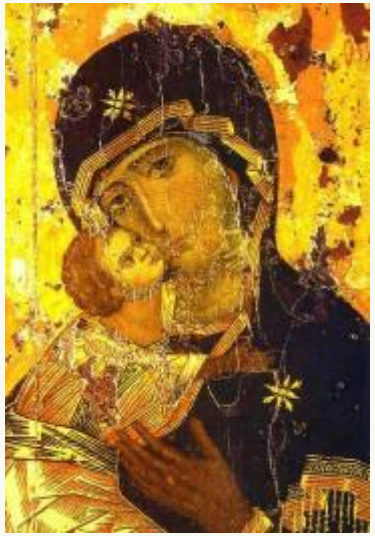
ORMYLIA FOUNDATION
ART DIAGNOSIS CENTER

WORKSHOP on Novel non-invasive technologies
assisted by robotic & Artificial Intelligence
for Cultural Heritage preservation & documentation
September 25th, 2018

Knowledge basis and annotation tools on FTIR spectroscopy, μ-Raman Spectroscopy, XRF analysis, Ultrasonic Scanning and Ultraviolet – Visible spectroscopy data

EU Sca4Reco project
"Multimodal Scanning of Cultural Heritage Assets for their multi-layered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing

Introduction



- **Problem:** decay of byzantine iconography and metallic objects that need restoration
- Decay obvious by the **human eye perspective**.
- Are all kinds of decay obvious? Decay that cannot be distinguished by human eye perspective.
- Which and how many are the kinds of decay? How can they be sorted?
- How many kinds can happen in the same time?
- How could kinds of decay be distinguished from the unaffected matrix of the object. Experience is necessary.

Expertise opinion. → **Subjective**

- **Scientific measurements** that display the kind and extend of the decay. → **Objective**

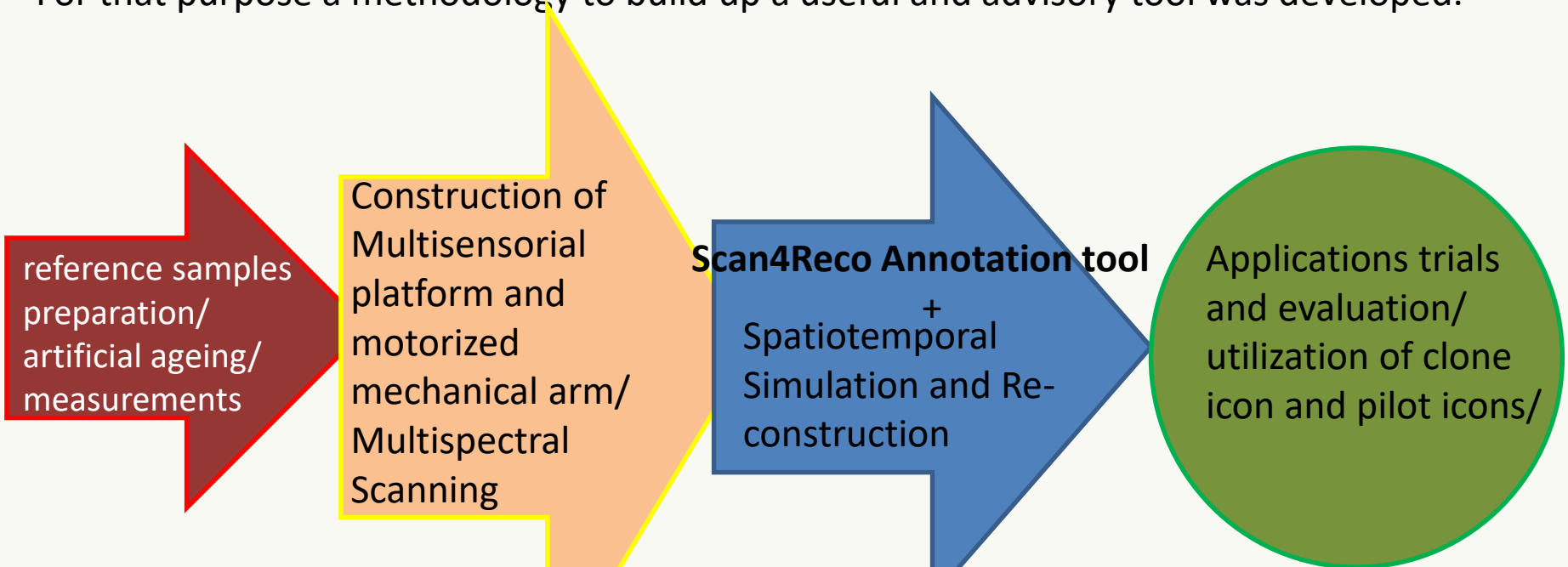
Introduction

Scientific documentation of the type of decay of painted and metallic (silver and bronze) objects by crosschecking measurements from different techniques-instrumentation.

Create an assisting tool for the user, that will facilitate the decision-taking.

The close to reality correct diagnosis is based on properly structured database and correct simulation based on aging.

For that purpose a methodology to build up a useful and advisory tool was developed.



Target

Main aim of Scan4Reco project related to the knowledge base:

Preparation of reference samples/ panel of colors based on materials used, techniques and stratigraphy of byzantine iconography/ metallic samples silver and bronze

Artificial ageing of reference samples (T0 up to T3, under temperature and UV variations)

Tested and studied after every ageing step using FTIR, UV-Vis, XRF, Raman, Ultrasound

Constitution of a concentrated and centered database that will train the spatiotemporal simulation algorithms - they will be used for calibration of the developing scanning techniques and most importantly they will assist in the extraction of the material specific ageing models

The construction of a software that brought all data together and lead to simulation potentialities and to an effort to subjective diagnosis based on ageing models.

Target

How could the scientific documentation be expressed, in order to categorize the decay, evaluate the degree and the combination of decays and propose restoration steps the for a painted object?

How could a documentation be evaluated and serve the purpose of diagnosis?

Does the stratigraphy of pigments influence the documentation results? Do the signals differentiate?

What factors influence the detectability of decay results on artwork?

Creation of knowledge base

Creation and preparation of a wooden panel with combinations of inorganic pigments based on the already existing ones in the Lab of “ORMYLIA” Foundation

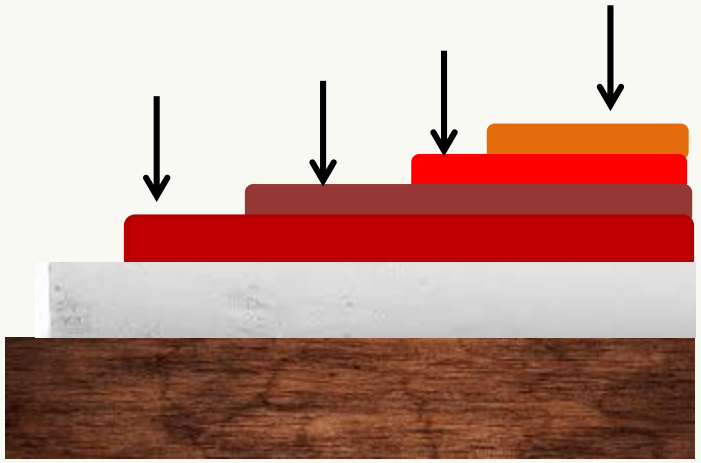
measurements

List of inorganic pigments

- massicot
- yellow, red and warm ochre
- hematite
- burnt sienna
- caput mortuum
- minium
- cinnabar
- green earth
- verdigris
- malachite
- ultramarine
- cobalt blue
- prussian blue
- indigo
- azurite
- carbon black

Creation of knowledge base

Layers of a single pigment



different pigment layers

Stratigraphy: Wooden carrier, preparation layer (chalk or plaster), pigment layers, coating (varnish mostly)

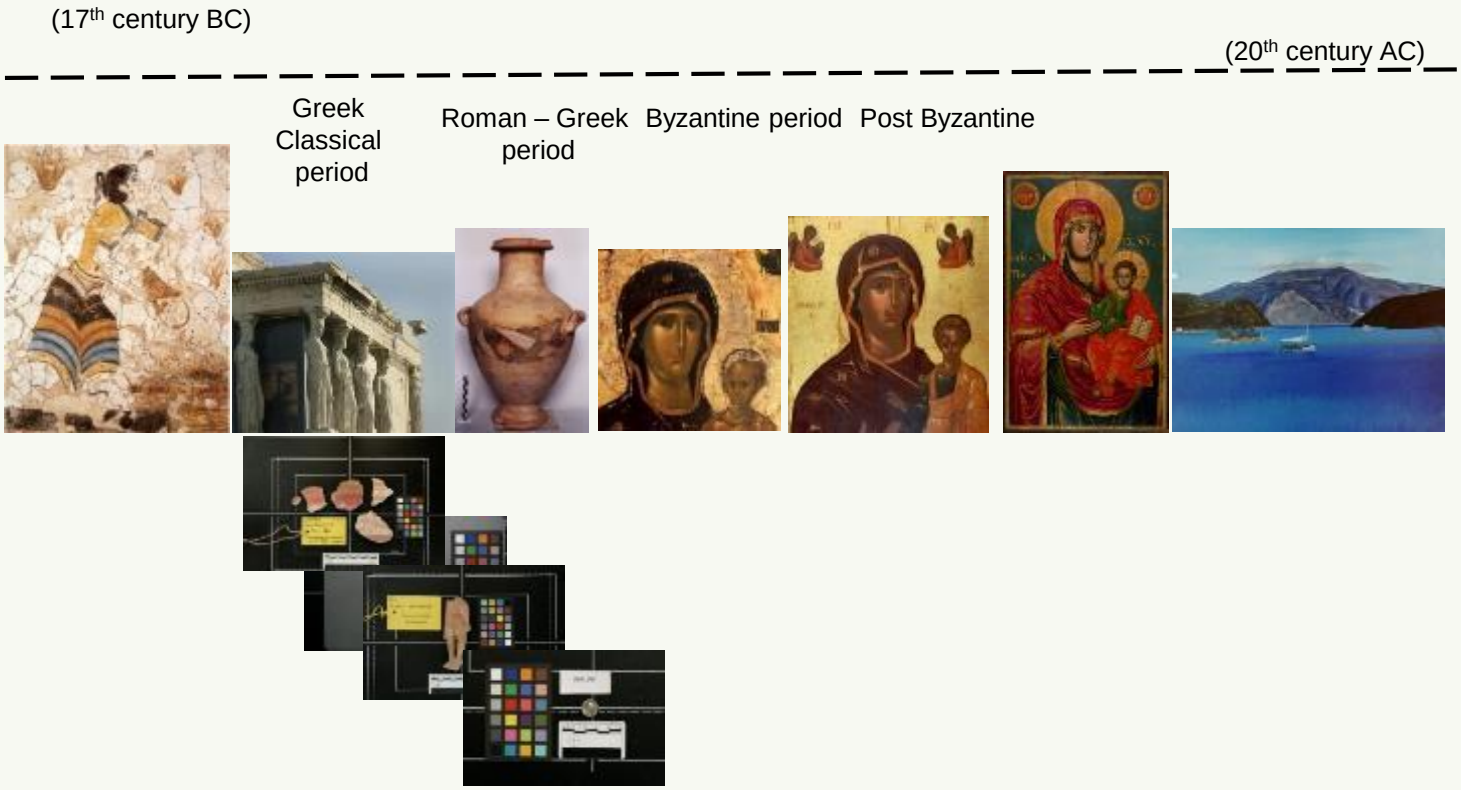
Measurements of all cases in order to cover all probable combinations

- Samples with stratigraphy of same pigment in some cases or a single layer of a pigment
- Samples with stratigraphy of different pigments
- Measurements on every layer and after every ageing step, that are called T0, T1, T2 and T3
- Measurements on varnished and un-varnished areas

Existing Knowledge base

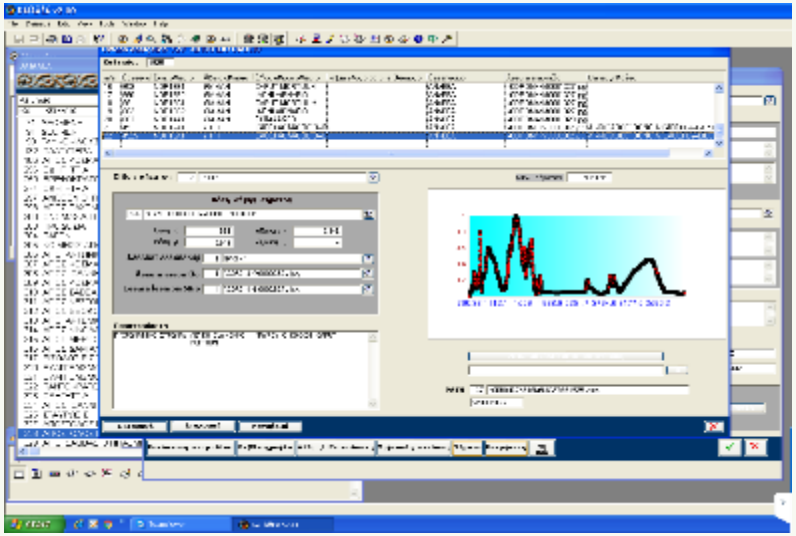
“ORMYLIA” Foundation Database from over 20 years of study on artworks and byzantine iconography

Research – Documented knowledge – Interdisciplinary study



Existing Knowledge base

“ORMYLIA” Foundation Database from over 20 years of study on artworks and byzantine iconography, over 8,500 samples



Knowledge base

- **“Ormylia” Foundation Database from over 20 years of study o byzantine iconography**
- **Scientific techniques – instrumentation**

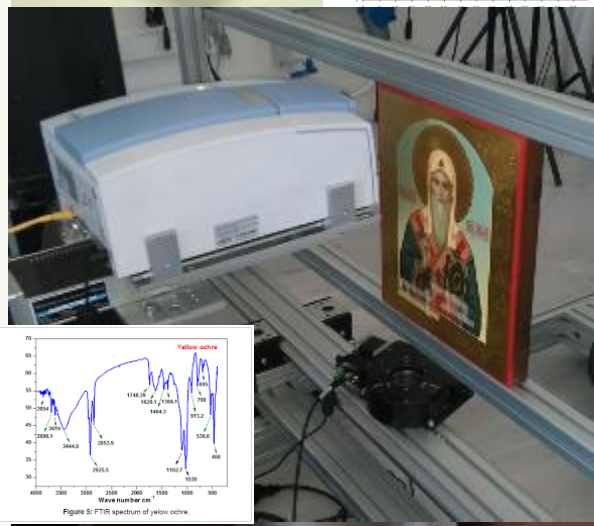
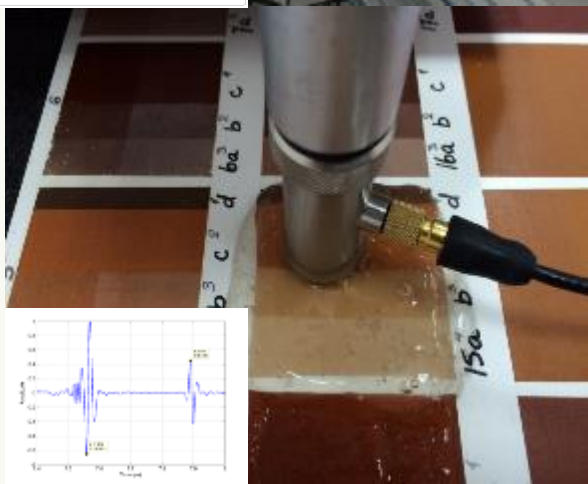


Figure 5: FTIR spectrum of yelow ochre.



	Contribution
X-Ray Fluorescence	Elementary analysis
FTIR Spectroscopy	Detection of variations of organic carrier - matrix of inorganic pigments
Ultrasonic scanning	Imaging of internal structure – changing of roughness of the surface – surface layers, µTomography

Knowledge base

- **Ormylia Foundation_Database from over 20 years of study on artworks and byzantine iconography**
- **Scientific techniques – instrumentation**

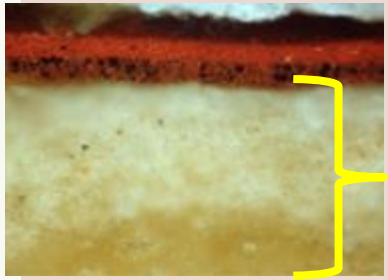
	Contribution
IR Imaging	Reveal underpainting and initial drawing, technology and style of creation, Pentimenti,
µRaman Spectroscopy	Identification of inorganic pigments
Ultraviolet – Visible Spectroscopy	Characterization of color (L*a*b color space)

Annotation tool – Ontology of the Pathology of a painted object

Wooden Carrier

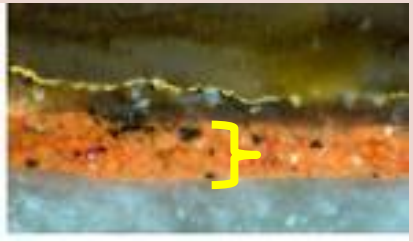
- LOSS OF PART OF WOODEN CARRIER
- LOSS OF PANEL
- BREAKING OF WOODEN CARRIER
- CRACKS OF WOODEN CARRIER
- ADDITION OF NEWER WOODEN SUPPLEMENT
- INSULT OF XYLOPHAGOUS PESTS (LIMITED, EXCESSIVE , NONE DAMAGE)
- INSULT OF FUNGUS
- BACKSIDE COATING : OIL, PREPARATION, PAINTING, INSCRIPTION , NUMBER
- MOISTURE SPOTS , KNOTS
- HUMIDITY SPOTS
- CURVATURE : NONE , SMALL, LARGE

Preparation layer



- TOTAL LOSS OF PREPARATION
- PARTIAL LOSS OF PREPARATION
- COHESION OF PREPARATION AND WOODEN CARRIER (HIGH , MEDIUM , LOW)
- COHESION OF PREPARATION AND PAINTING SURFACE (HIGH, MEDIUM , LOW)
- Cracks
- DETACHMENT OF PREPARATION

Paint layer

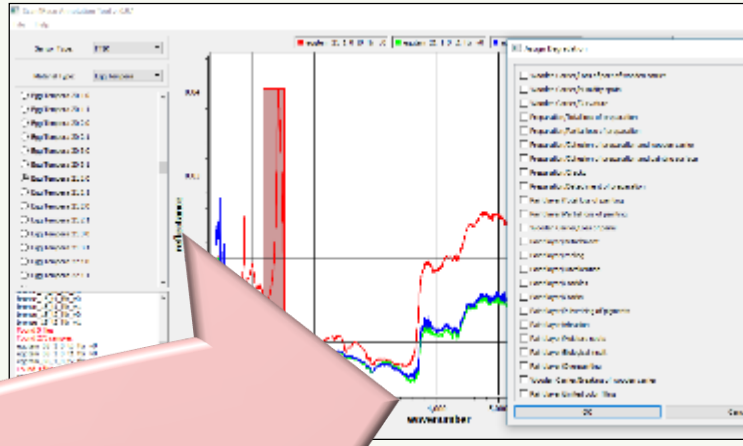


- TOTAL LOSS OF PAINTING
- PARTIAL LOSS OF PAINTING
- DETACHMENT
- PEELING
- DISCOLORATION
- CRACKLES
- CRACKS
- PULVERIZING OF PIGMENTS
- ABRASION
- MOISTURE SPOTS
- BIOLOGICAL INSULT
- LOSS OF BONDED WATER
- OVERPAINTING : TOTAL , LOCAL , BACKGROUND, PERIMETRICAL , ELSE
- COLOR FILLING : LIMITED , EXCESSIVE

Protecting coating

- VARNISH LOSS : LIMITED , EXCESSIVE
- OXIDATION
- WAX DEPOSITS
- SOOT AND REST AIR POLLUTANTS' DEPOSITS

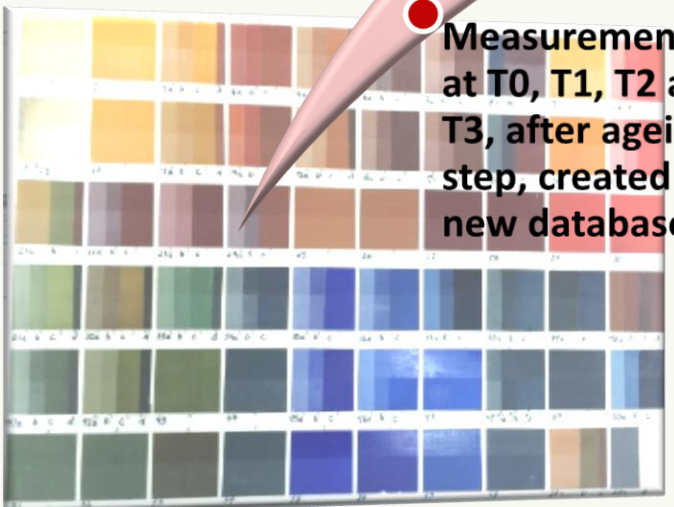
Knowledge base – Scan4Reco



Annotation tool Software designed and implemented for Scan4Reco

Already existed database from recent knowledge

Measurements at T0, T1, T2 and T3, after ageing step, created a new database



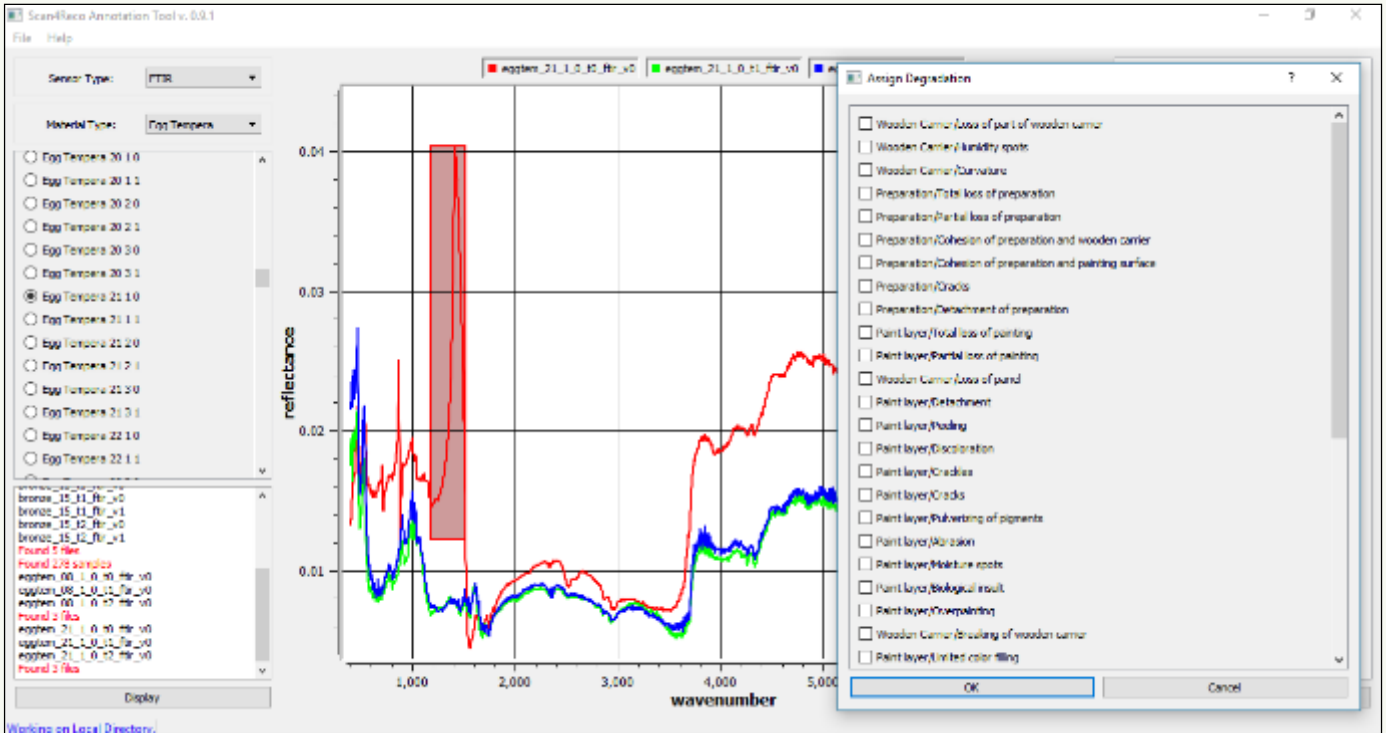
Experts

Ontology of Pathology

Annotation tool

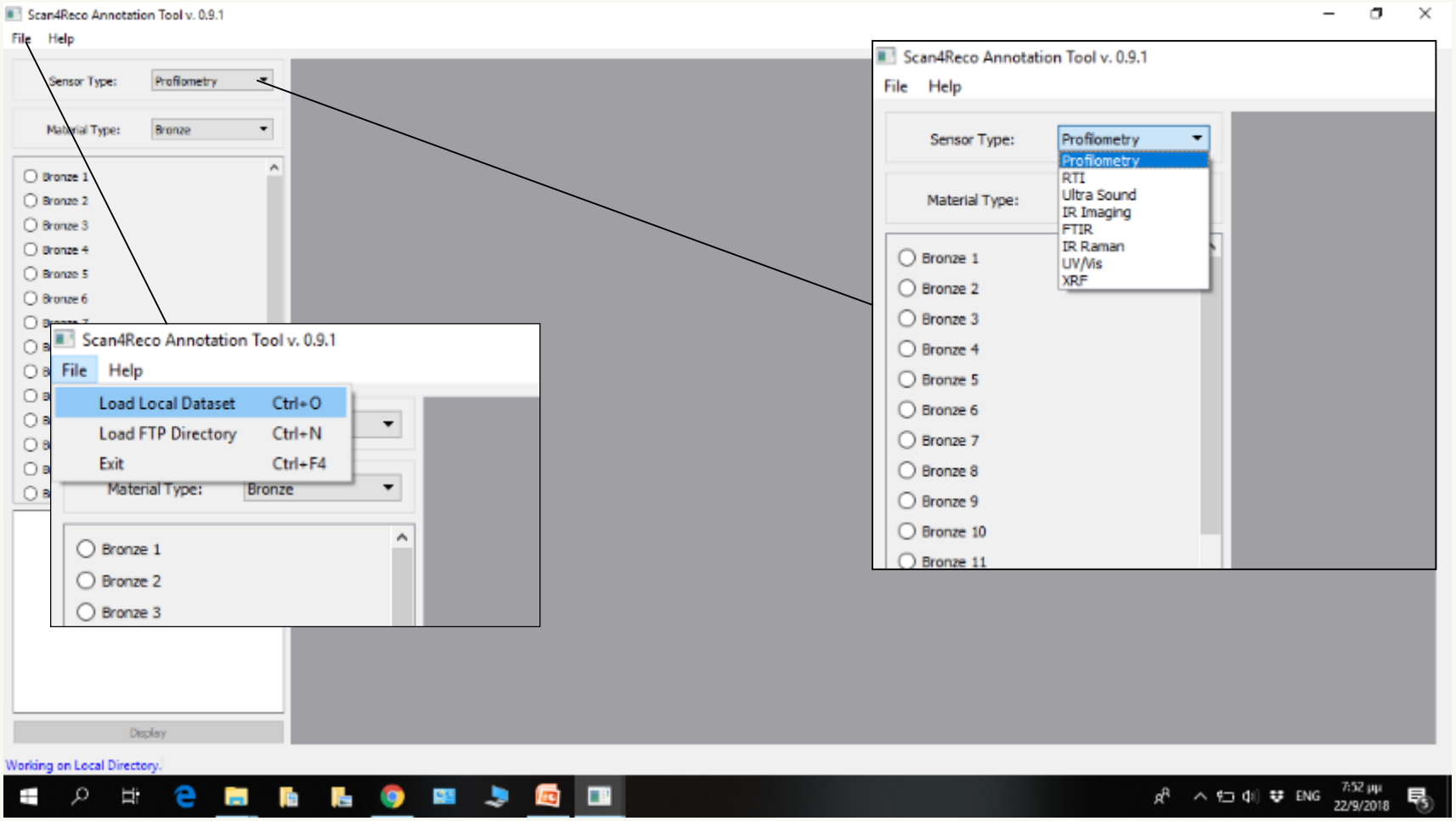
Problem: Too many scientific data, Raman spectra, FTIR spectra, XRF spectra, UV-Vis spectra, profilometry data, Ultrasonic signal values, IR imaging data. Measurements at initial time and measurements at every ageing step. All these data should be rearranged and given in a data base that could facilitate and emerge the impact of ageing on samples by relating the latter to a defined pathology.

Solution: Annotation tool arranged the measurements according to ageing time and according to Infra Structure. Pathology was cross-checked to each peak shift and each variation that could be attributed to decay due to ageing.



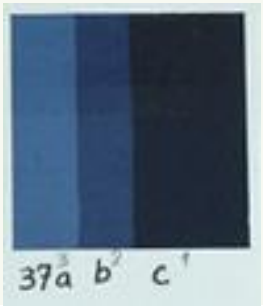
Annotation tool

Software that offers the ability to load our dataset, the measurements that a scientist produced, supporting data from 8 different techniques
Overlay diagrams allowed the annotation of spectra and connection to the pathology

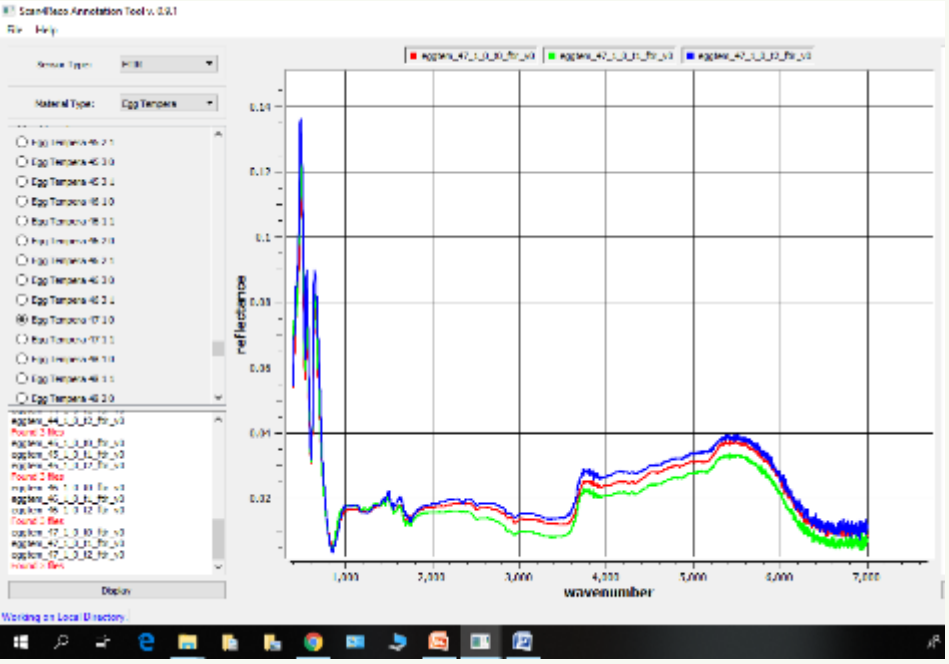


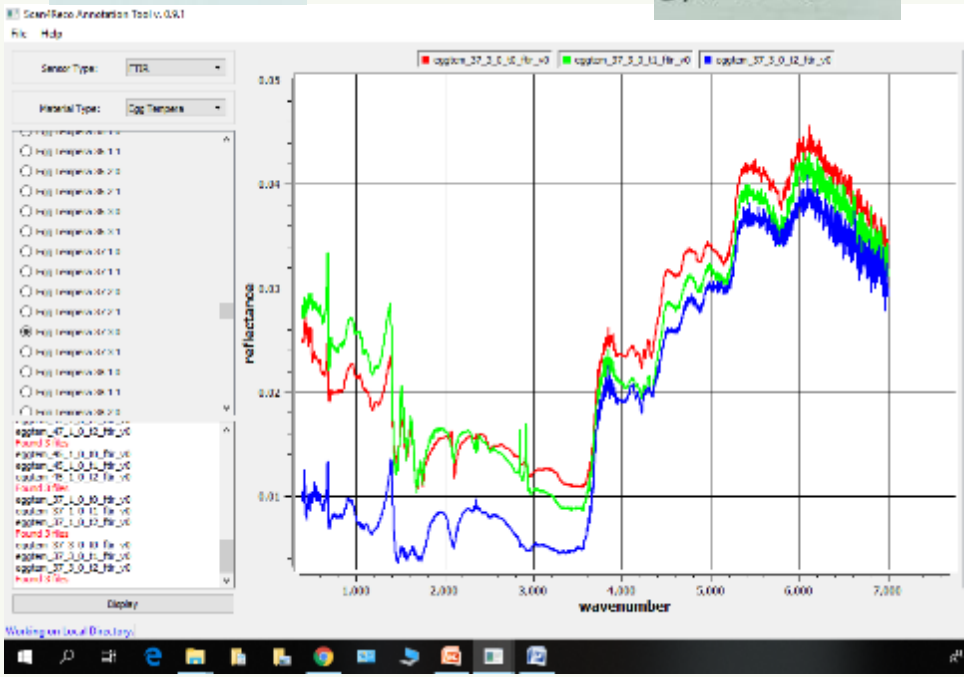
Annotation tool – FTIR overlay spectra

Cobalt blue
at T0, T1 and T2
Stable behavior
of the pigments carrier



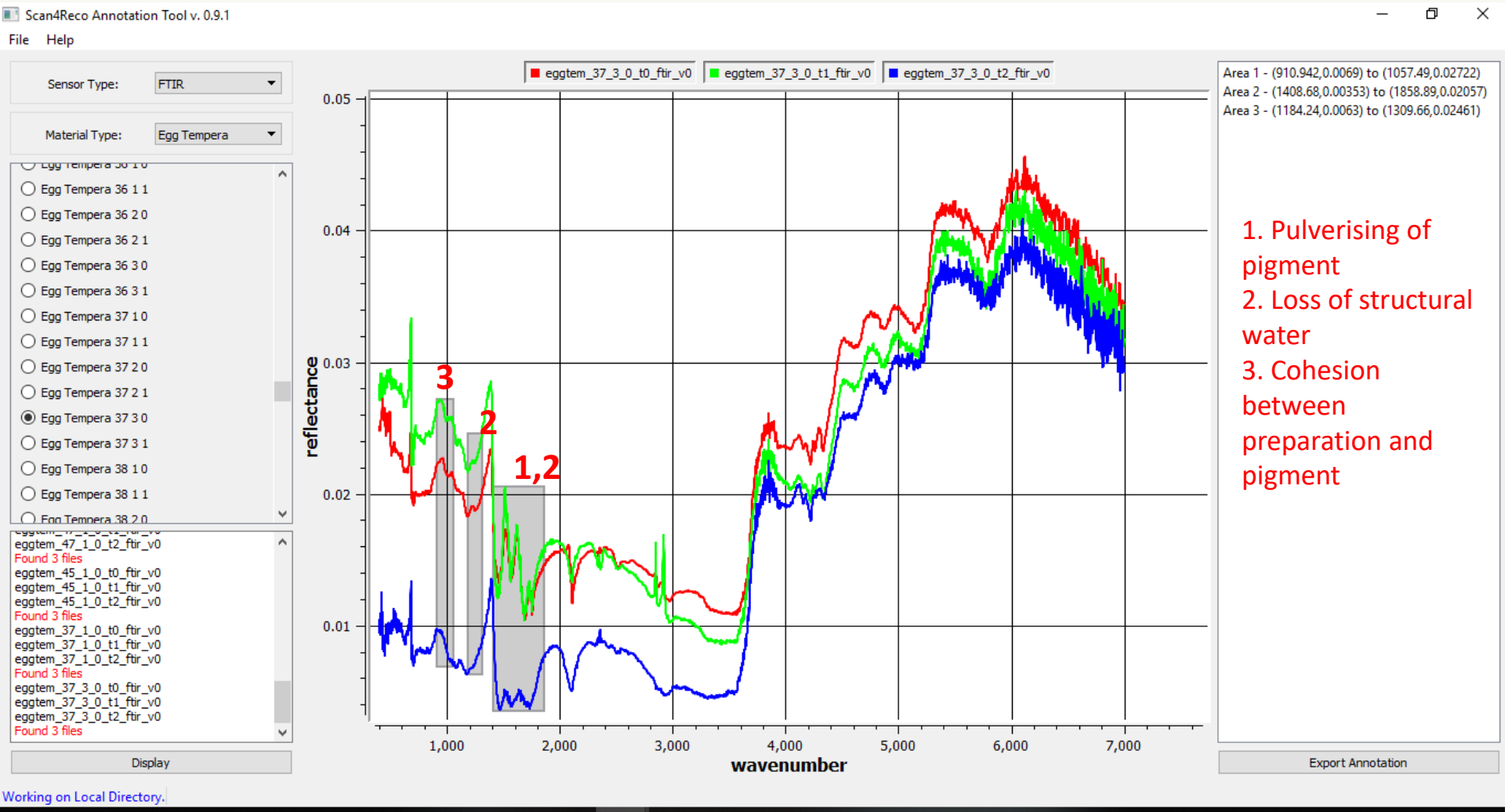
Prussian blue
at T0, T1 and T2
Pigments peaks
unaffected



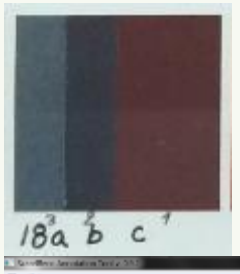


Annotation tool – FTIR overlay spectra

FTIR measurement of **Prussian blue** at T0, T1 and T2

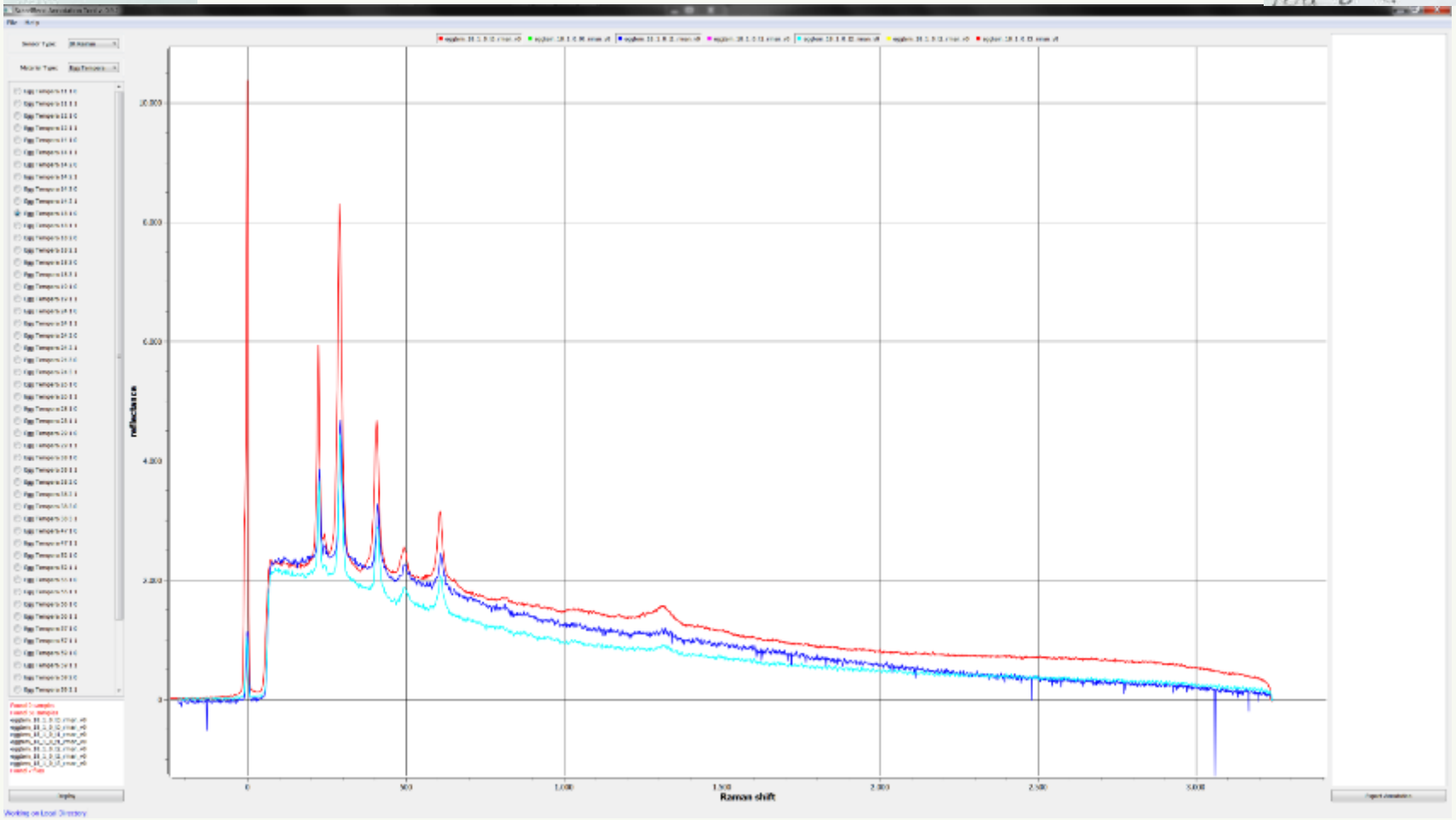


Annotation tool – µRaman overlay spectra



Caput mortuum + **azurite** at T0, T1, T2 and T3

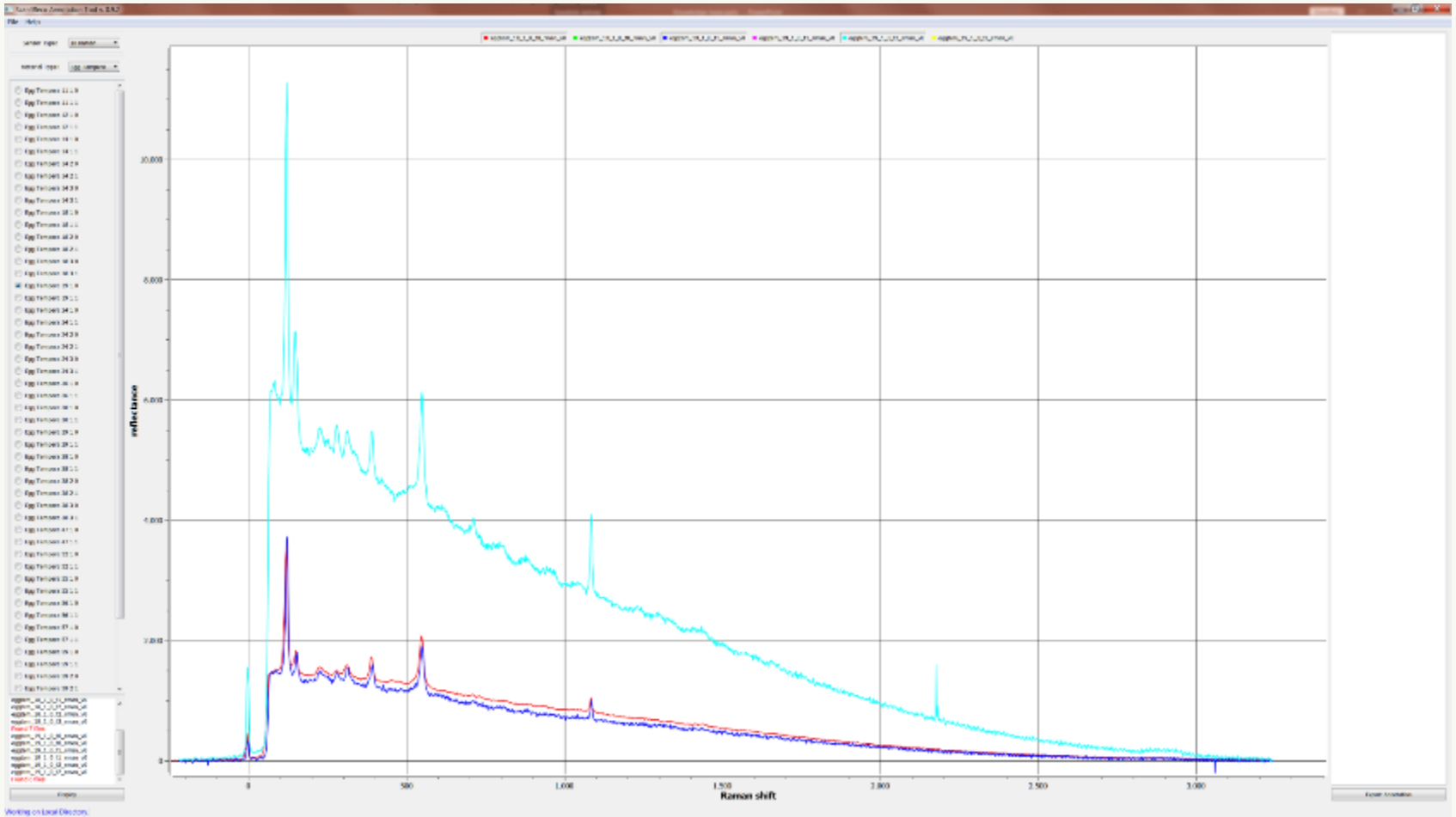
Quality of pigment remained unaffected. Intensity of signal is connected to pulverizing of the pigment



Annotation tool – µRaman overlay spectra

Minium at T0, T1, T2 and T3

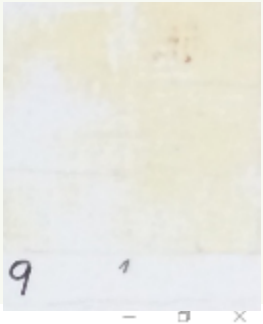
Quality of pigment remained unaffected. Intensity of signal is connected to pulverizing of the pigment



Annotation tool – UV-Vis overlay spectra

Minium at T0 and T1

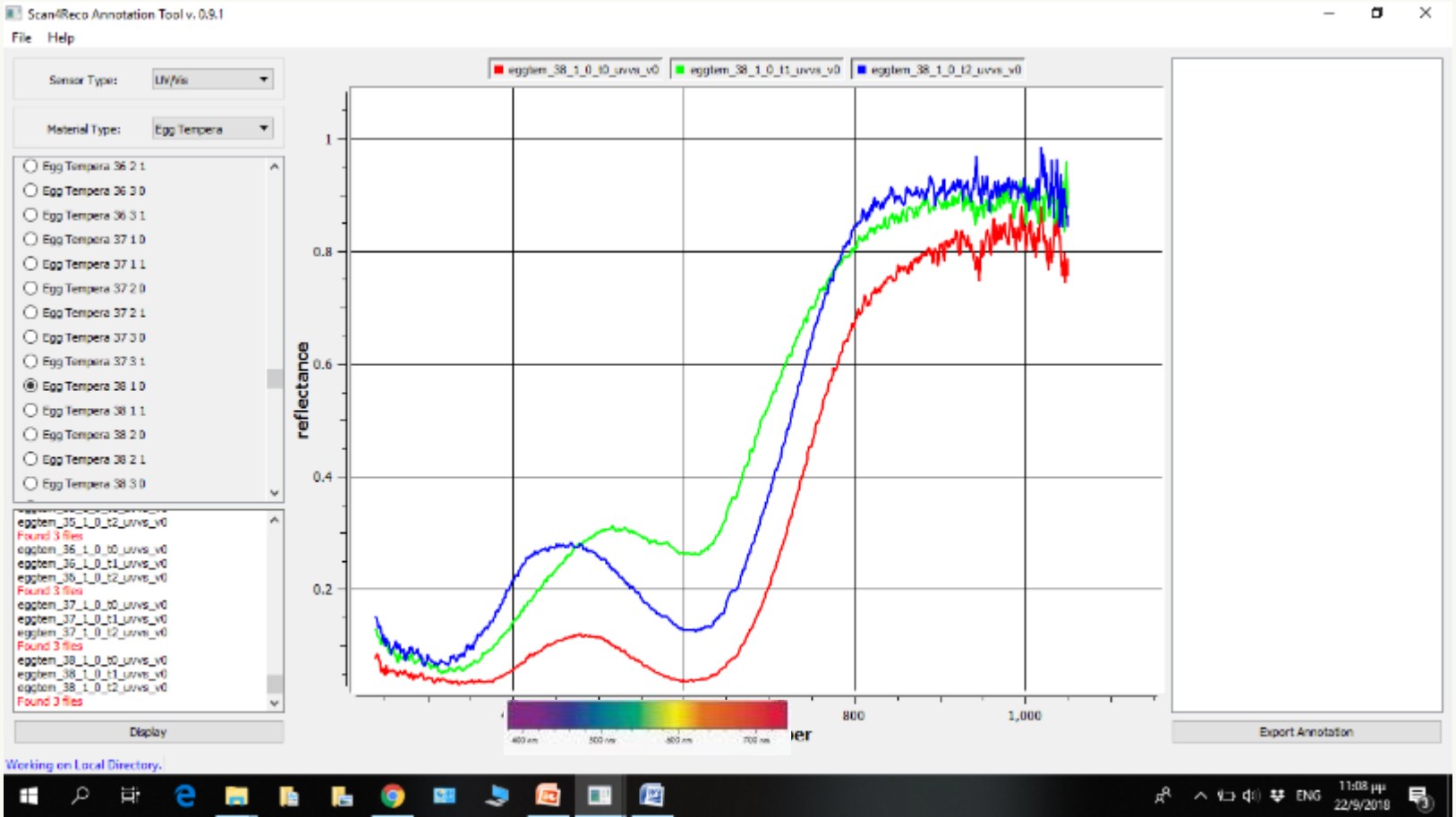
Change of luminescence, change of hue
and change of saturation of the color



Annotation tool – UV-Vis overlay spectra

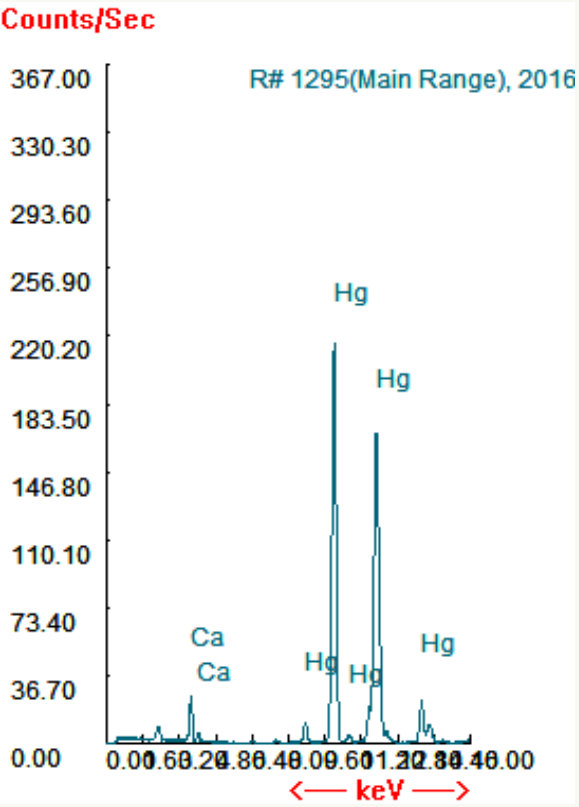
Indigo at T0, T1 and T2

Change of luminescence, change of hue and change of saturation of the color

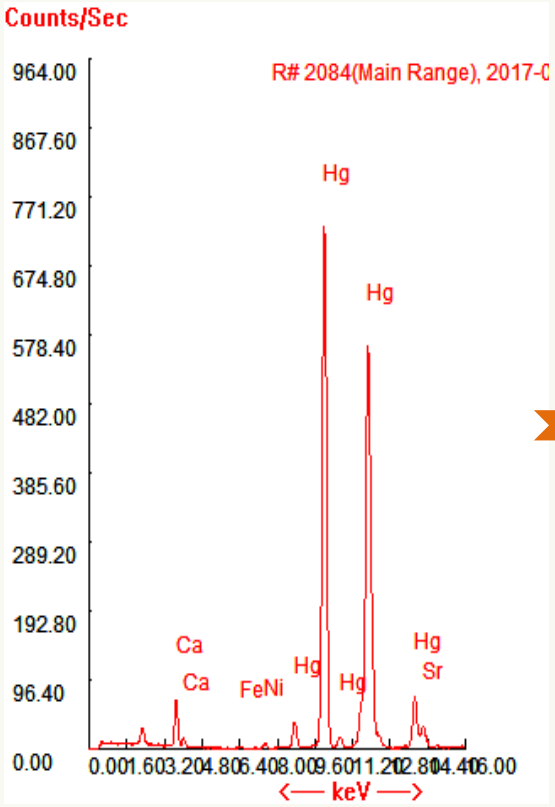


Annotation tool – XRF

Cinnabar at T0



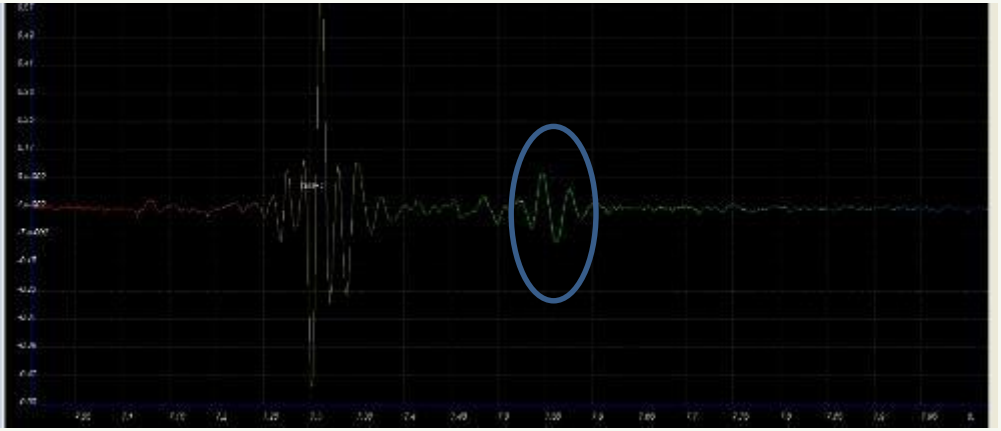
Cinnabar at T2

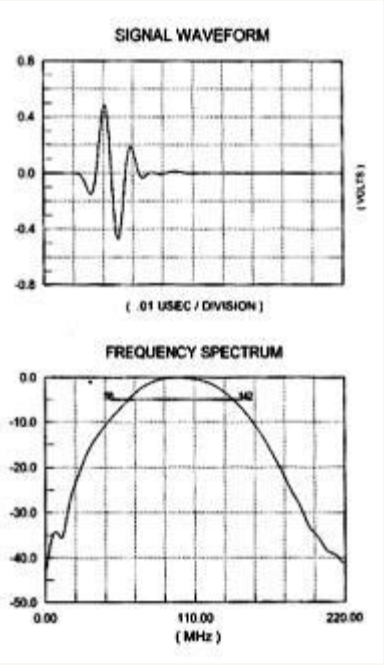


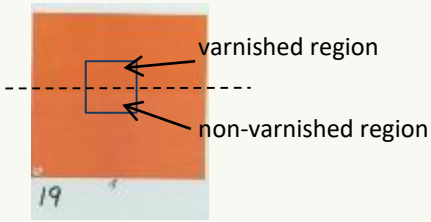
1. Pulverising of pigments
2. Damage of carrier of pigment
3. Cohesion between preparation and pigment layer

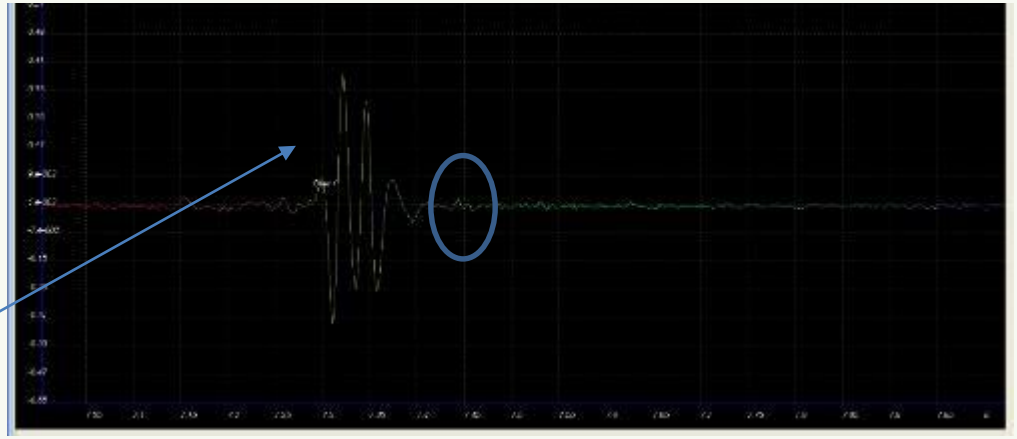
Percentage of heavy metals is given as a proportion of measured area

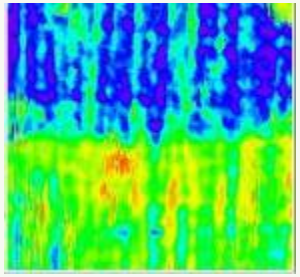
Annotation tool – Ultrasonic scanning





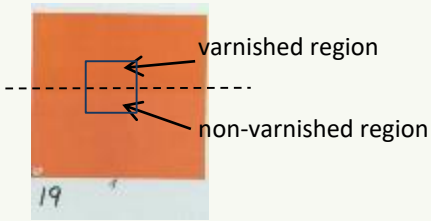


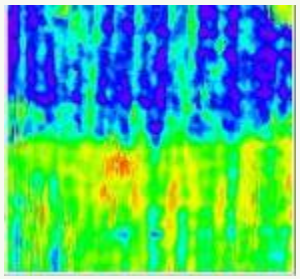




Time Of Flight of the first echo Image or Amplitude Image revealing the roughness

Annotation tool – Ultrasonic scanning





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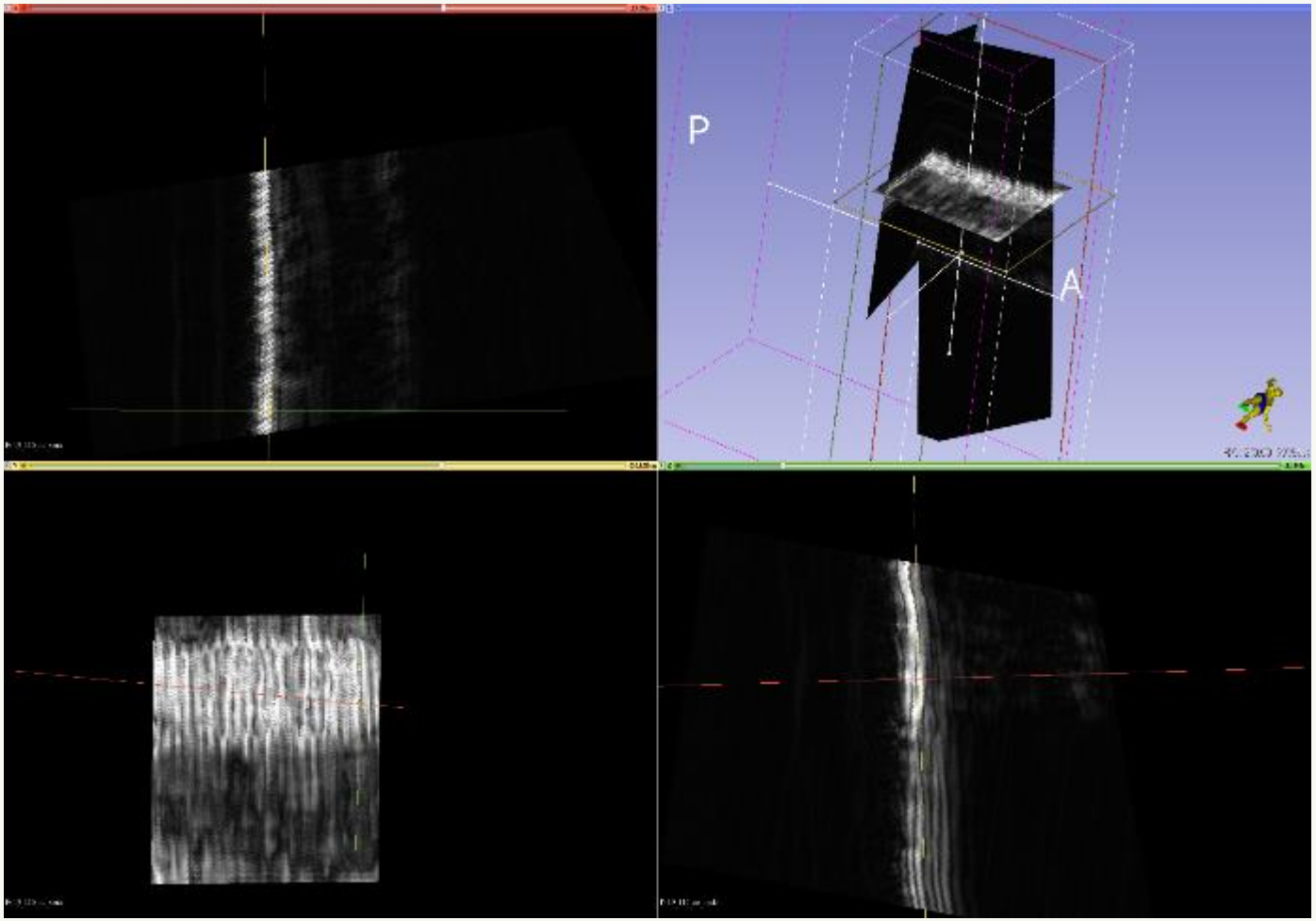
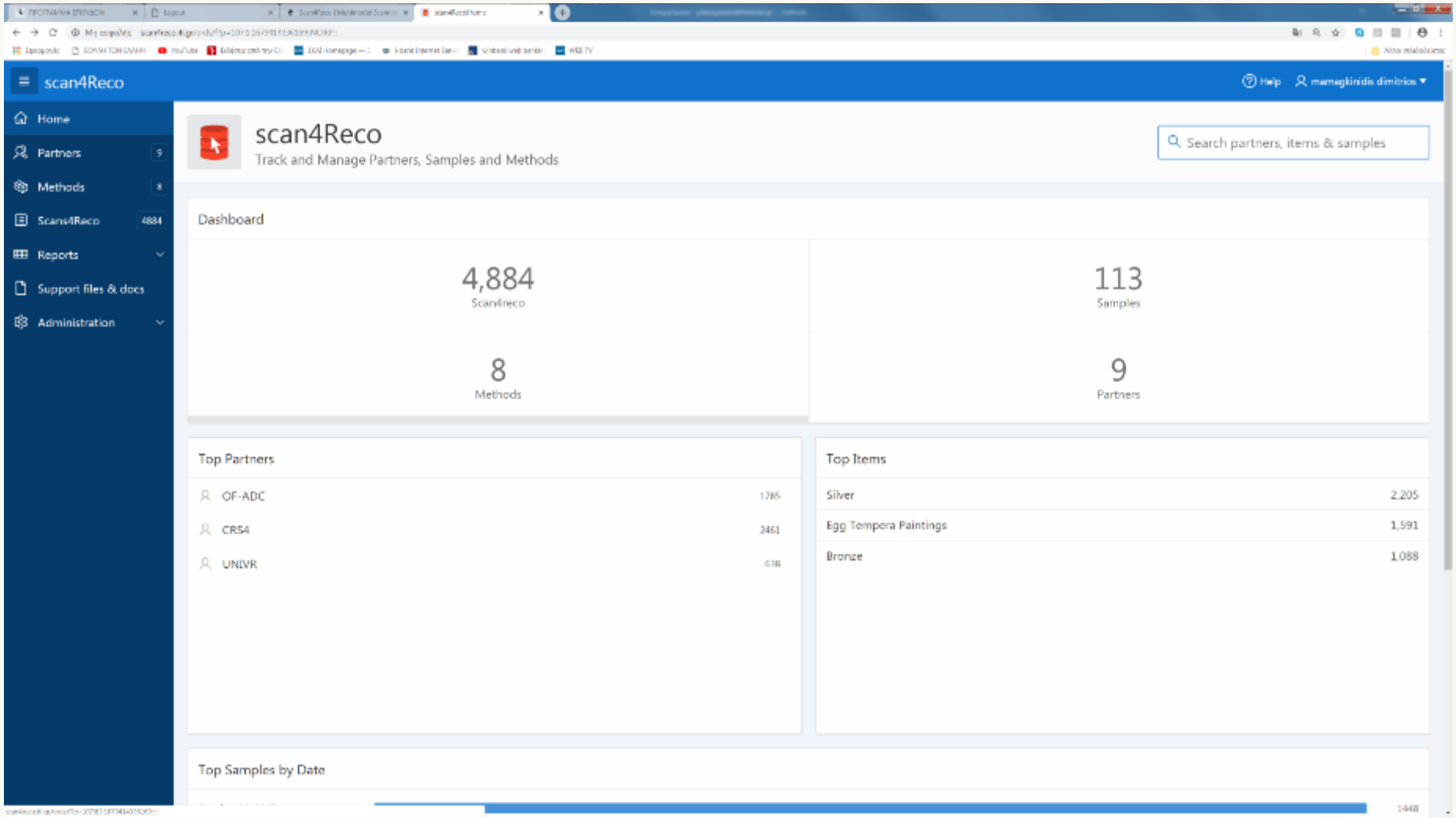


Annotation tool – On-line database

www.scan4Reco.gr and sign in to a friendly on-line database, containing techniques, measurements at every ageing step, sorted by material type.



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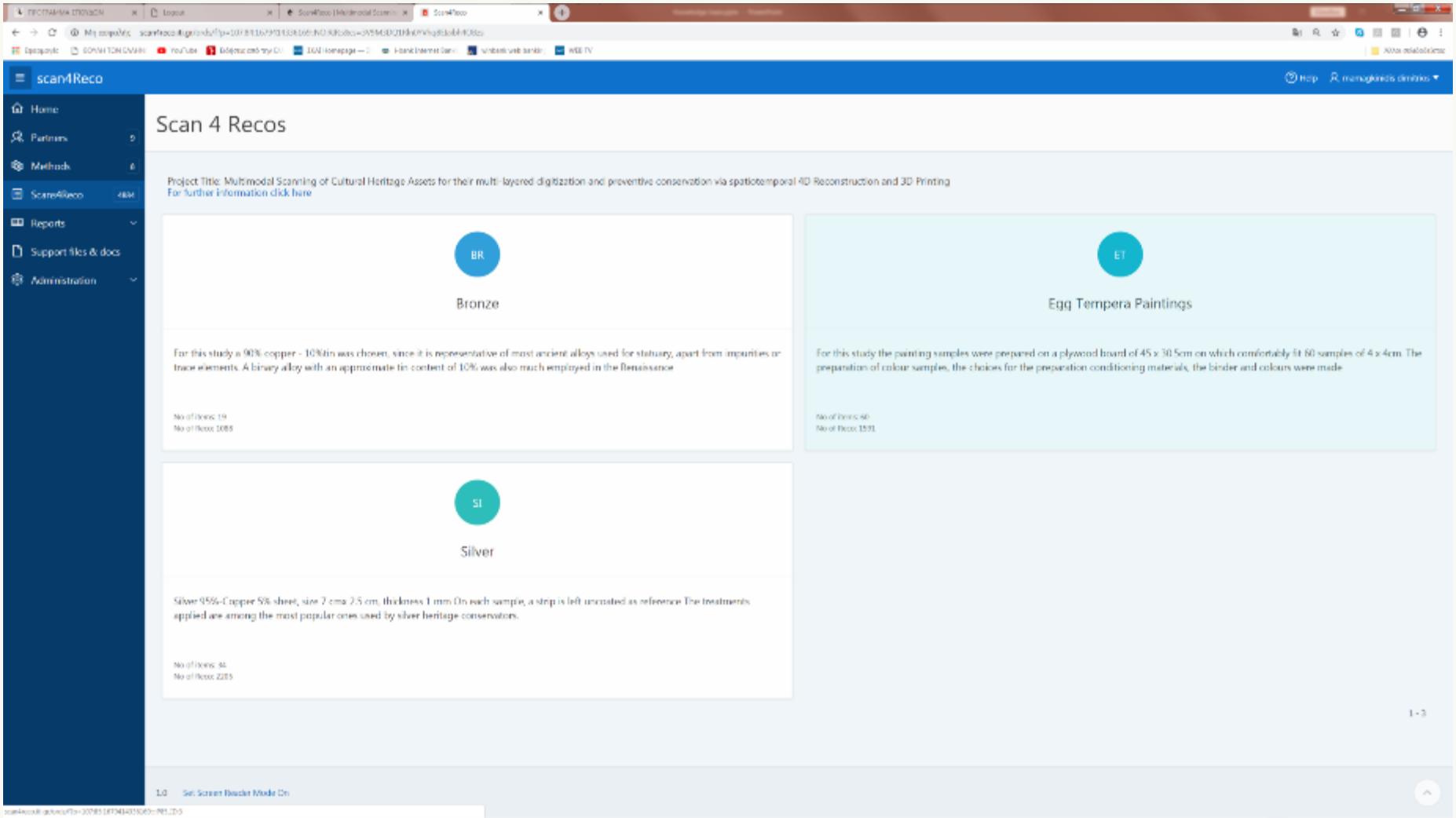

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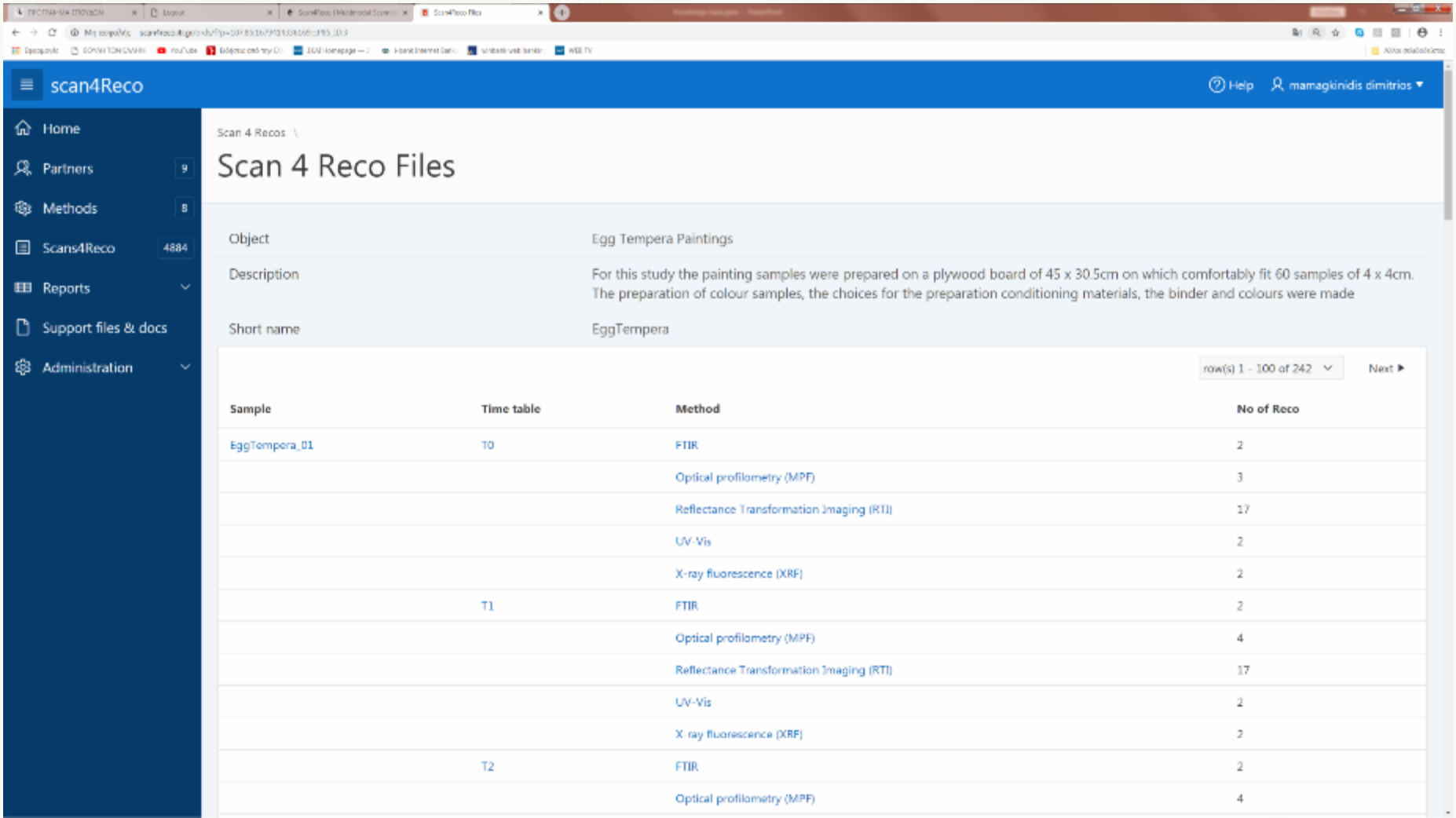

Annotation tool – On-line database

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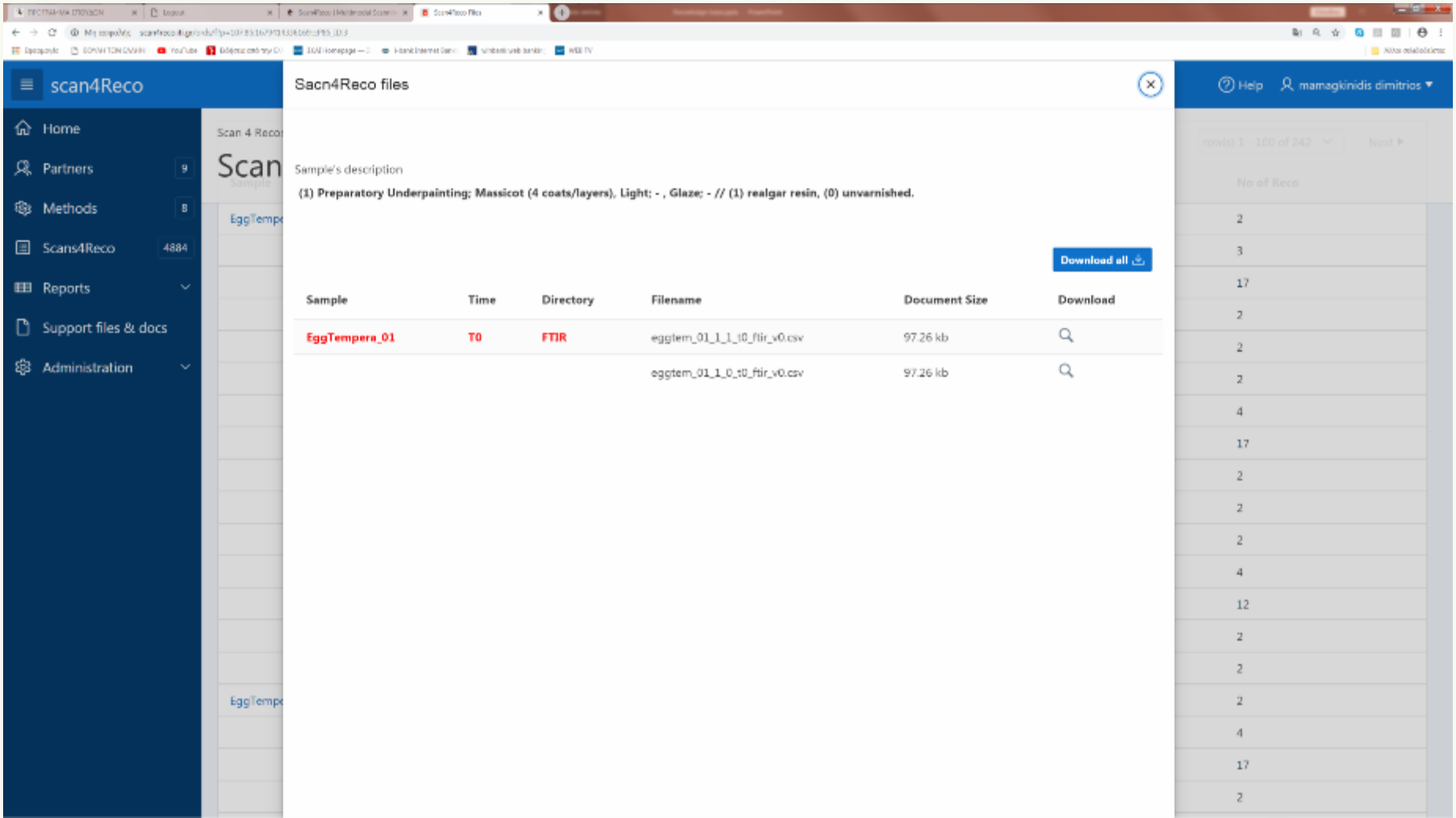

Conclusions

- The application of annotation tool facilitated the connection of ageing impact on samples to the pathology
- Data from 8 different instrumentation techniques were collected and grouped in a single tool providing the possibility to observe and annotate them in parallel
- The decay of materials and pigments in time was recorded and displayed by overlay diagrams, still to be used for the evaluation of measurements on objects under restoration
- Evaluation of the impact of stratigraphy on every measurement technique
- Relation of the decay with the pathology
- Information about the ageing behavior of every inorganic pigment separately or not
- A useful tool-database for experts on internet