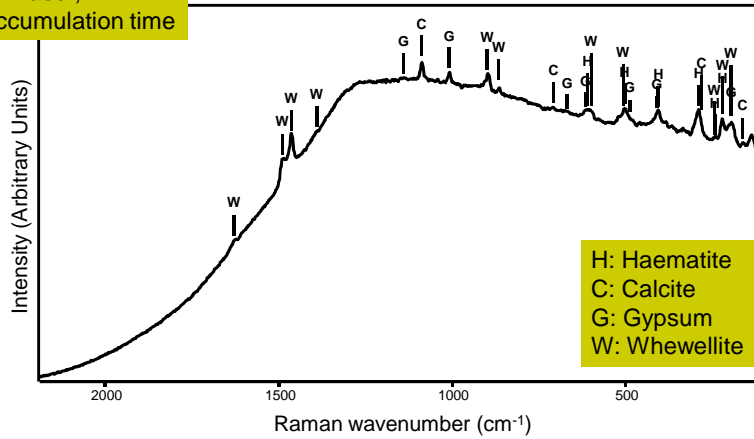


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Mobile Raman Spectroscopy

785 nm laser,
60s accumulation time



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Conclusions



Raman spectroscopy is a powerful technique that has many different applications in archaeometry

Mobile instrumentation, adapted for archaeometrical research becomes increasingly important in this expanding research field

Combination with other techniques, such as XRF provide very useful (complimentary information)

We look forward to further improve and optimise our approach in this highly interesting but challenging research field!

