THE BRITISH MUSEUM

OCT4ART
OPTICAL COHERENCE TOMOGRAPHY FOR EXAMINATION OF ART

OCT in the context of other techniques for examining and analysing works of art

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Examination and analysis techniques

- Two slightly different perspectives

- In the Museum:

The researcher has some pressing questions and has good access to their collections, but the analytical equipment needed to answer some of these is not available to them and the cost of equipment or external analysis is rather high.

- In the University:

The researcher has developed a promising piece of analytical equipment, so availability and cost are not issues, but good applications for the technique on works of art require access to collections and research questions.

Examination and analysis techniques

- What type of information is produced?
- Does the technique require contact or samples?
- How representative are the results?
- Cost of equipment or analysis?

Examination and analysis techniques

- What type of information is produced?
  - Structural information (biological/petrographic/metallurgical microscopy, boroscopy, imaging techniques, radiography, SEM, computed tomography)
  - Elemental information (SEM/EDX, XRF, PIXE, AAS, etc.)
  - Molecular information (Raman spectroscopy, XRD, GC-MS, HPLC, other chromatographic techniques, FTIR, etc.)
  - Dating (radiocarbon dating, stable isotope analysis, etc.)

Examination and analysis techniques

- Does the technique require contact or samples?
  - Non-invasive (microscopy, boroscopy, imaging techniques, radiography, Raman spectroscopy, X-ray fluorescence, PIXE, computed tomography, etc.)
    [many are also non-contact]
  - Non-destructive (biological/petrographic/metallurgical microscopy, SEM/EDX*, XRD*, FTIR*, etc.)
    [* can be used without sampling in some cases]
  - Destructive (GC-MS, py-GC-MS, HPLC, LC-MS, other chromatographic techniques, LIBS, radiocarbon dating, stable isotope analysis, etc.)

Examination and analysis techniques

- How representative are the results?
  - Point information on the surface (Raman spectroscopy, XRF, XRD, PIXE)
  - Stratified point information (biological/petrographic/metallurgical microscopy, SEM, XRD, FTIR, GC-MS, HPLC and other chromatographic techniques)
  - Surface imaging or mapping (microscopy, ultraviolet fluorescence and other imaging techniques)
  - Collapsed 3D information (X-radiography, neutron radiography)
  - Stratified area information (computed tomography, confocal microscopy, OCT)

Examination and analysis techniques

- Cost of equipment or analysis?
  - Routine low-cost methods (microscopy, ultraviolet fluorescence and some other imaging techniques)
  - Basic museum ‘toolkit’ (biological/petrographic/metallurgical microscopy, FTIR, SEM/EDX, Raman spectroscopy, XRF, XRD, GC-MS, HPLC, X-radiography) [EU-ARTECH MOLAB initiative]
  - Specialist techniques through collaboration (PIXE, computed tomography, neutron radiography, SIMS, PGAA, etc.)
  - Bought in services (radiocarbon dating, stable isoptope analysis, etc.)

Examination sequences: current techniques

- A few questions can be answered using a single technique, e.g.

What is the crystalline degradation product on the surface of a metal sculpture? (XRD)

Is a portable diptych made of bone or ivory? (biological microscopy)

Was a particular modern adhesive used in this repair? (FTIR)

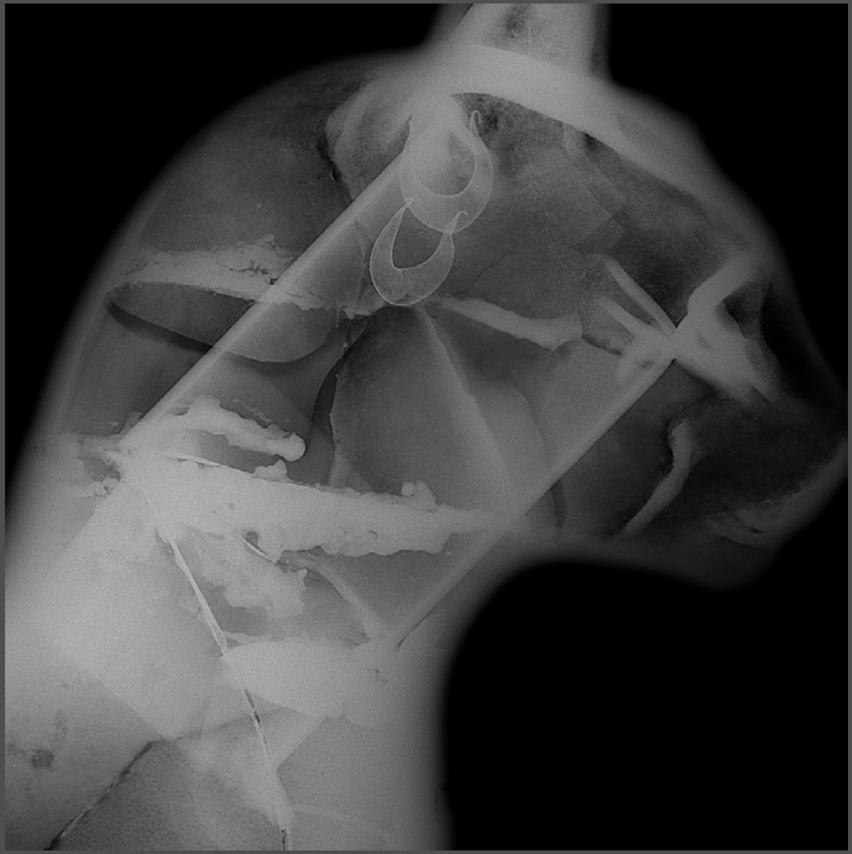
- But most research requires a combination of techniques:

Examination sequences: current techniques

- Example: The Geyer Anderson cat

Examination sequences: current techniques

- Example: The Geyer Anderson cat



- X-radiography
  - High-quality original casting by lost wax method
  - Damaged at a later date and re-joined with an insert to support head

Examination sequences: current techniques

- Example: The Geyer Anderson cat

- Boroscopy
  - The head cavity is blocked with clay-like material
- Microscopy
  - Some fibres from the interior are modern cotton wool
  - Older fabric (flax) and skin remains suggest the statuette may have acted as a ‘coffin’

Examination sequences: current techniques

- Example: The Geyer Anderson cat

- XRD and Raman spectroscopy
  - Original patina comprises cuprite: copper (I) oxide and atacamite: basic copper chloride
  - Applied coating comprises basic lead carbonate, barium white, chrome yellow and Prussian blue – most likely ‘Brunswick green’.

Examination sequences: current techniques

- Example: The Geyer Anderson cat

- XRF spectrometry
  - Main casting: 84.7% copper, 13% tin, 2.1% arsenic & 0.2% lead
  - Jewellery: 92% gold, 6% silver & 2% copper (earrings); 79% gold, 15% silver & 6% copper (nose ring); udjat plaque is silver
  - Stripes on tail: 94.6% copper, 3% tin, 1% arsenic, 0.7% lead, 0.8% iron

Examination sequences: the role of OCT

- How do the properties of OCT fit into the earlier matrix?

- What type of information is produced?
  - Mainly structural
- Does the technique require contact or samples?
  - Non-invasive and non-contact
- How representative are the results?
  - Gives stratigraphy across an area
- Cost of equipment or analysis?
  - Relatively inexpensive – could be part of the ‘toolkit’

Examination sequences: the role of OCT

- Example: Persian tiles
  - Part of an international (France, Germany, UK) project to examine nineteenth century Persian glazed tiles to study the method of production, look for materials that help date the tiles and criteria that could assign tiles to particular workshops

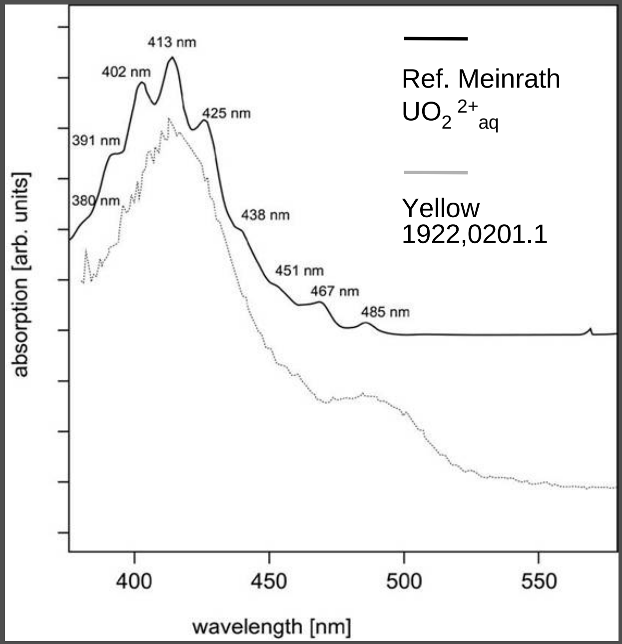


Examination sequences: the role of OCT

- Example: Persian tiles

BM 1922,0201.1 visible image

Ultraviolet luminescence image



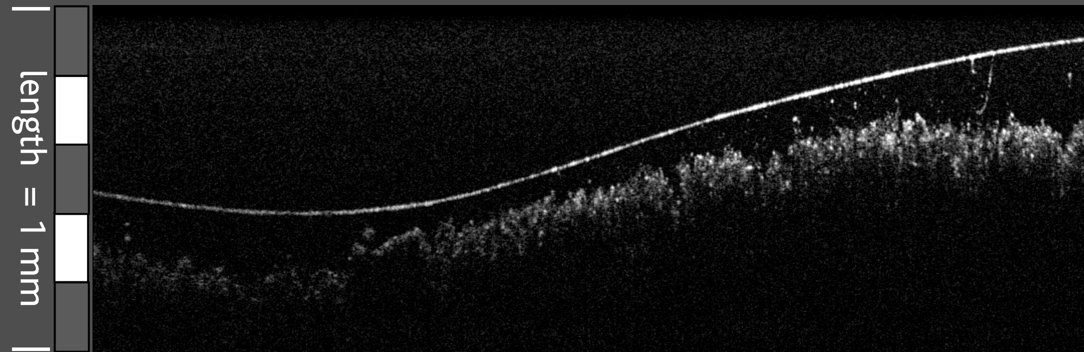
Visible spectroscopy

- Ultraviolet luminescence imaging
  - Old repair visible to upper right and the pigment from the green area fluoresces strongly
- Visible spectroscopy
  - Shows that a uranium-containing yellow is mixed with a blue in the green areas of the tile

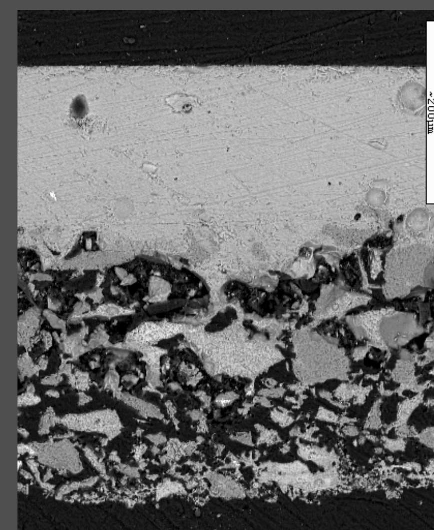
Examination sequences: the role of OCT

- Example: Persian tiles

Non-invasive examination of BM G.313 by OCT using equipment from Nottingham Trent University



OCT image (horizontal axis exaggerated)
Thickness = 0 to 1 mm with a mean of ~200 µm

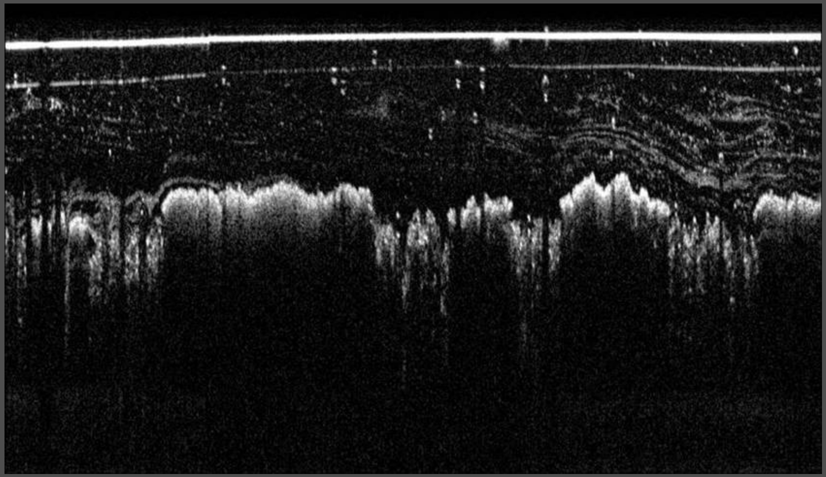


Back scattered SEM image through the glaze
Scale bar = 200 µm

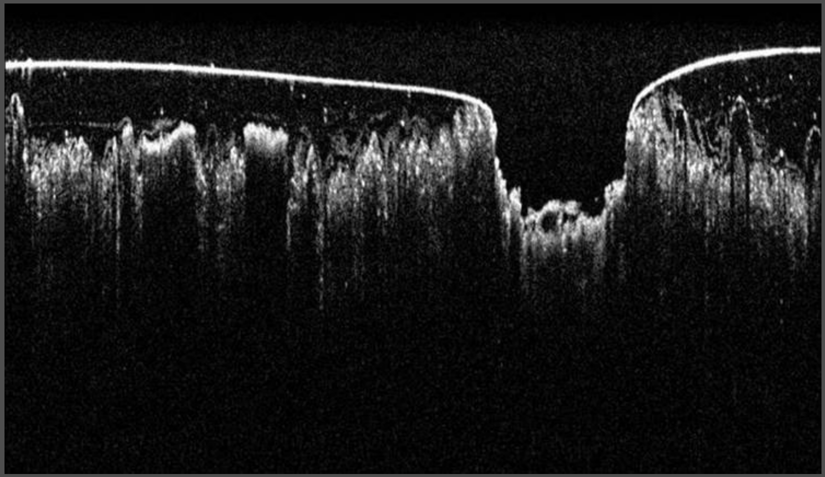
- Optical Coherence Tomography
  - Was used to profile the depth of the glaze across a large area of the tile
- Scanning Electron Microscopy (SEM)
  - The back-scattered image of a sample confirmed the depth of the glaze

Examination sequences: the role of OCT

- Example: Persian tiles



OCT image of tile G.313 (horizontal axis exaggerated)
Note mixing of the glaze and body colour



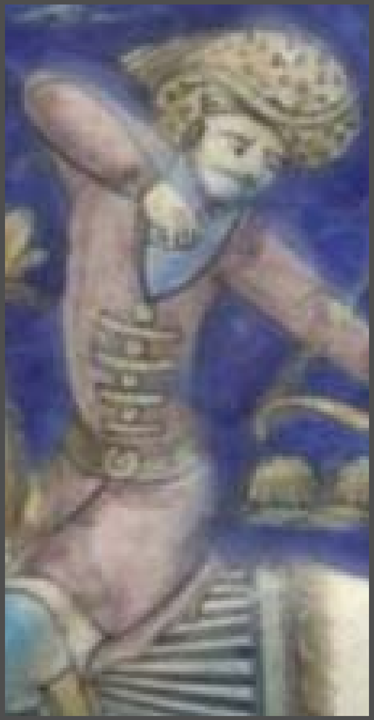
OCT image of a surface defect on tile G.313
(horizontal axis exaggerated)

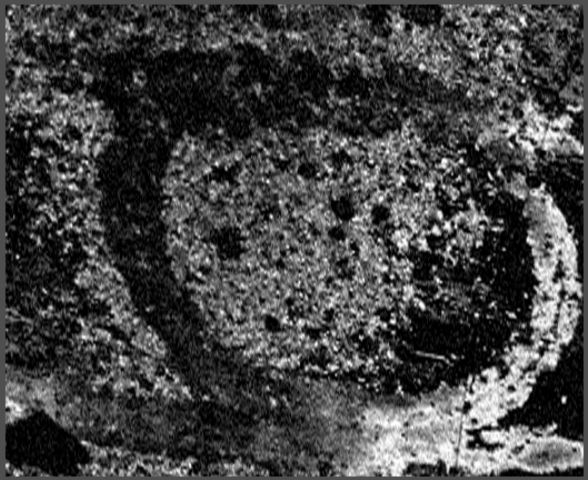
- Optical Coherence Tomography
  - Was used to profile the depth of the glaze and to look for points where body colour had mixed with the glaze
- X-ray fluorescence spectrometry (XRF)
  - XRF cannot detect elements in the pigments of the body colour where the glaze is thick. OCT informed the positions at which XRF was conducted – where the glaze is thin or body colour is mixed in the glaze

Examination sequences: the role of OCT

- Example: Persian tiles

BM G.313 visible image





En-face OCT map of the area, showing the raised decoration applied over the body colour

BM G.313 detail

Conclusions

- The role of OCT in examination
- Investigating stratigraphies and internal features
- Fast non-contact assessment of moderate sized areas for surveying and to identify suitable sample sites
- Mapping the distribution of materials identified by other techniques across much larger areas
- Real time measurements of processes of change
- Identifying materials?

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