Mathematicians

helping

Art Historians
and
Art Conservators

Three examples:

Frescoes in Eremitani church in Padua, Italy

Massimo Fornasier et al.

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New (re)attributions based on threadcounts

Rick Johnson et al.

Three examples:

Frescoes in Eremitani church in Padua, Italy

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New (re)attributions based on threadcounts

Rick Johnson et al.

Virtually aging/rejuvenating paintings

1. Reconstructing destroyed frescoes,

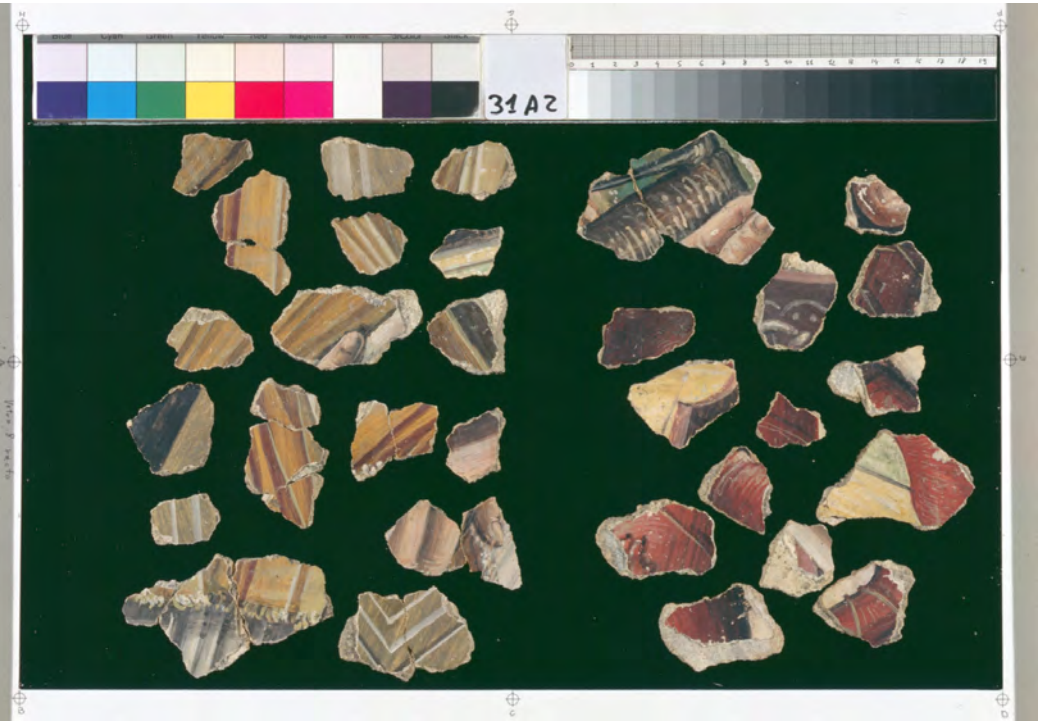
Eremitani church in Padua, Italy

Massimo Fornasier et al.


KODAK Color Control Patches

August 1992: start of concerted large-scale effort to reconstruct the frescoes

First: cleaning, stabilizing, cataloguing of all fragments



Next (1995-97): digitization of numbered fragments on 38 CD-ROM

Fragments: number = 80,735

total surface = 77.47 sq. m

typical size: 5 to 6 sq. cm

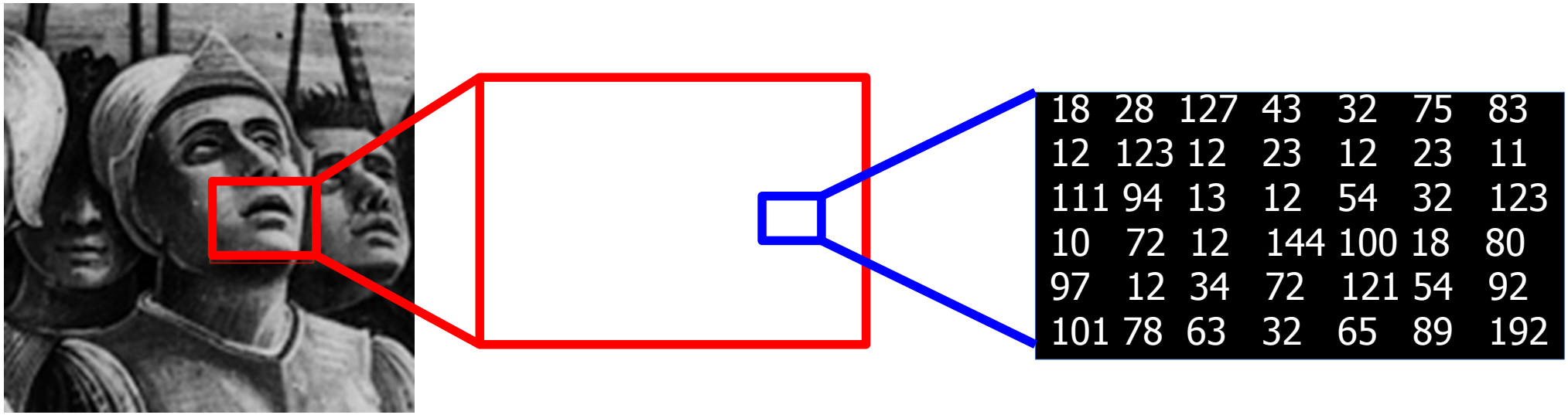
Original size of lost painted area: > 800 sq. m

Very few contiguous fragments

For each fragment: location unknown

rotation unknown

Fast method needed to place each fragment!



Digitized images:

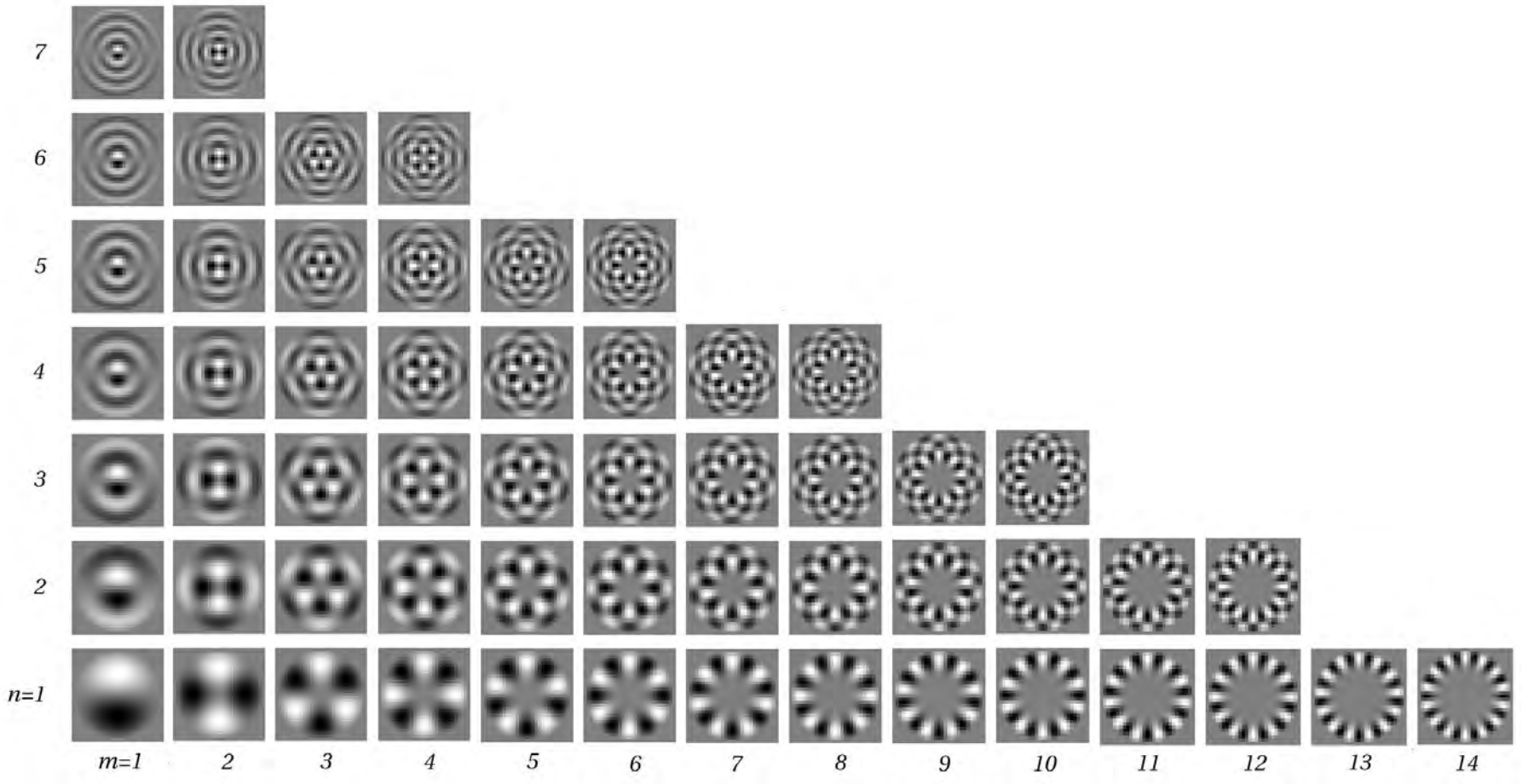
pixels ⟶ grey value: number between 0 and 255

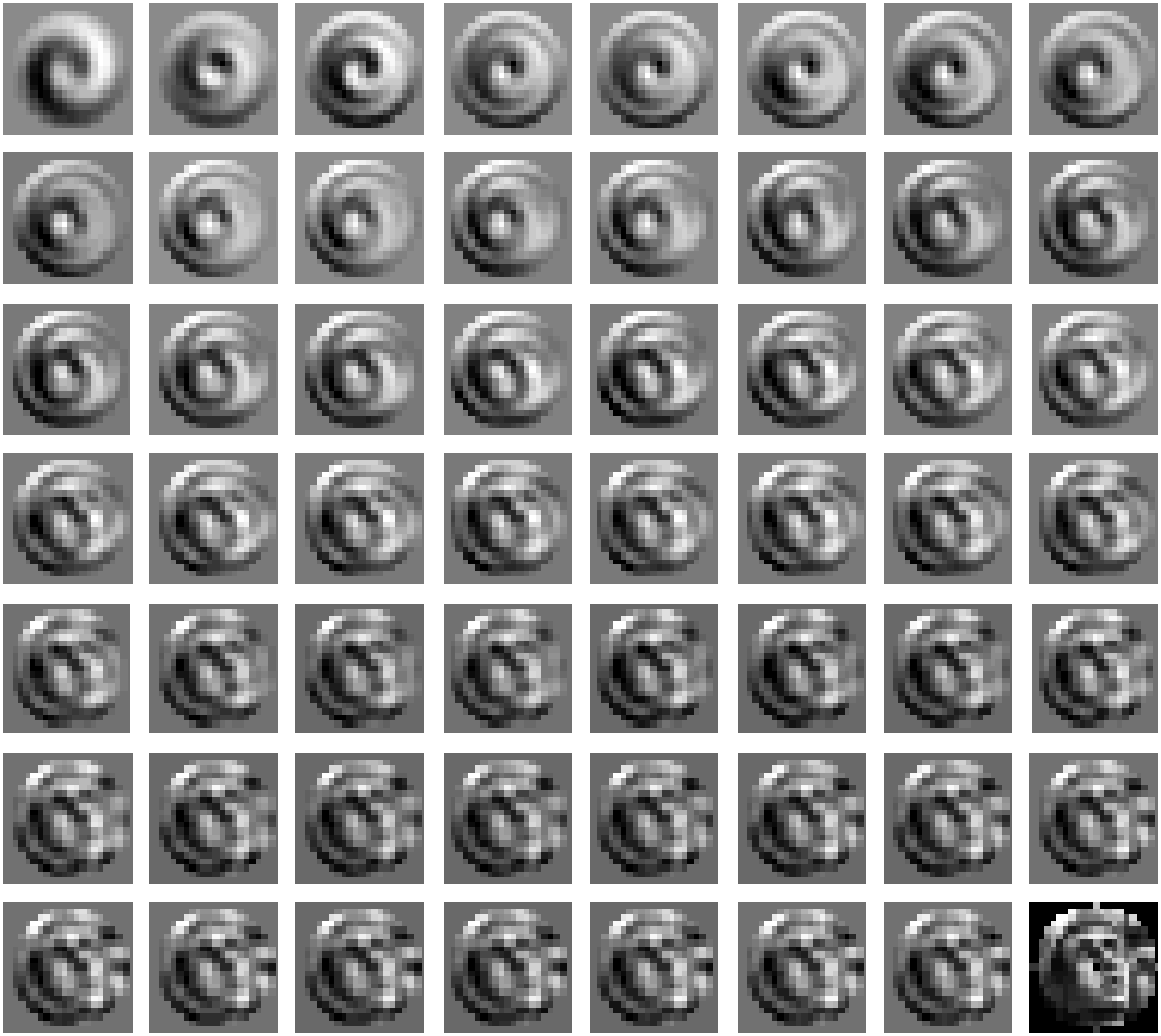
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	49	50	65	82	103	0	0
0	0	51	68	73	93	93	0	0
0	0	62	85	96	116	104	0	0
0	0	68	97	121	128	115	0	0
0	0	83	98	123	123	112	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0
0	0	0	0	95	0	0	0	0
0	0	0	57	93	101	0	0	0
0	0	56	68	88	97	106	0	0
0	49	49	65	85	116	115	116	0
0	0	51	70	91	116	125	0	0
0	0	0	65	90	111	0	0	0
0	0	0	0	78	0	0	0	0
0	0	0	0	0	0	0	0	0

Represent the information in each fragment so that rotation is easy to compute/recognize:

use **circular harmonics**





The circular harmonics make it easy to find the representation of a rotated image I :

I can be decomposed into circular harmonics:

$$I = a1\ H1 + a2\ H2 + a3\ H3 + a4\ H4 + \ldots.$$

Then the rotated version $Rot(I)$ has the form:

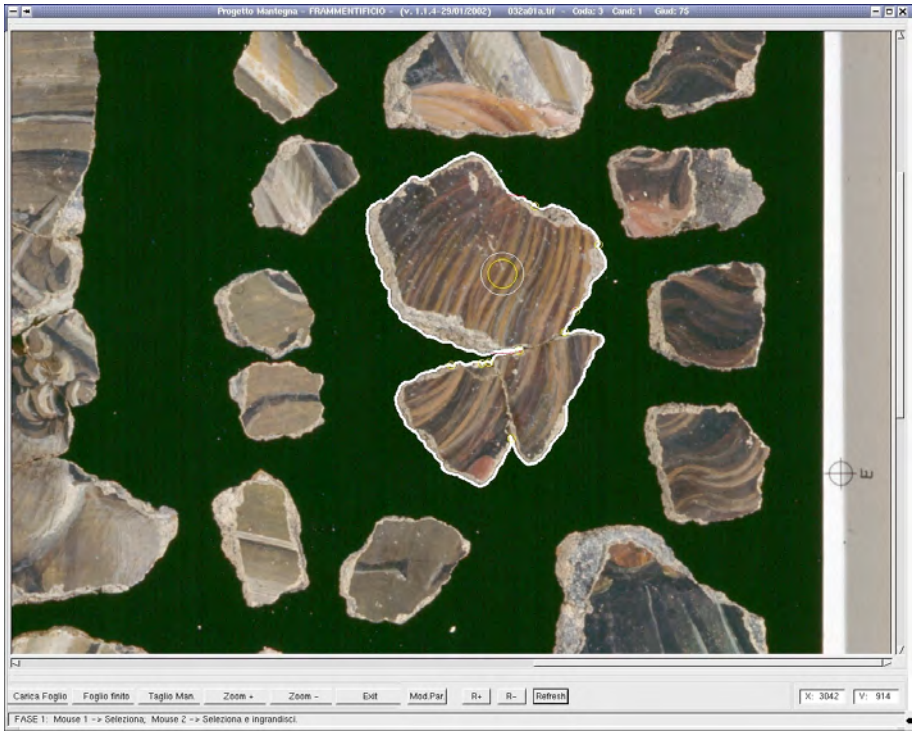
$$Rot(I) = r1\ a1\ H1 + r2\ a2\ H2 + r3\ a3\ H3 + r4\ a4\ H4 + \ldots.$$

Mantegna Project 2001-04

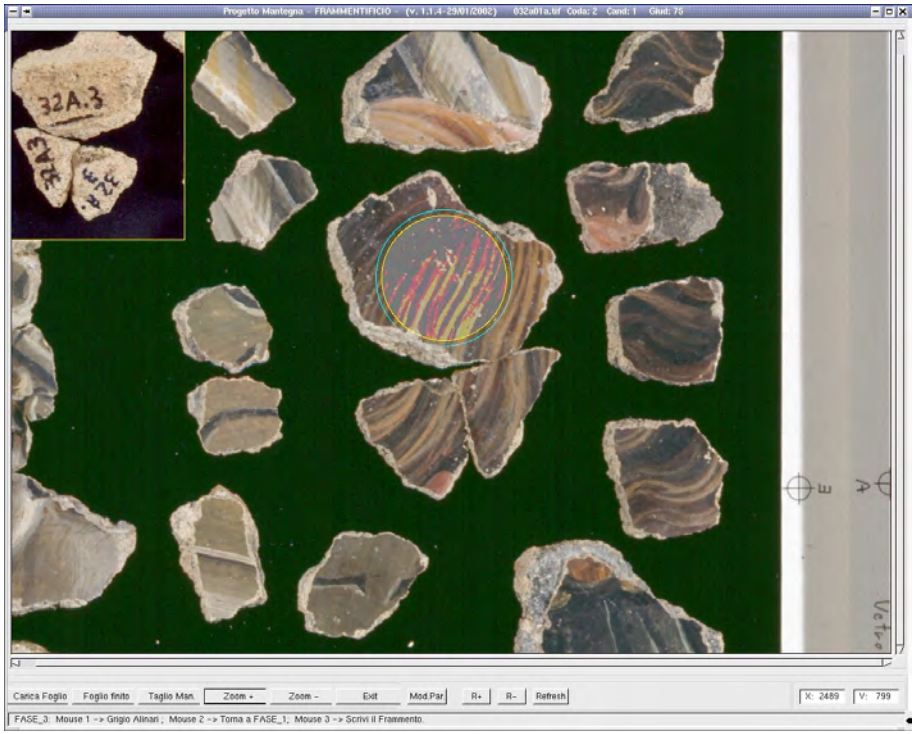
> 50 volunteers from the universities of Padua, Venezia and Udine, from the departments of

Cultural Heritage Conservation,
Art History,
Literature,
Philosophy,
Psychology,
Political Science,
Mathematics and
Engineering.

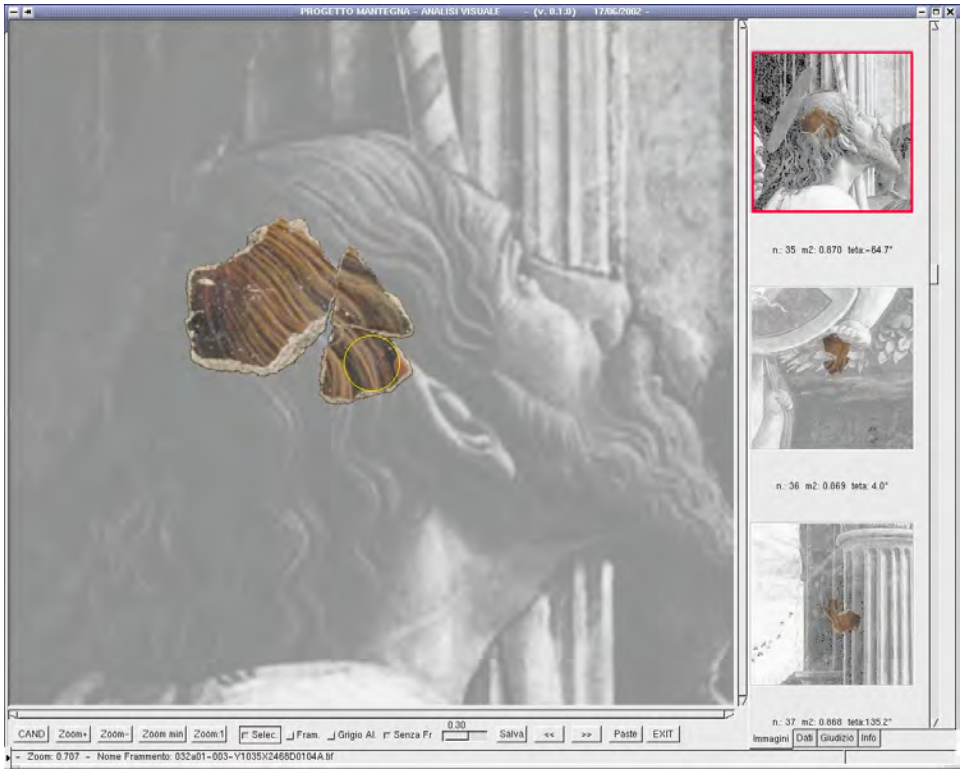
Mantegna Project 2001-04

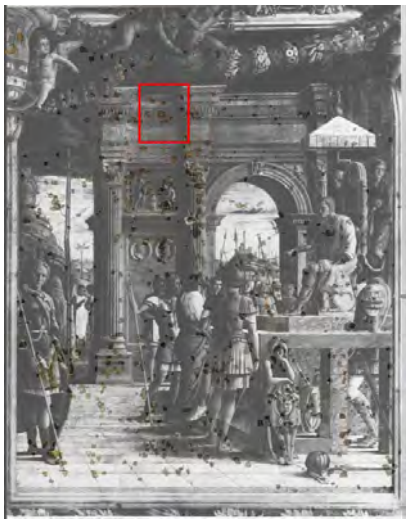


Mantegna Project 2001-04



Mantegna Project 2001-04

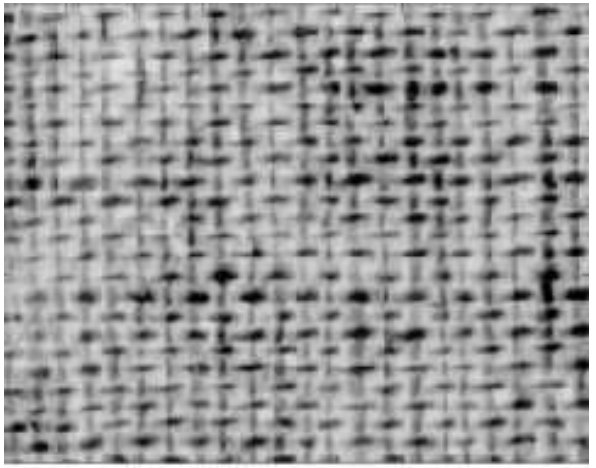


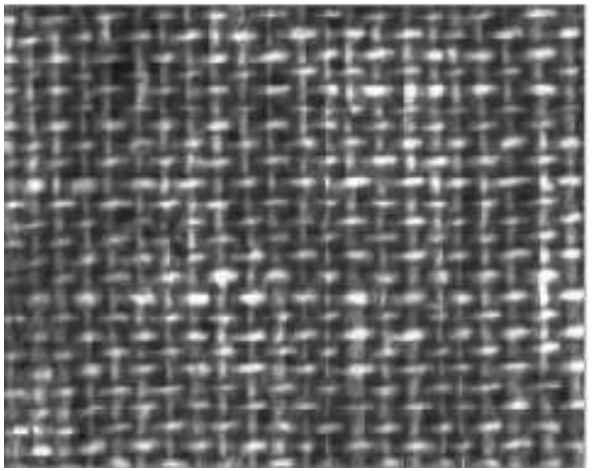


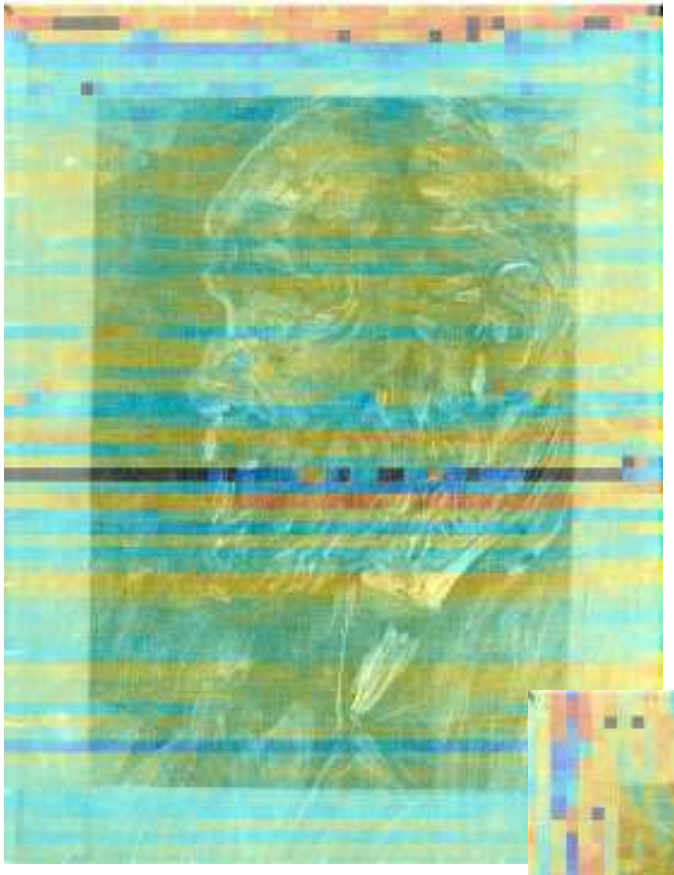
2. Automatic threadcounting for

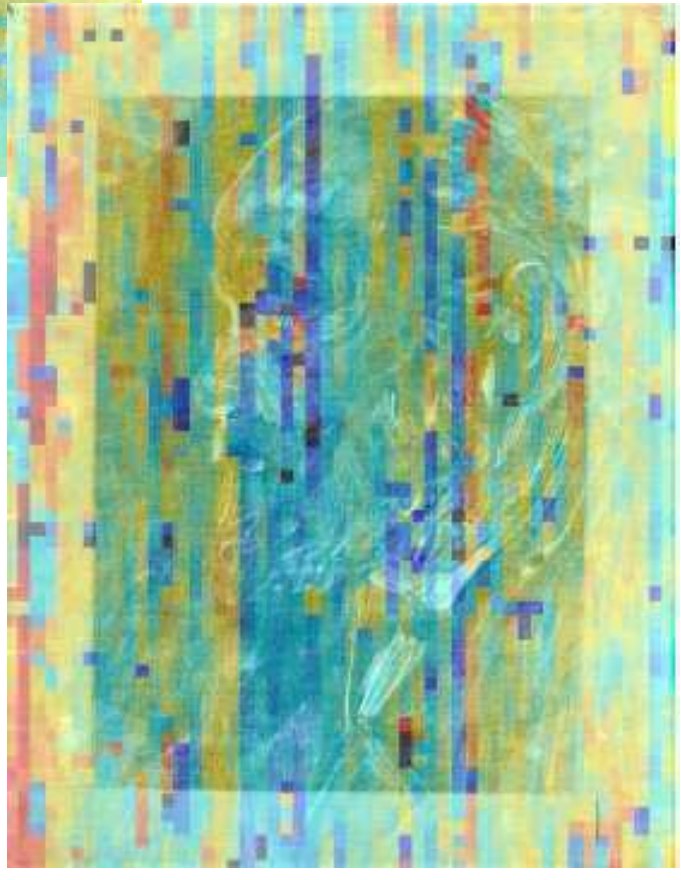
paintings on canvas

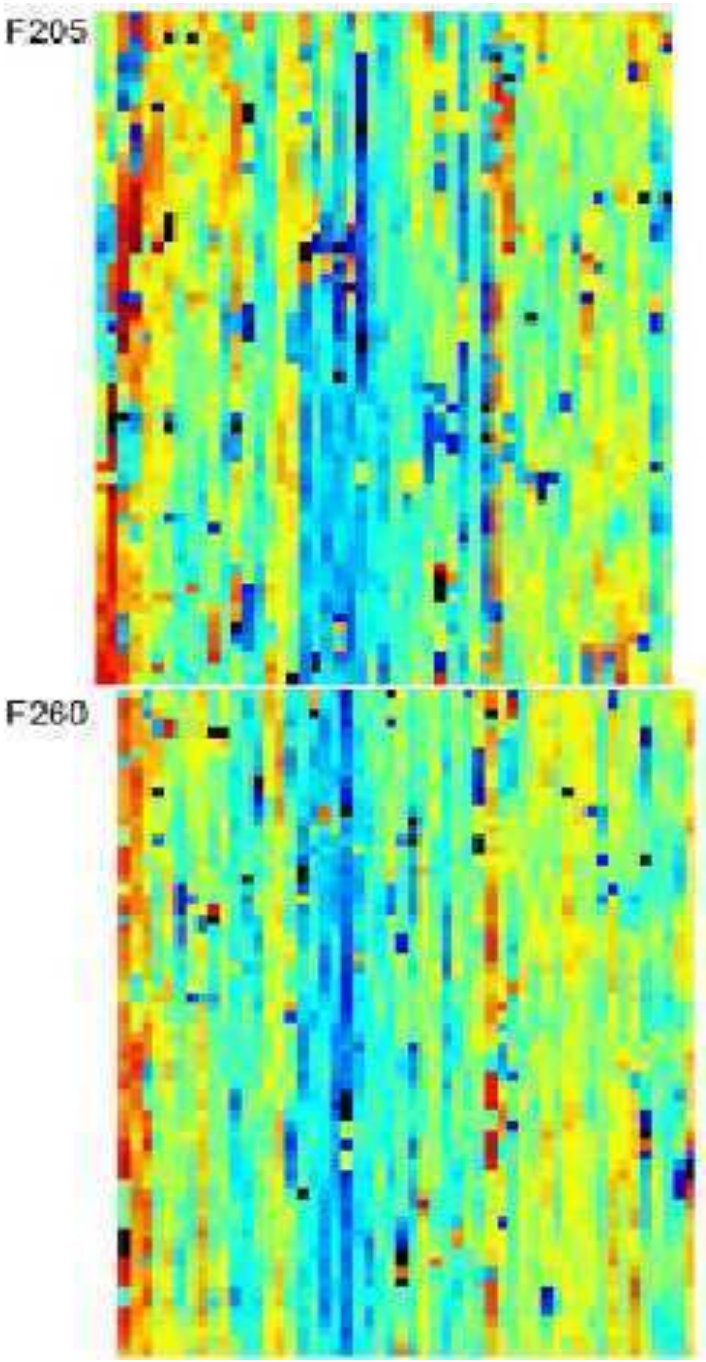
Rick Johnson et al.







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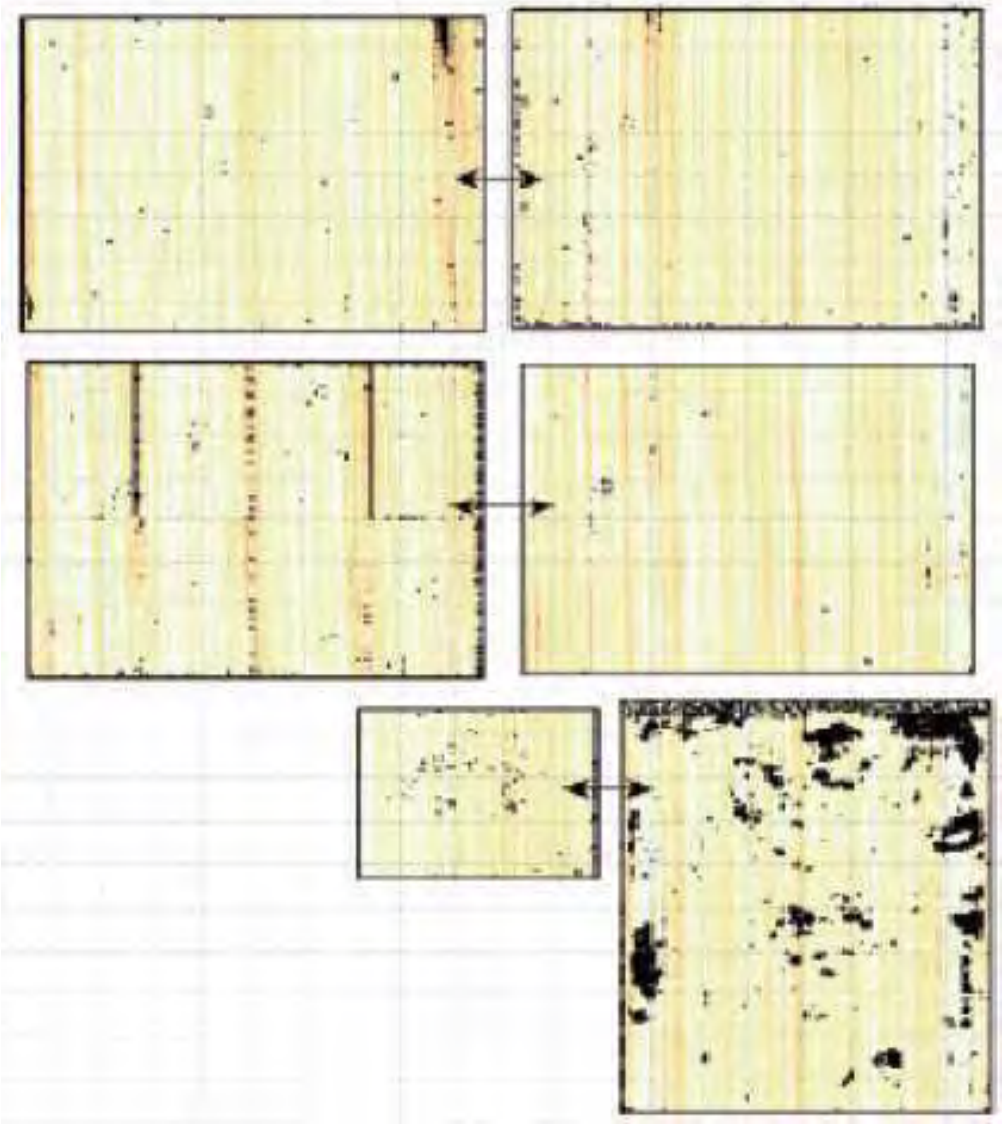
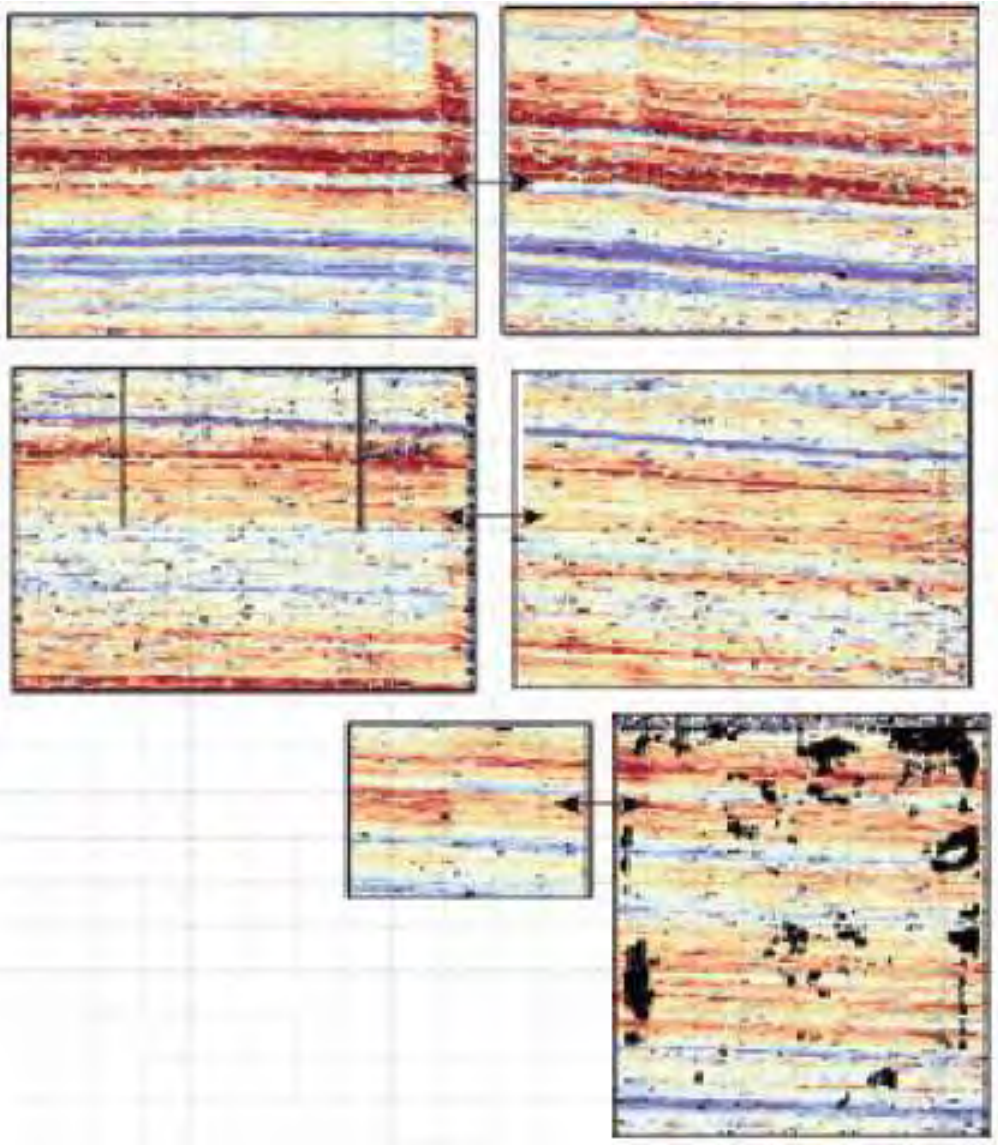
F260





3. Virtual aging/rejuvenating of paintings on panel: the Ghissi project

Collaboration Duke University & North Carolina Museum of Art

First a digression on how

“Mathematics and Image Analysis for Art Conservation and Art History”

became part of what I do.

Lady 6mm Under

About 9 years ago: started work on applications of image analysis to art history

art conservation

First projects: distinguishing style

distinguishing originals from copies

Determine information at different scales

Determine information at different scales

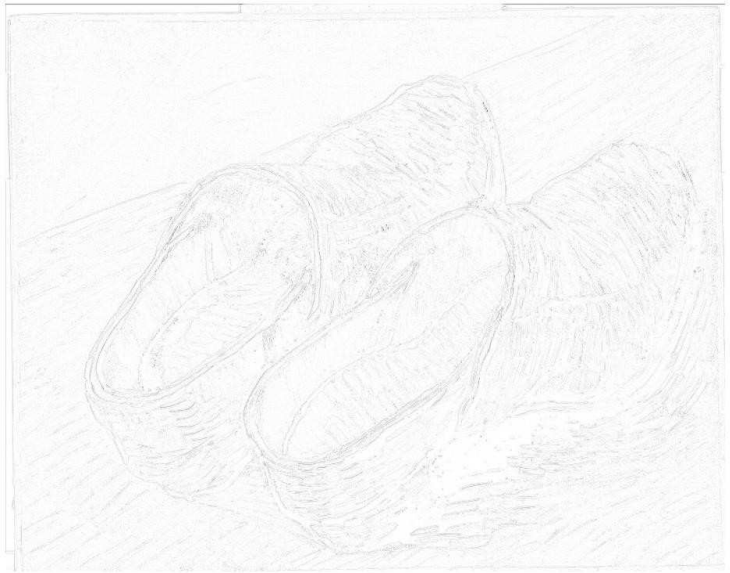
blur

Determine information at different scales

blur

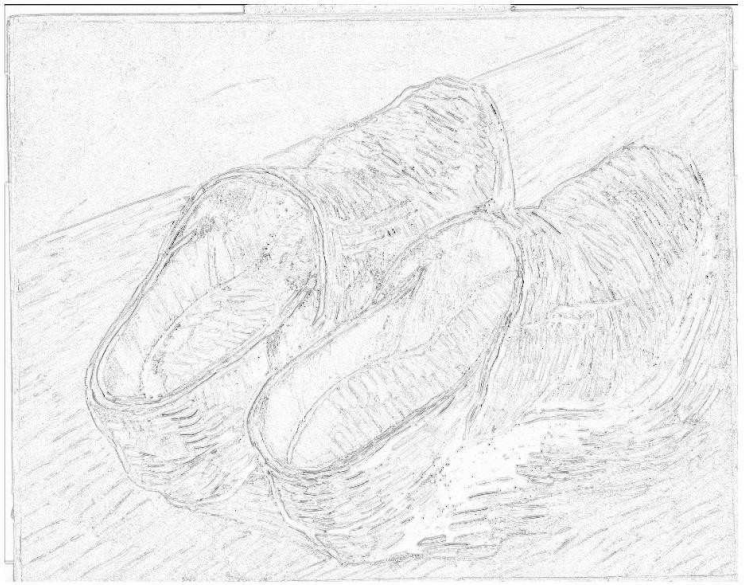
and find the
difference

Determine information at different Scales



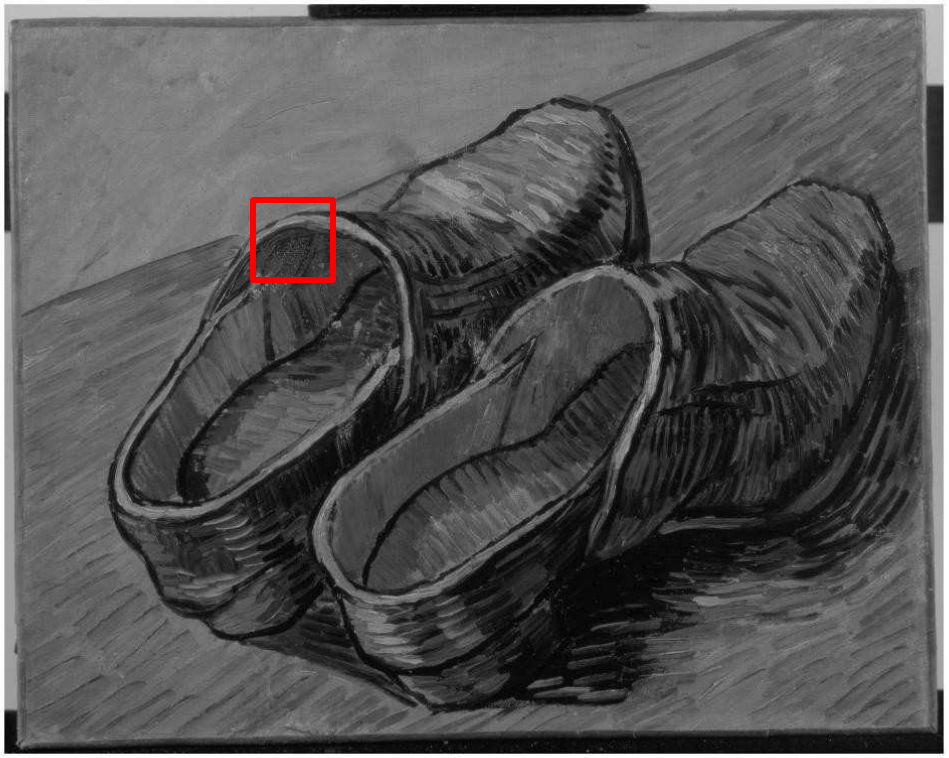
Difference = A - B

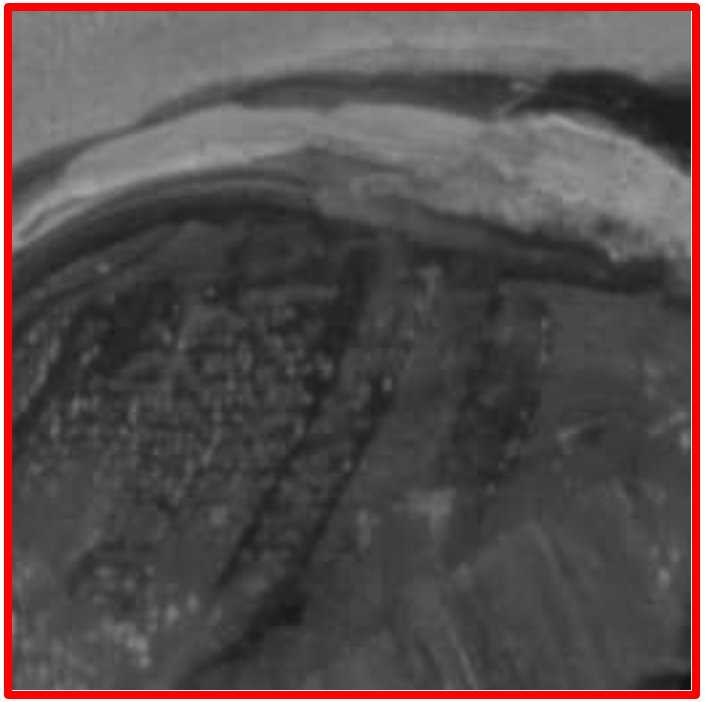
Determine information at different Scales

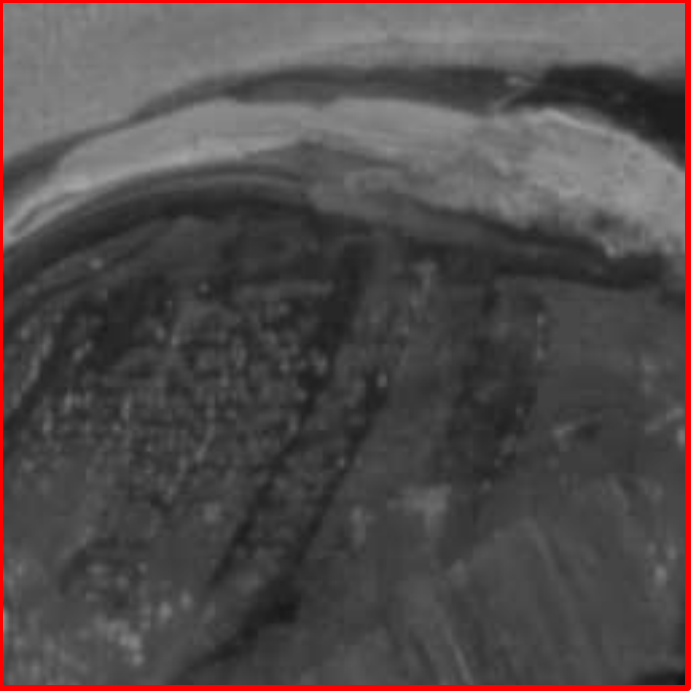


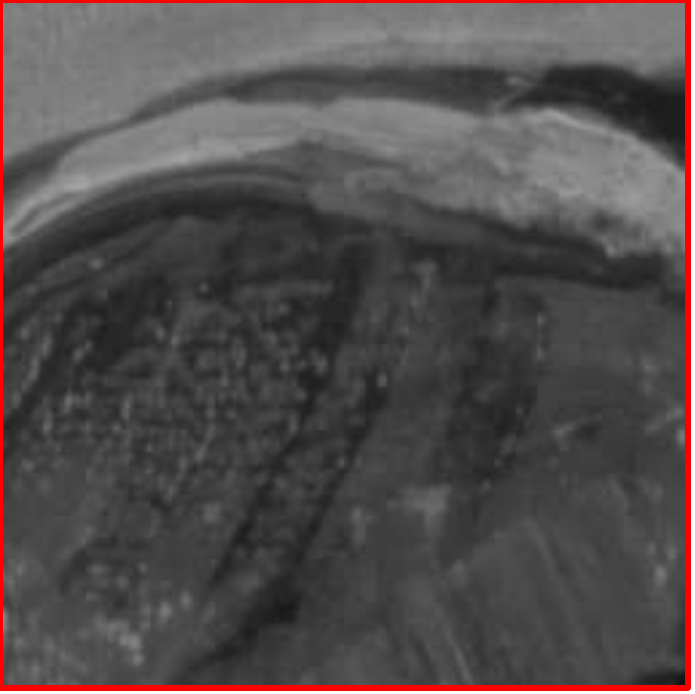
Difference = A - B

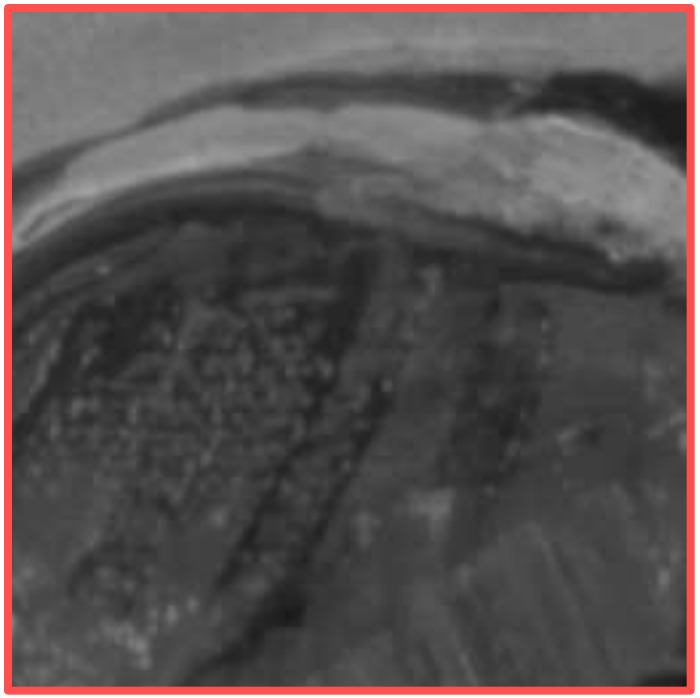
Determine information at different Scales

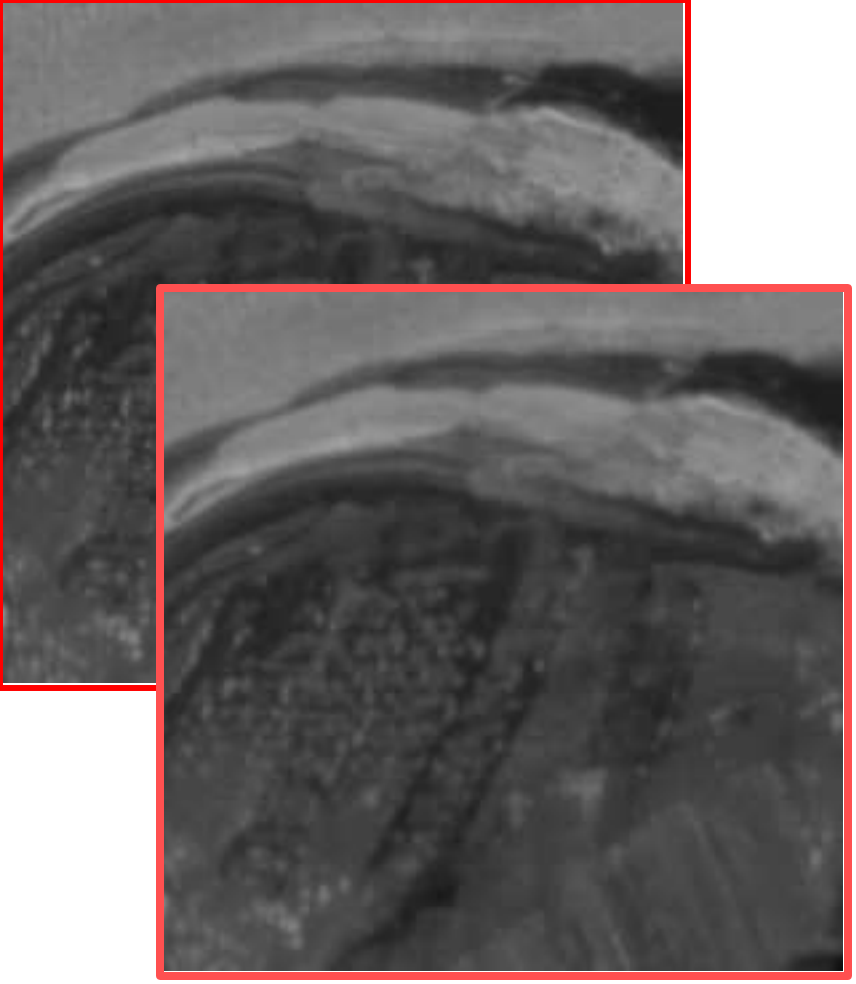


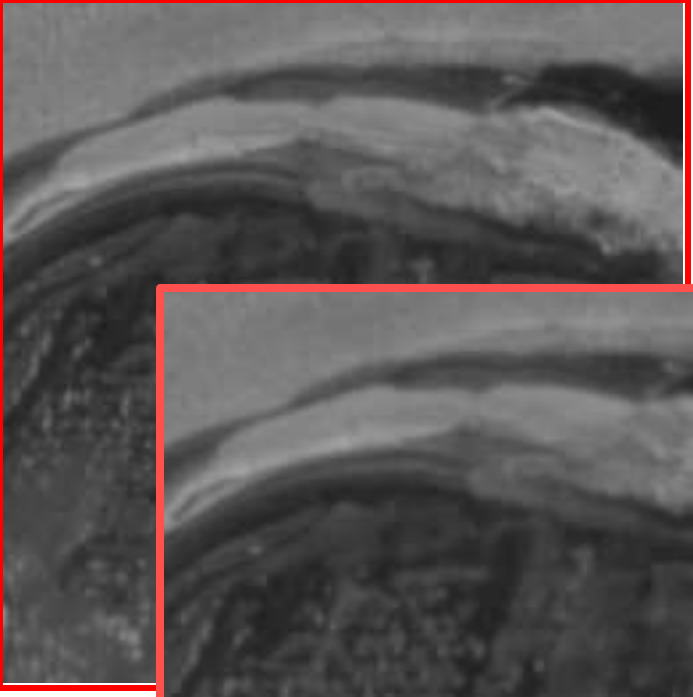


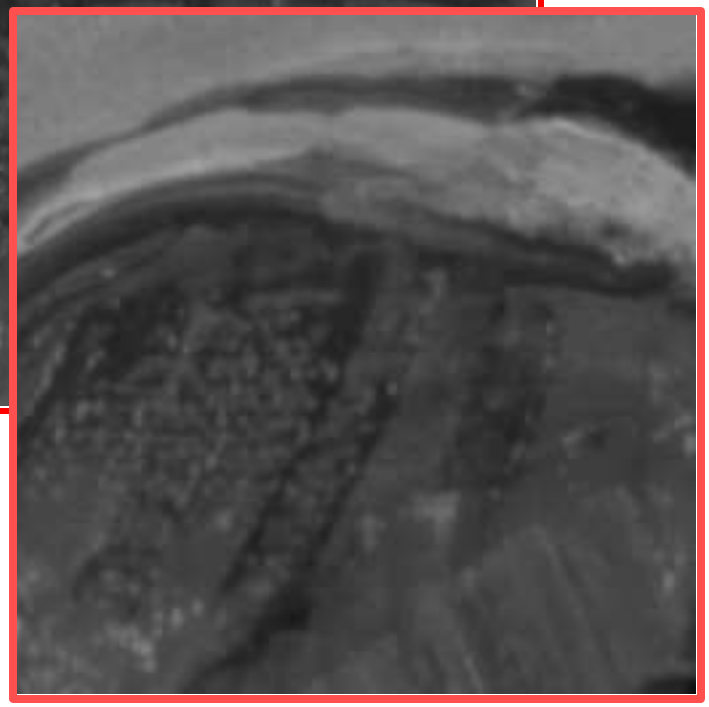


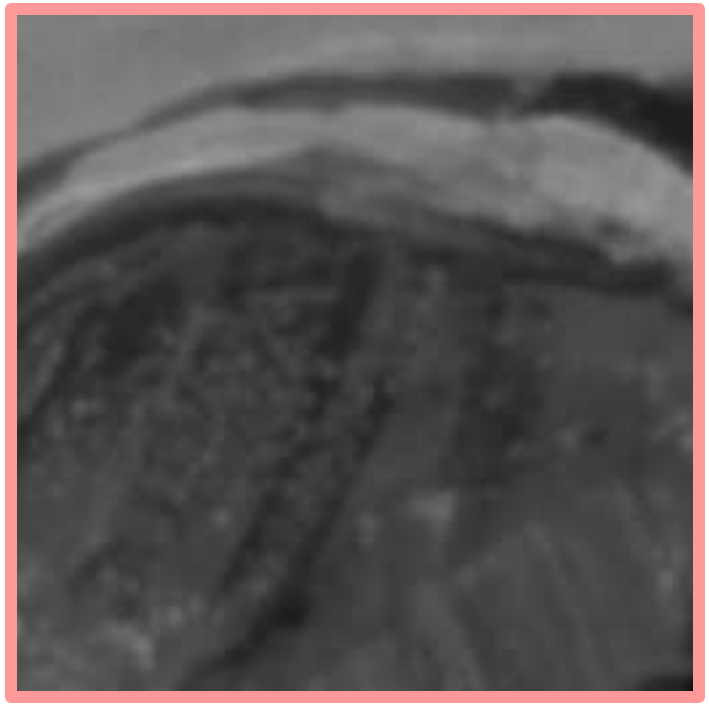


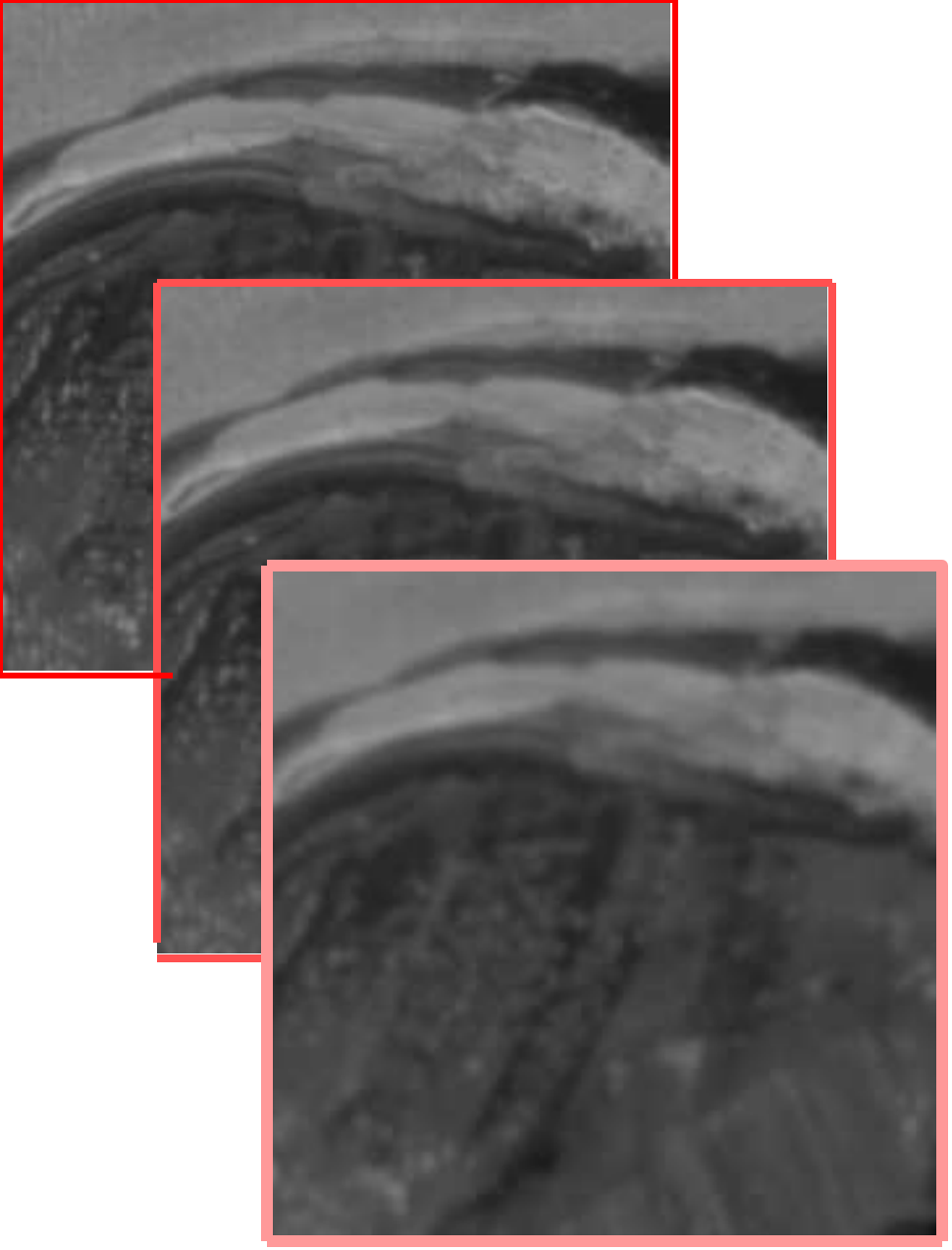


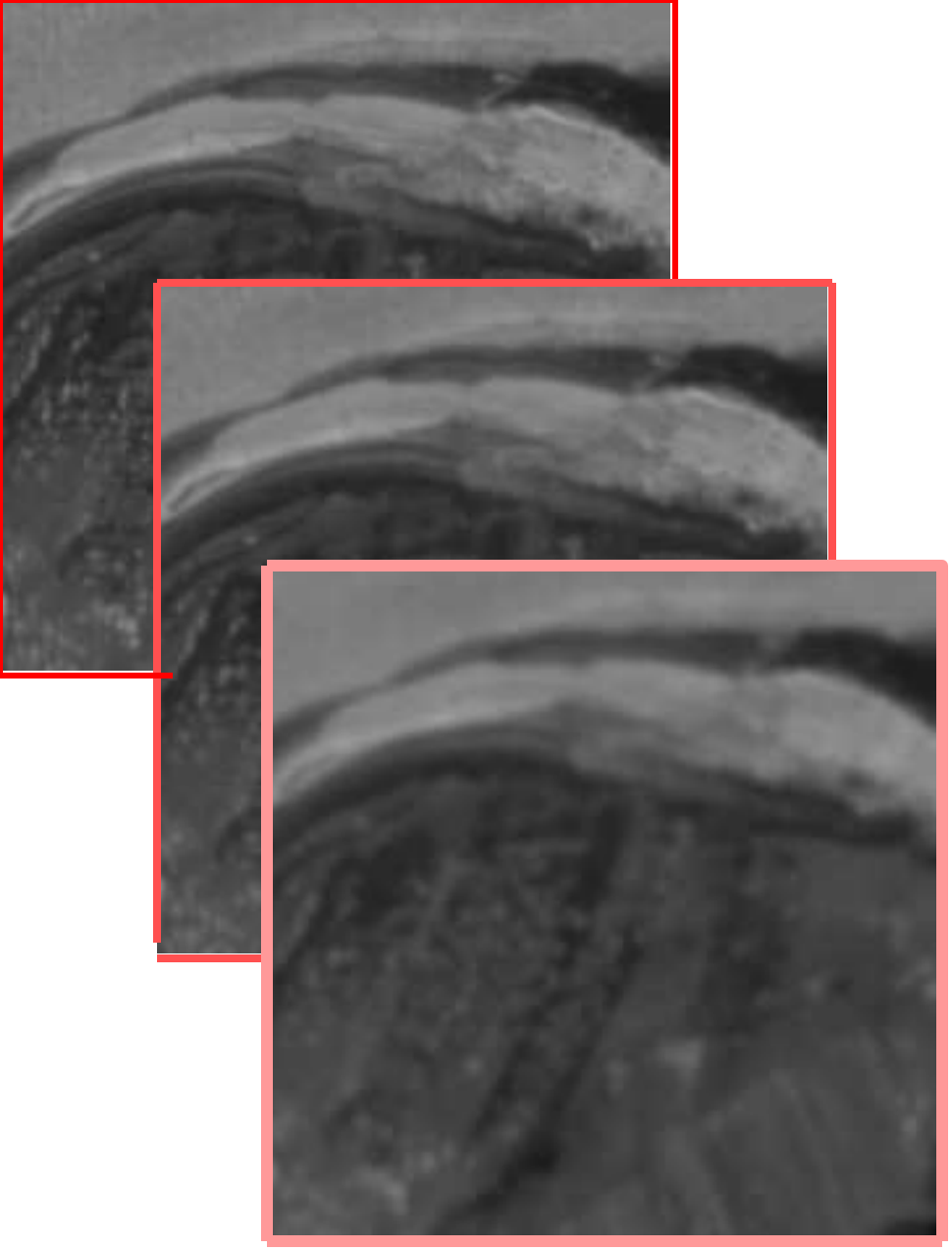


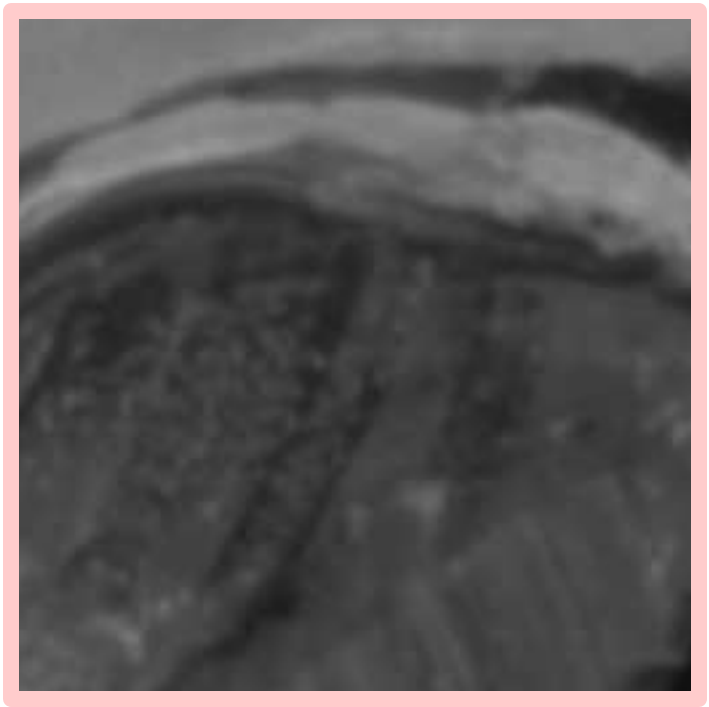


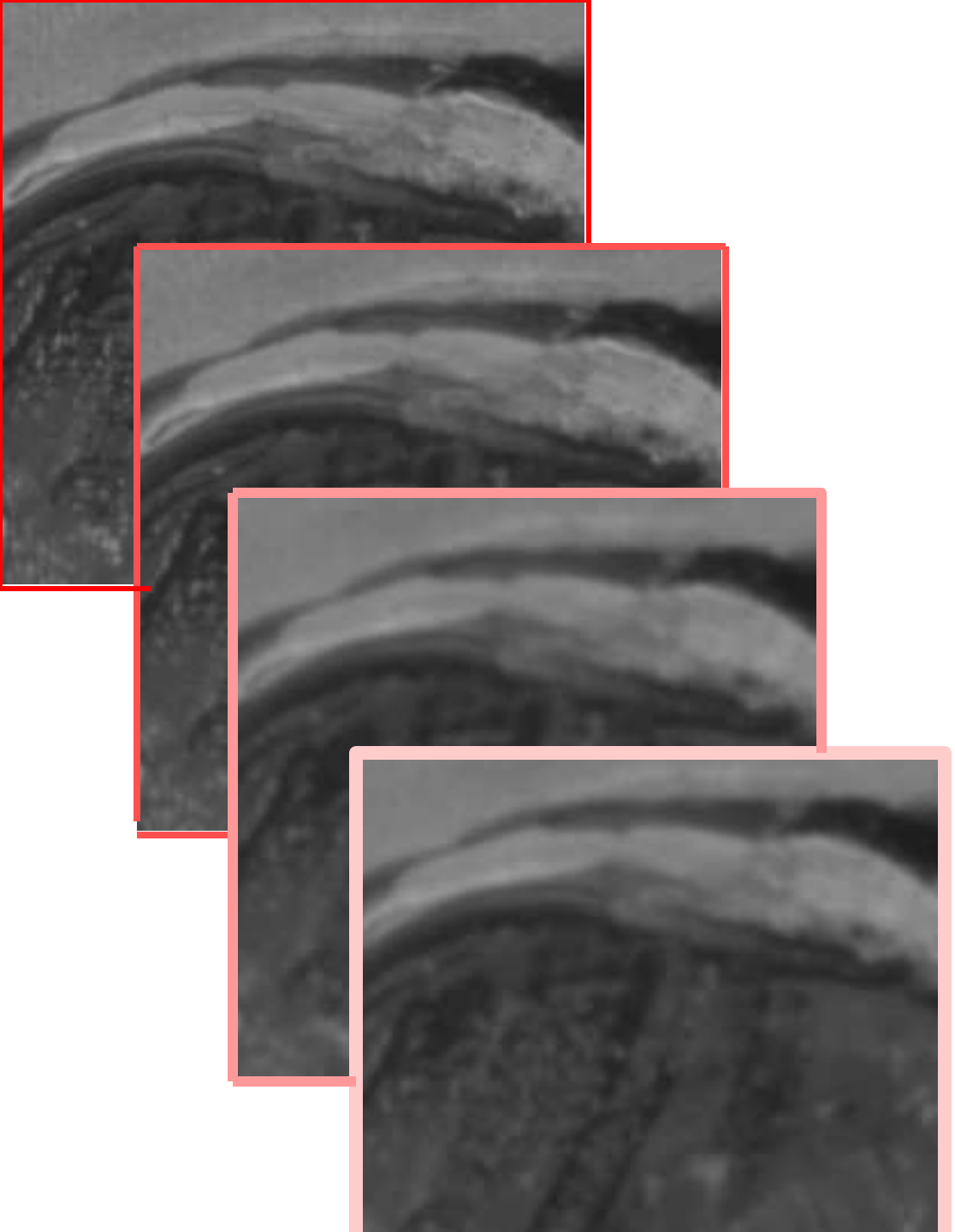


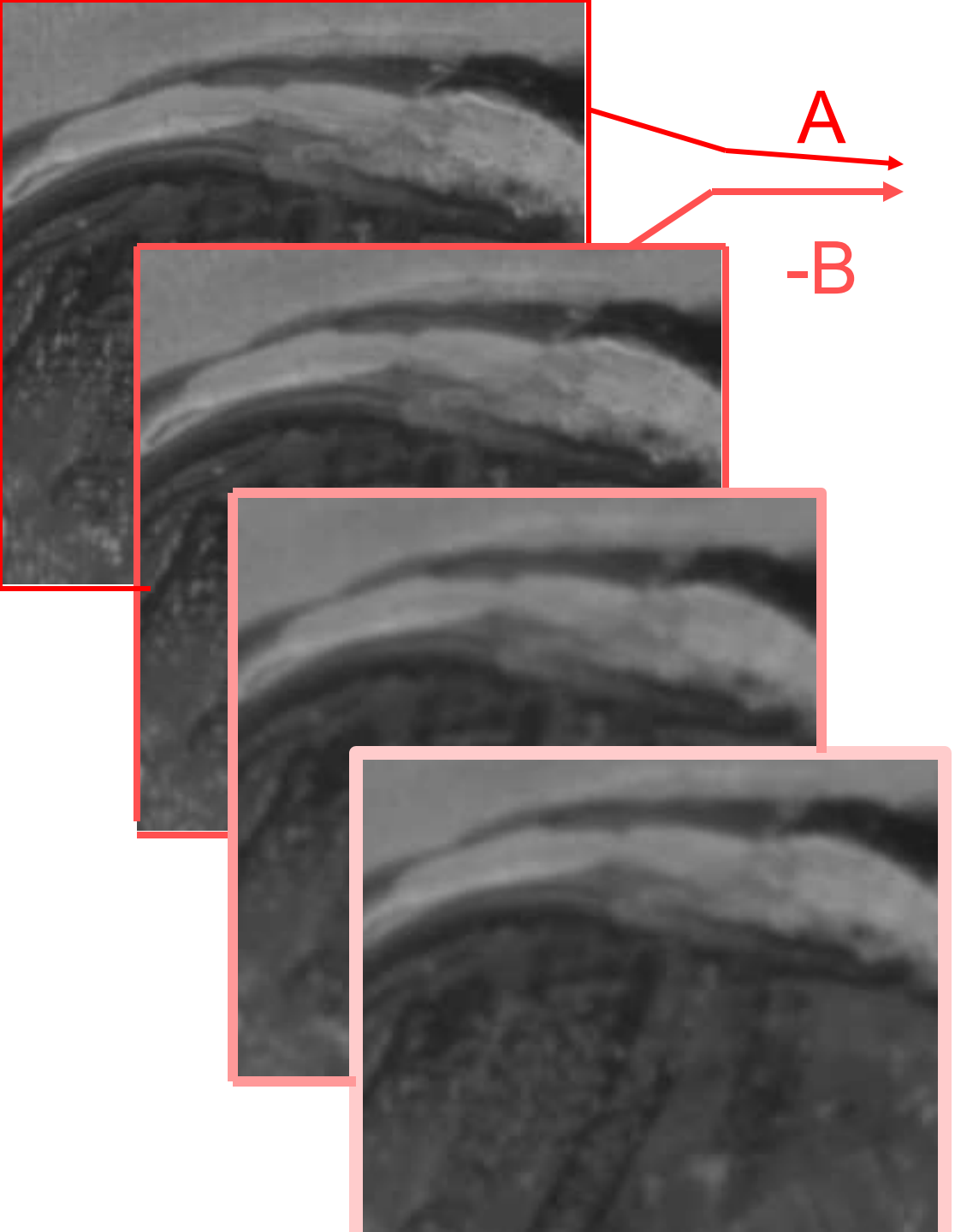


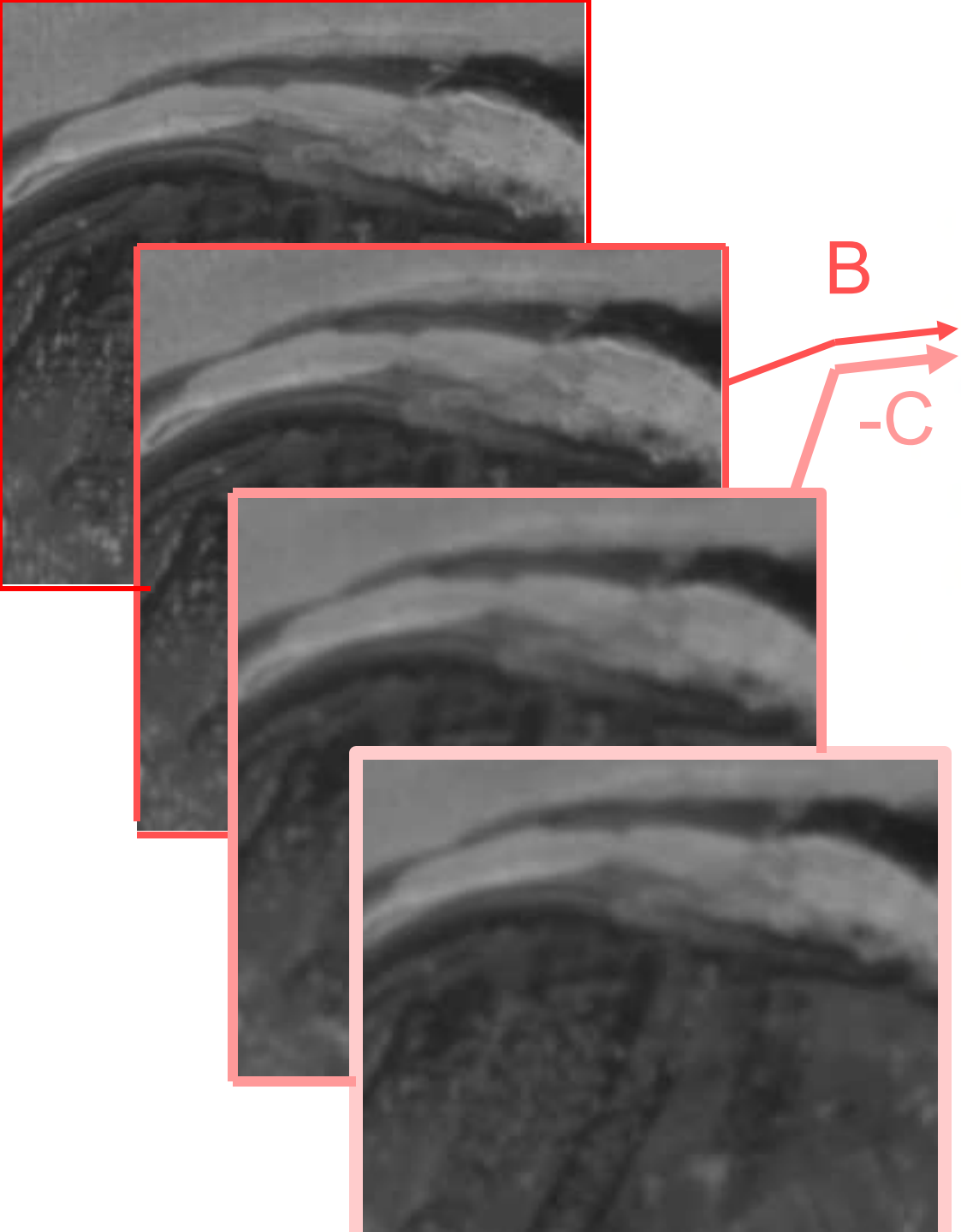


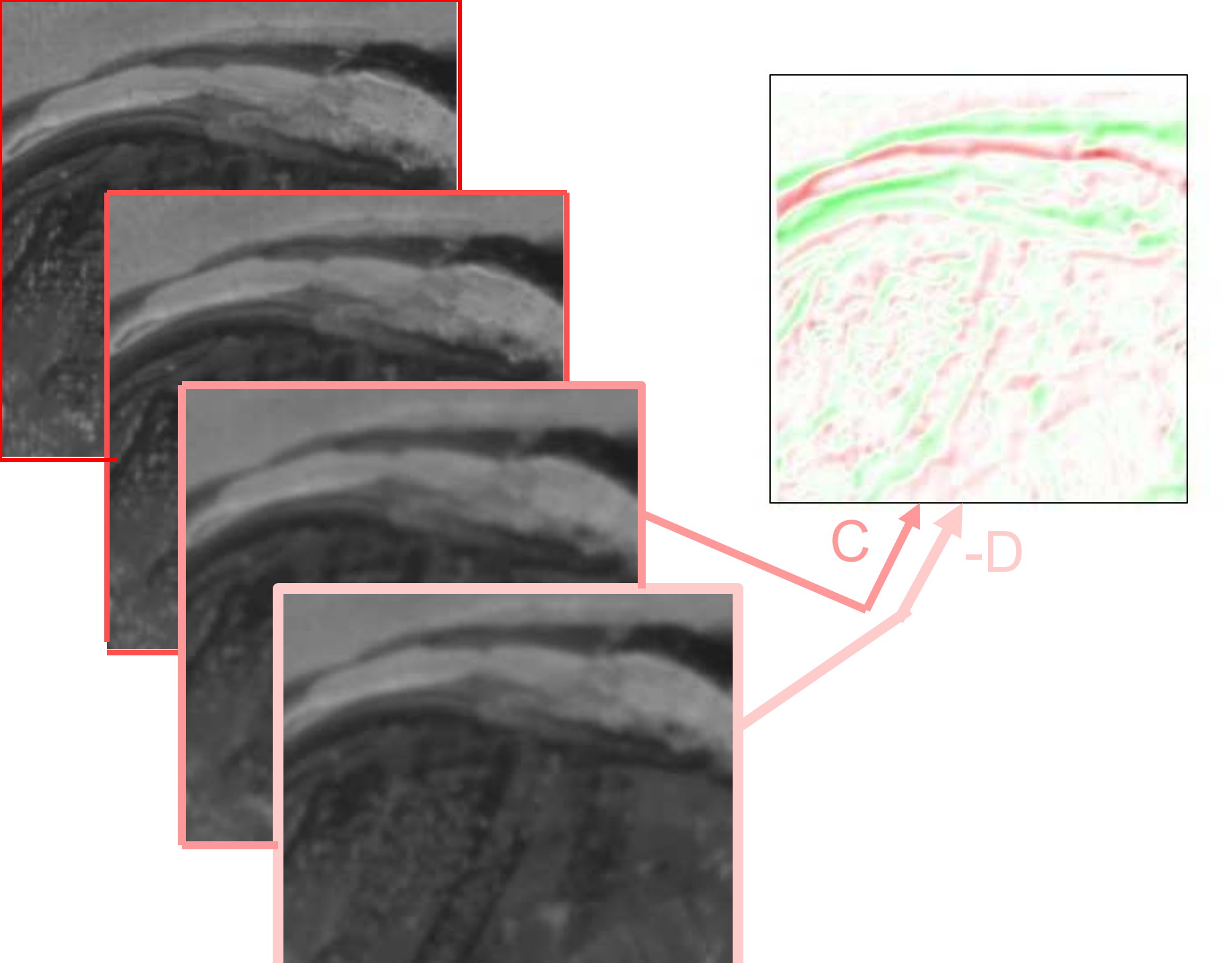


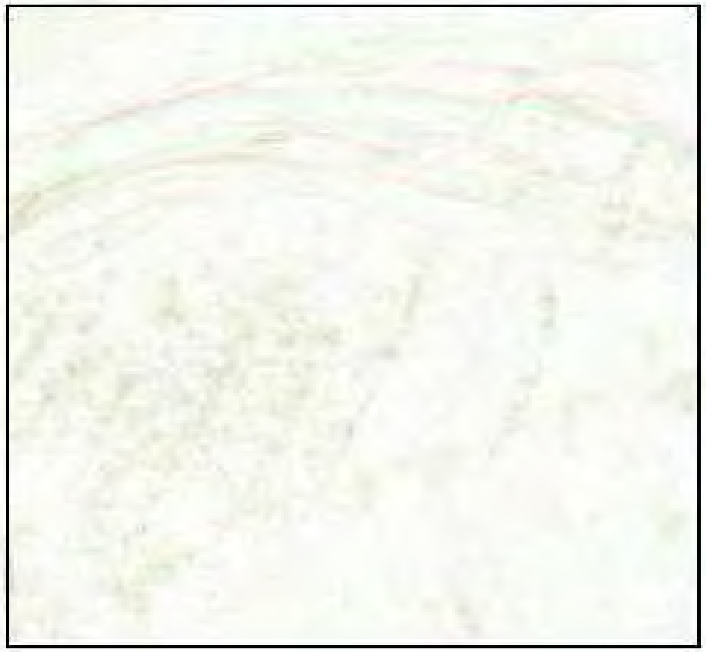


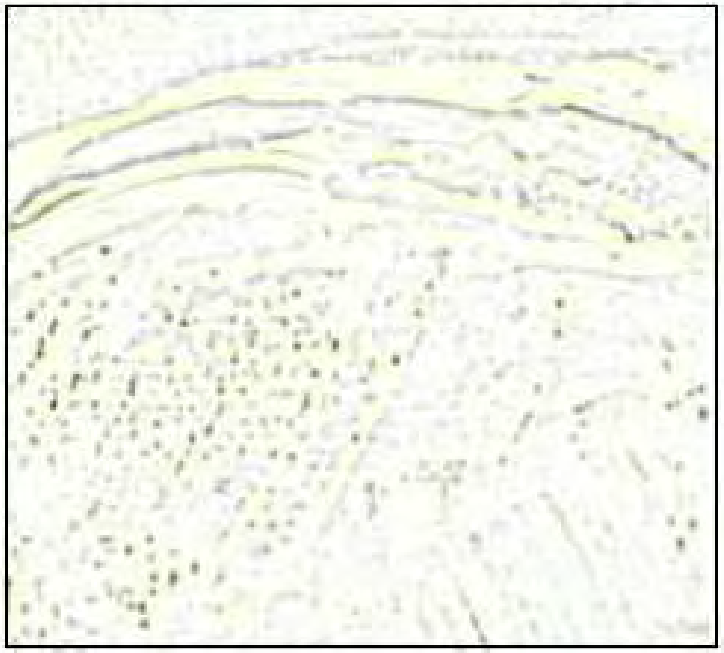


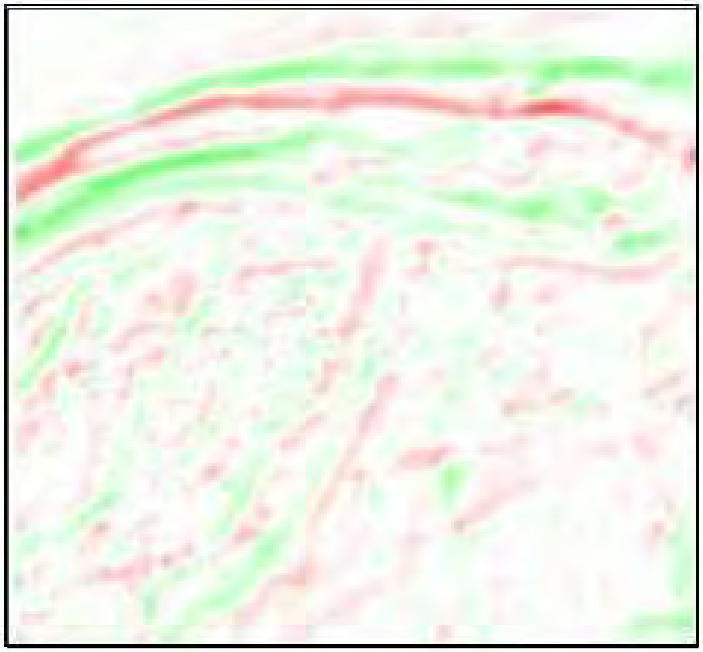

A
-B

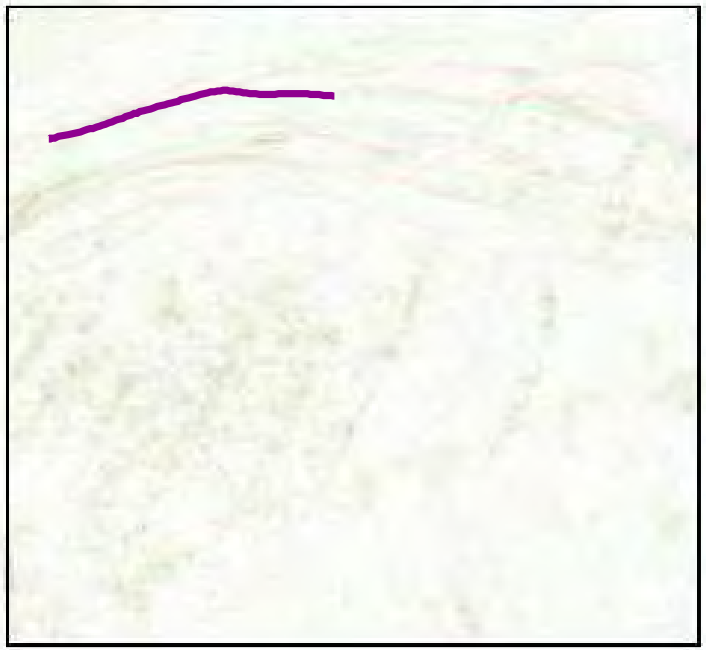

B
-C

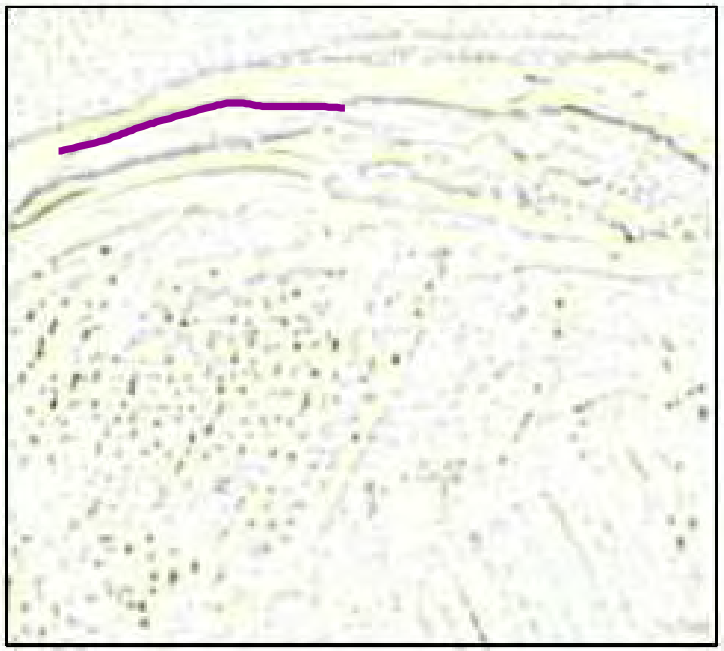

C
-D

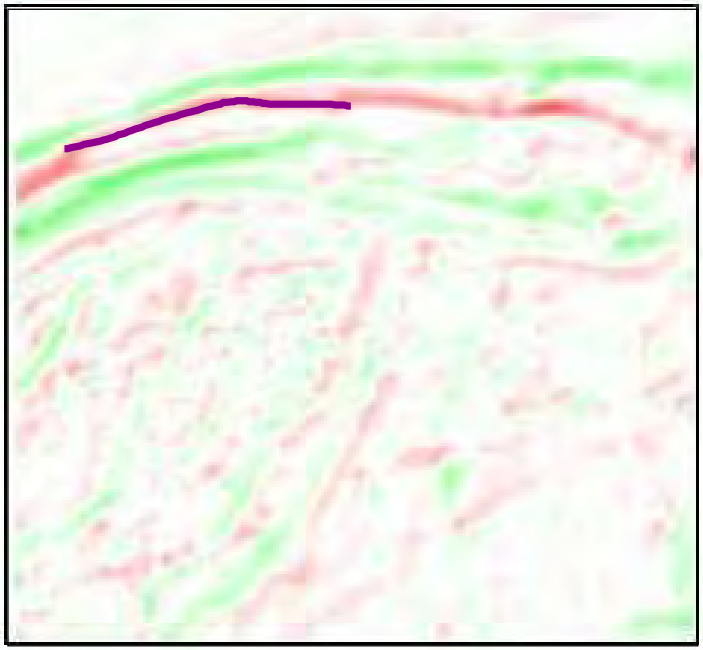


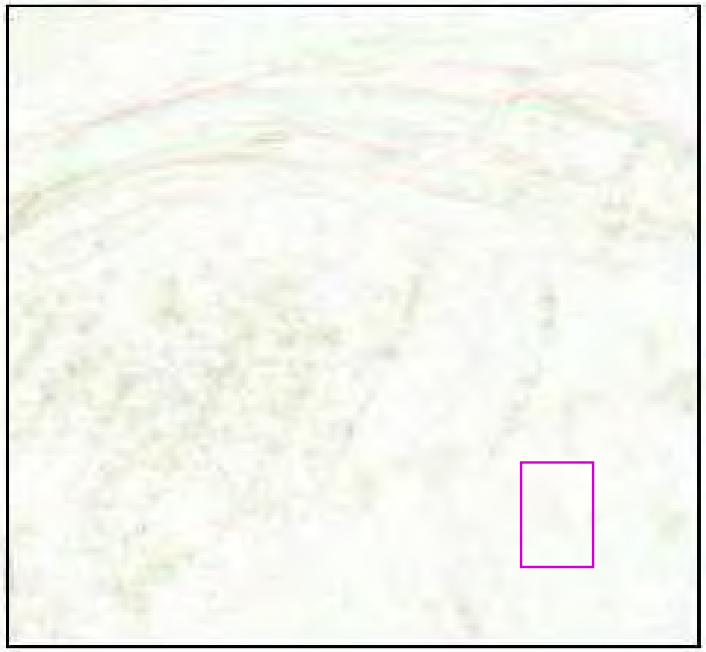


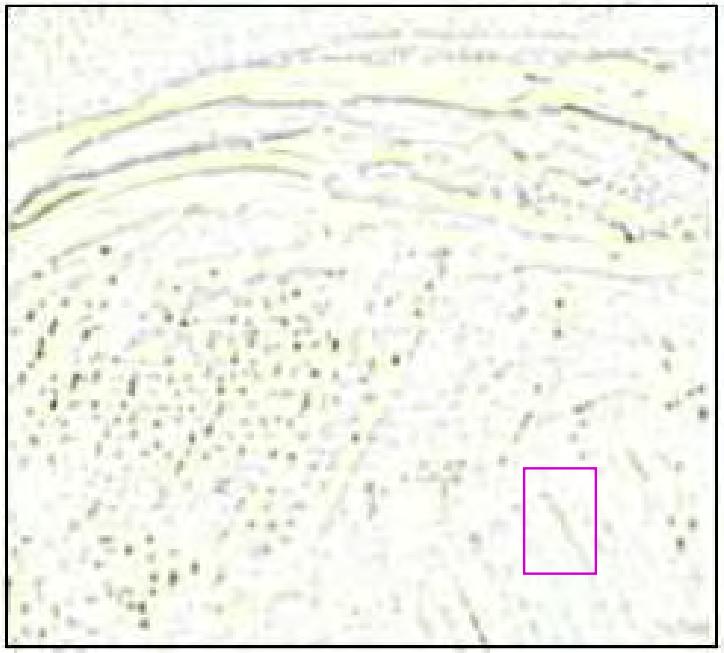


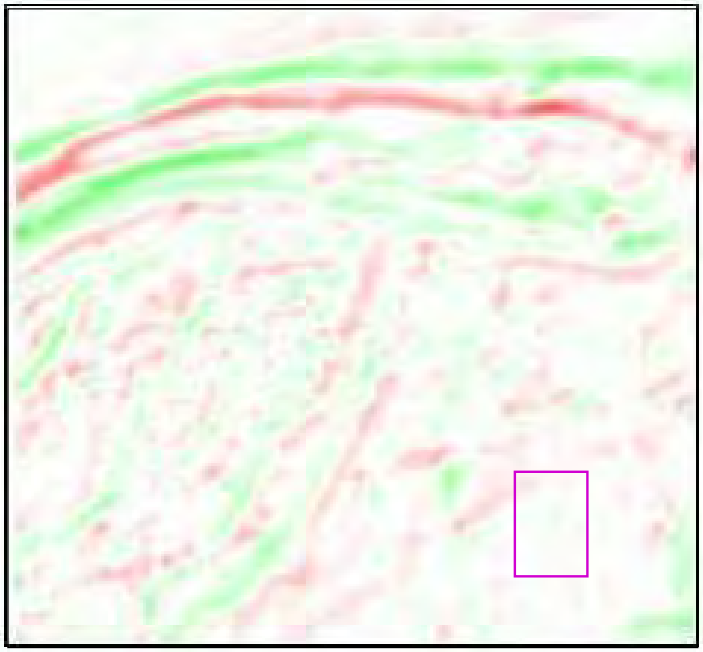


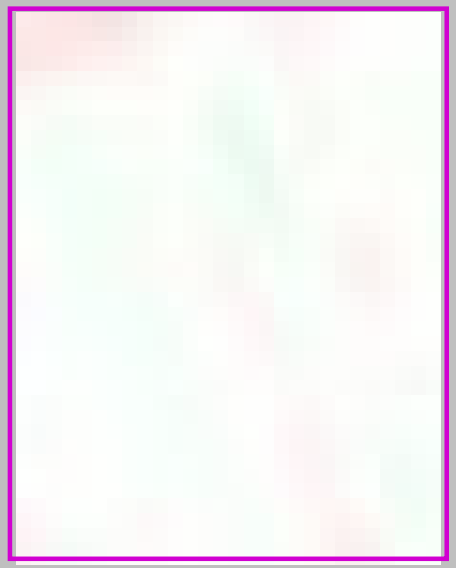










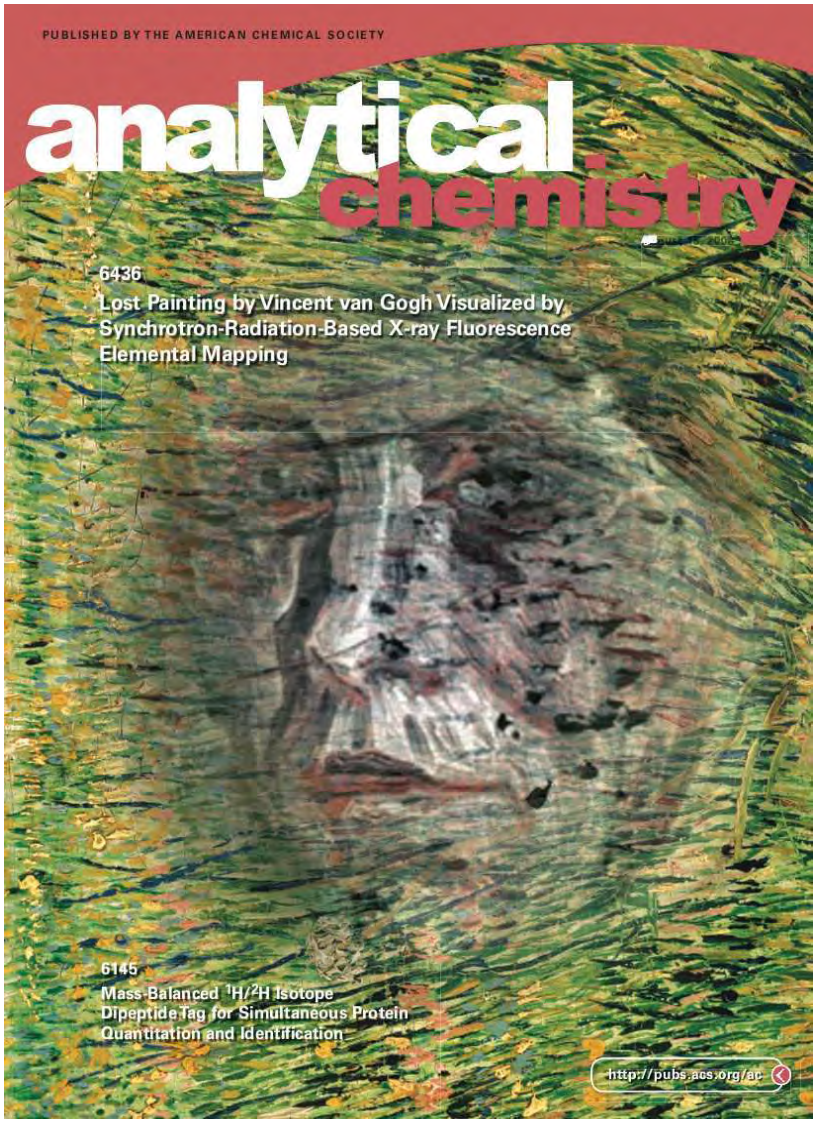


Based on wavelet features: defined distance between patches of paintings

→ visualize similarity

(movie)

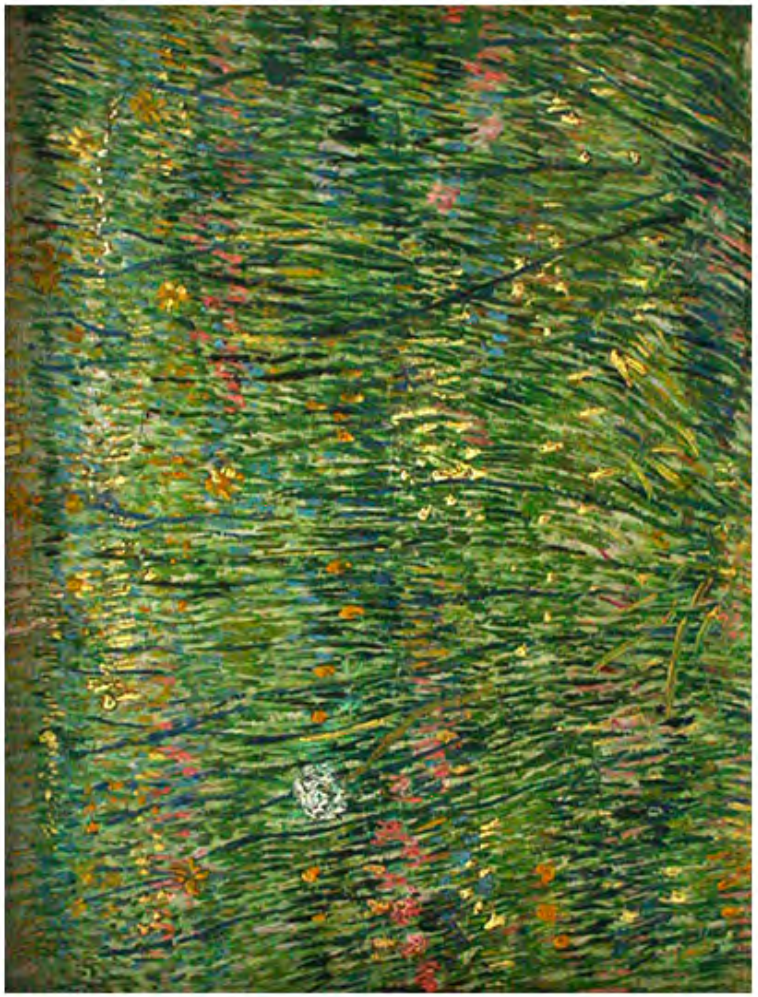
Next: other types of challenges



Joris Dik

and

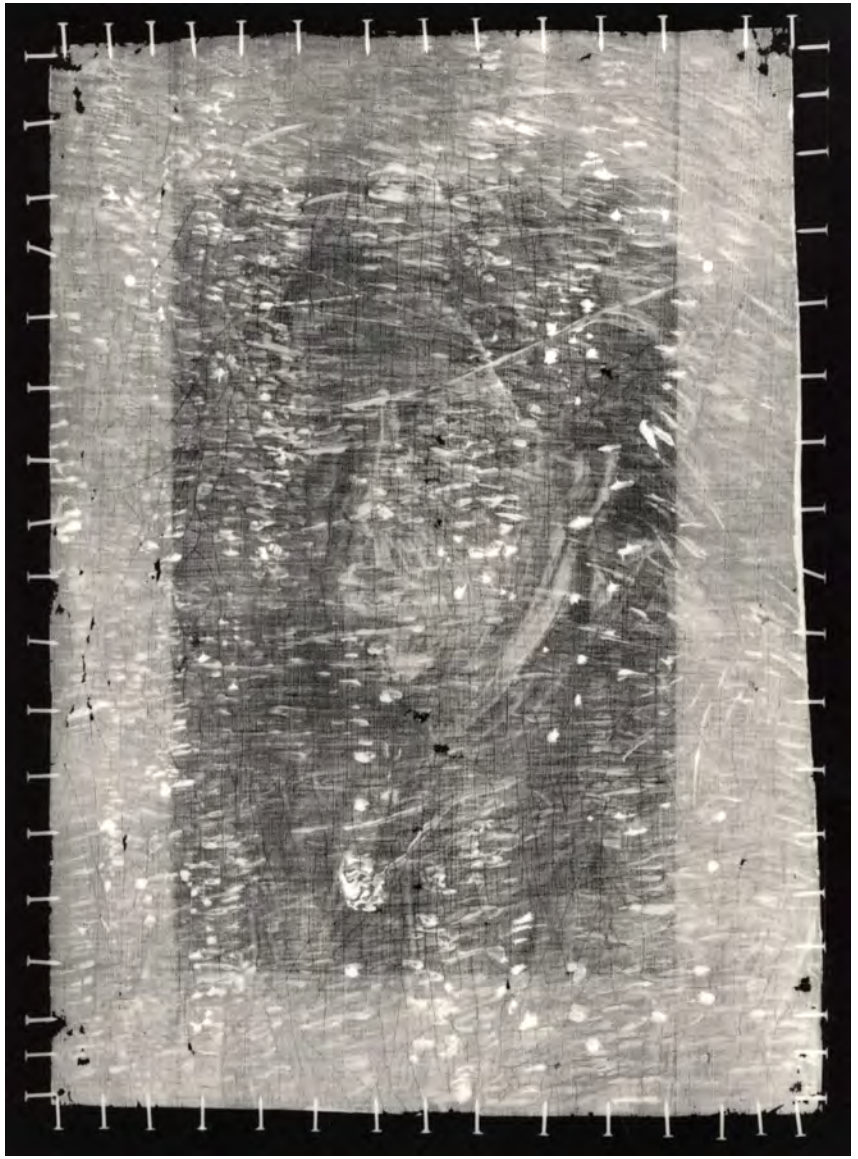
Koen Janssen



Van Gogh:

Patch of Grass

(Paris period)



Van Gogh:

Patch of Grass

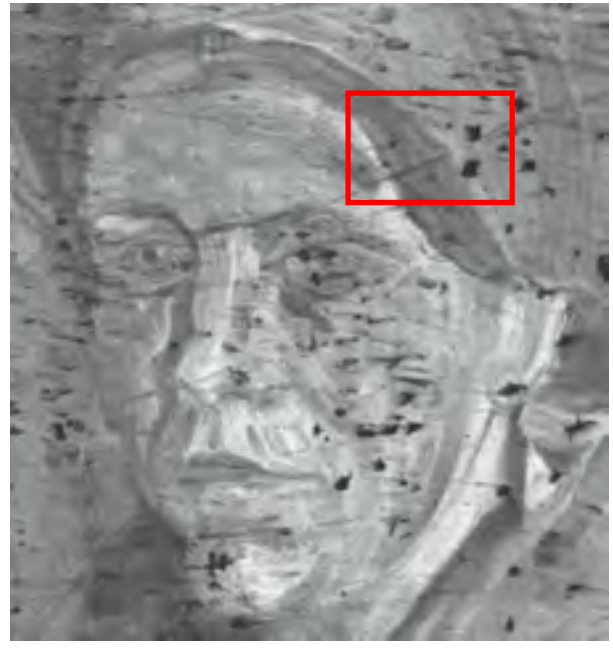
(Paris period)

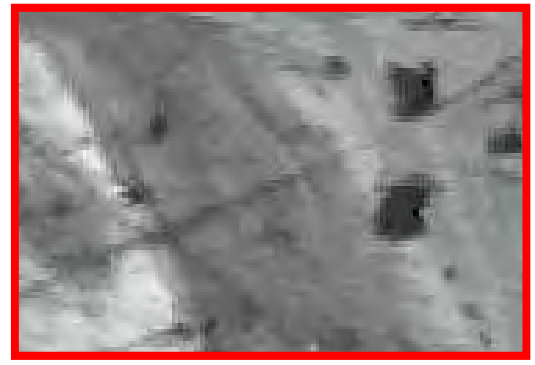
X-ray shows portrait

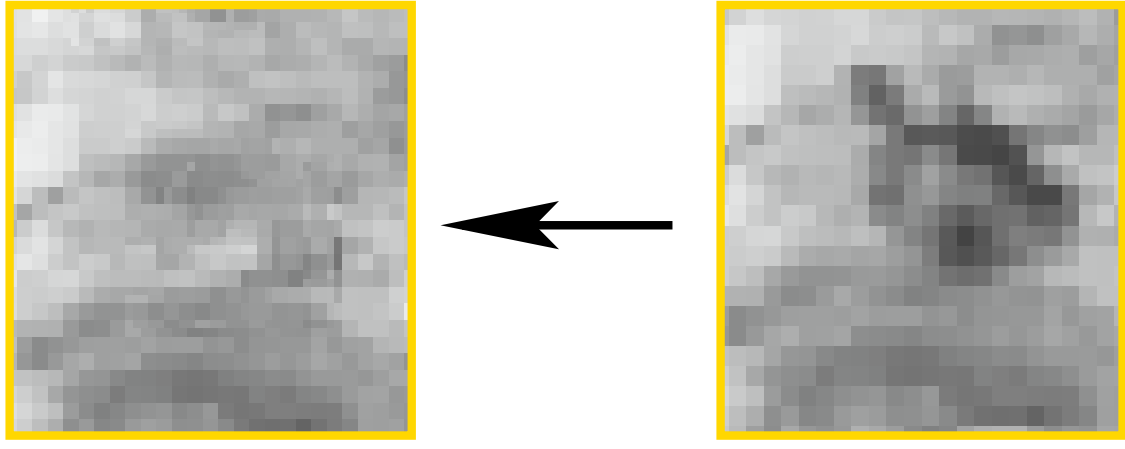
from Nuenen period

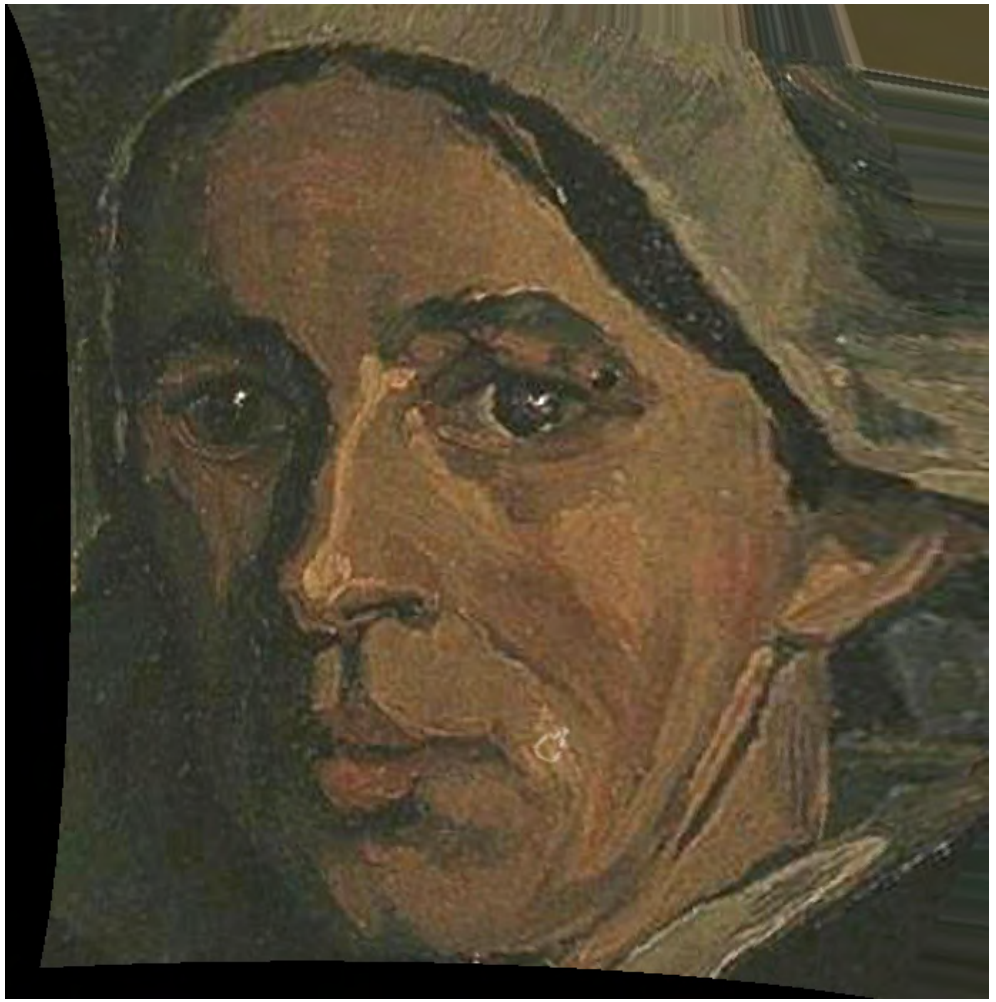
As

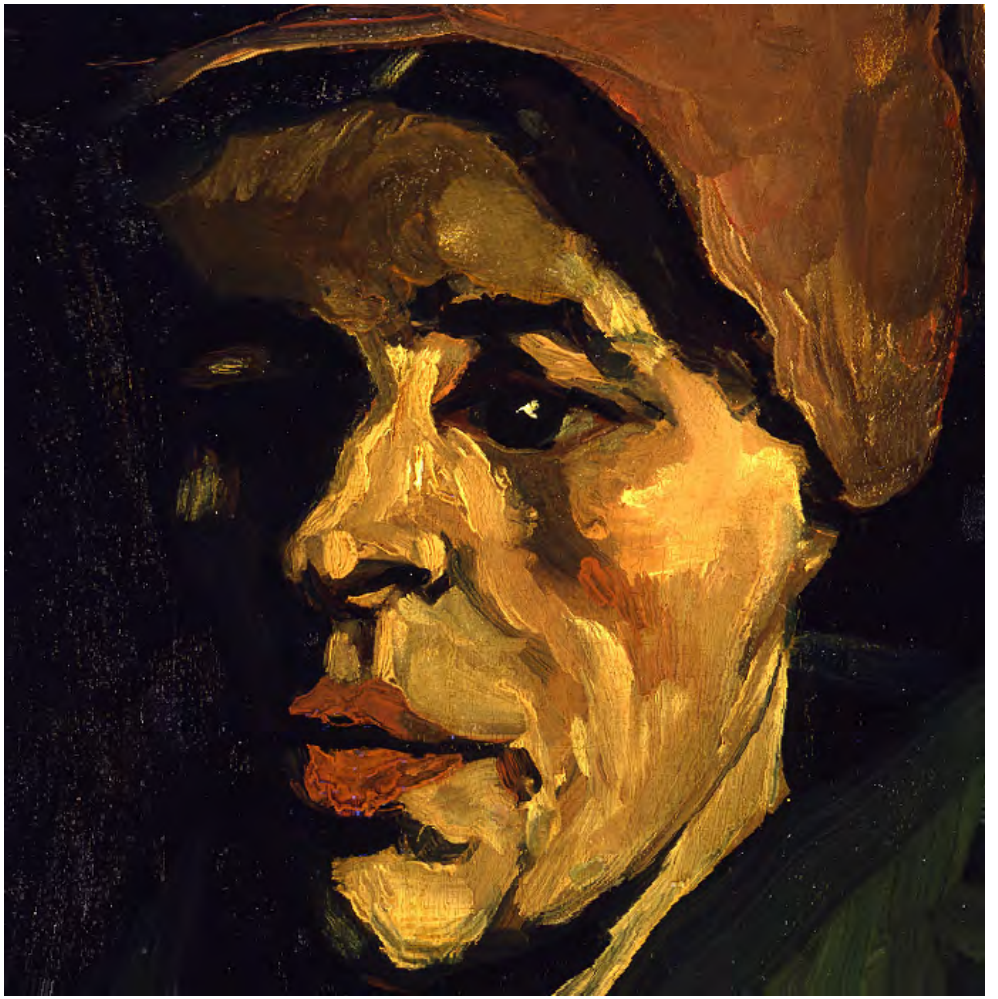
Sb

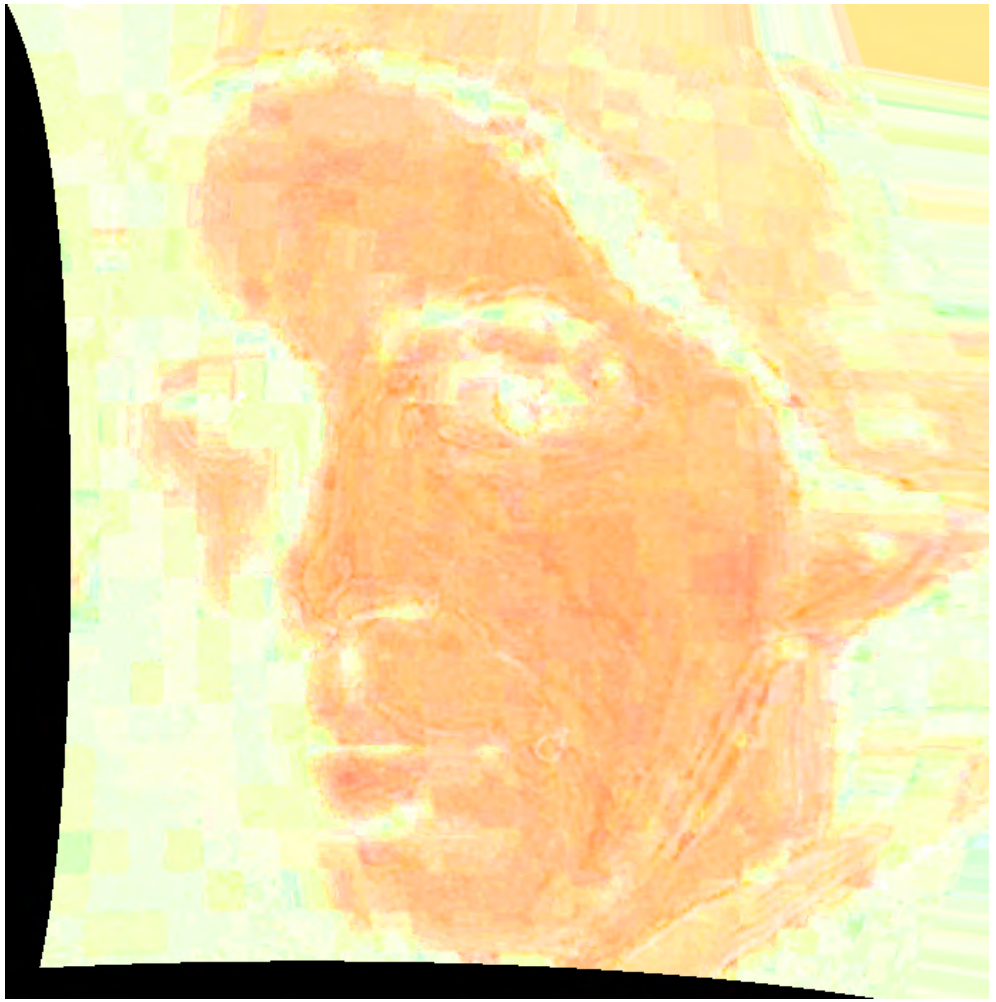












Reunited

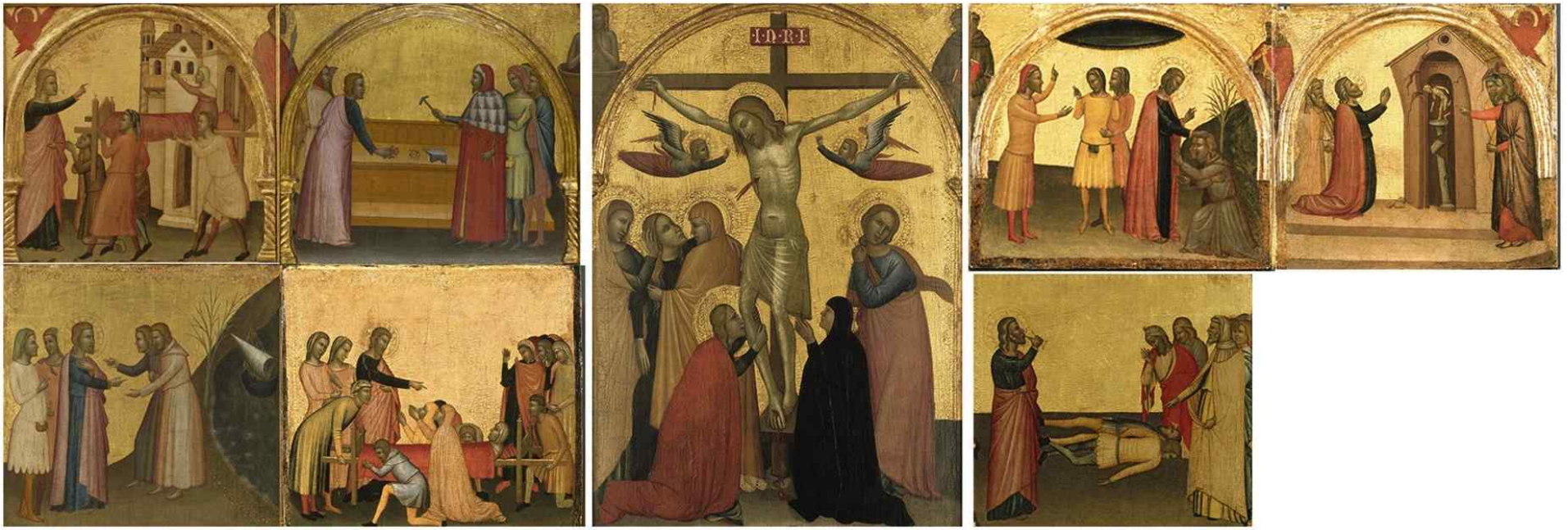
An art historical and digital adventure

Ghissi altarpiece: 3 panels in NCMA

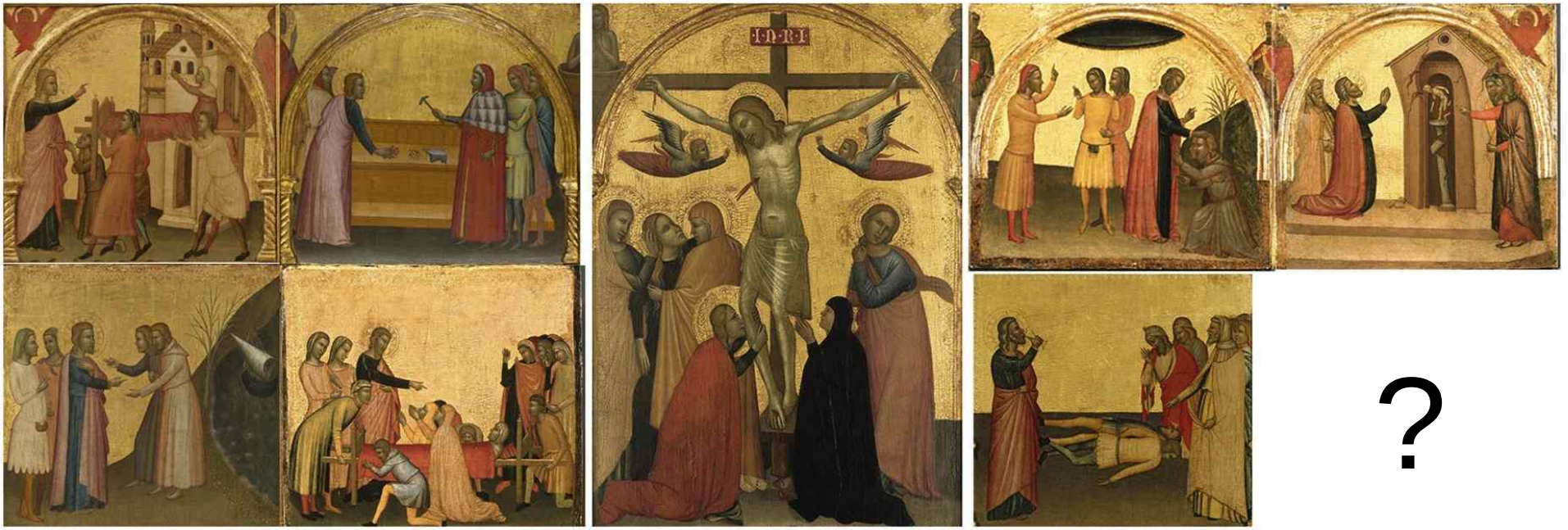
1 in Portland Art Museum

3 in Metropolitan Museum of Art, NY

1 in Art Institute, Chicago



1 missing ...



?

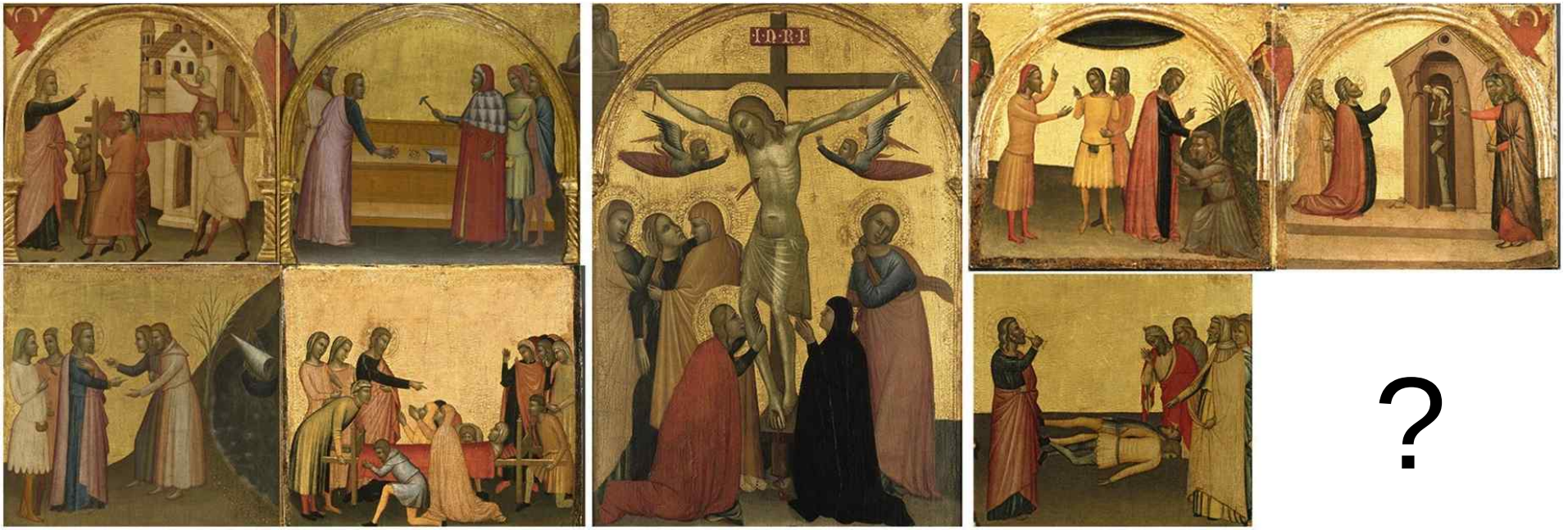
Charlotte Caspers

Artist
Art Conservator
Art Reconstruction

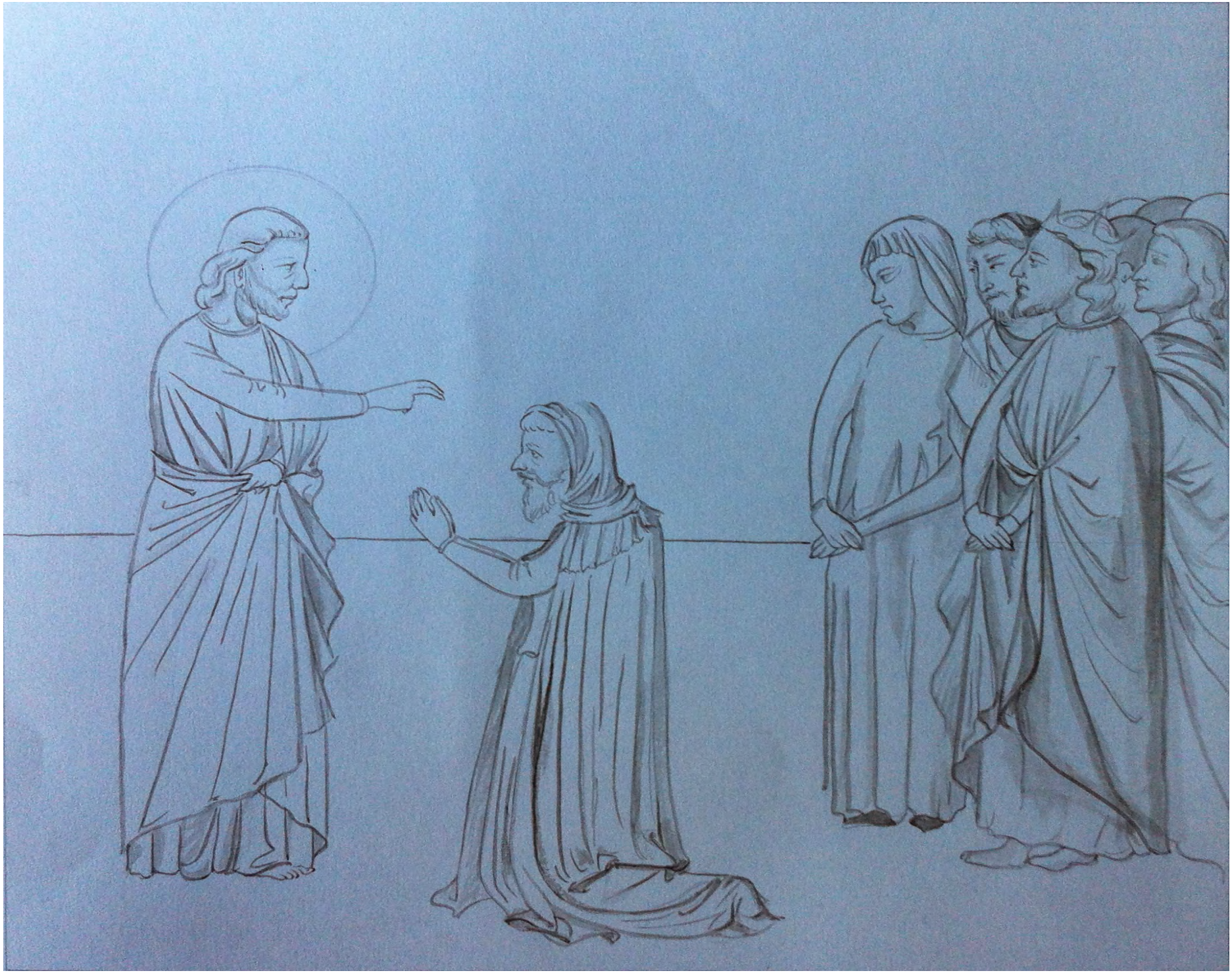
commissioned by
NCMA to recreate
the missing panel

The story followed the life of St. John the Evangelist as described in the “Golden Legend”, a medieval bestseller.

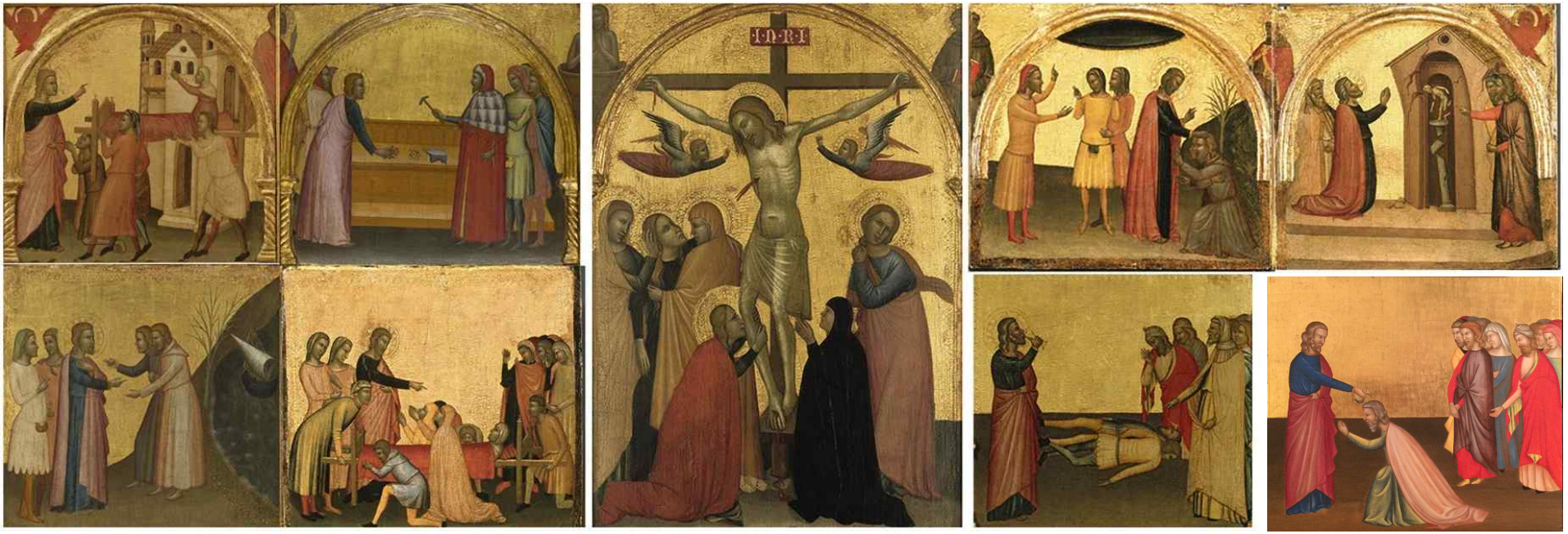
This allowed a guess for the topic of the missing scene


I·N·R·I

?




New panel is gorgeous – fresh colors, gleaming gold and punchmarks
Also: documentary made of its realization


I·N·R·I

Problem: new panel is so beautiful:
vivid colors, shiny gold, sparkling accents

Authentic 14th century panels would look dull and faded in comparison …

Use image analysis and image processing to "age" the panel; aged copy can then be displayed next to old panels, and new panel separately.

To do “virtual aging”:

* determine color correspondences, and
  use them to “remap” colors
* introduce cracks
  (need to study existing craquelure for this)
* “age” gold-leaf work

Printout of virtually aged Caspers panel was used for the “Reunited” exhbition in NCMA, Sept 2016-March 2017, and now in Portland Museum of Art (Oregon)


I·N·R·I

Can then also “virtually rejuvenate” old panels:

* detect and inpaint cracks
* using color correspondences determined earlier, “remap” old colors to “new”
* rejuvenate gold-leaf work

Studying and Removing Cracks

Craquelure: very dense – not easy to detect automatically all cracks and only cracks …

Previous experience in doing this

Ghent Altarpiece

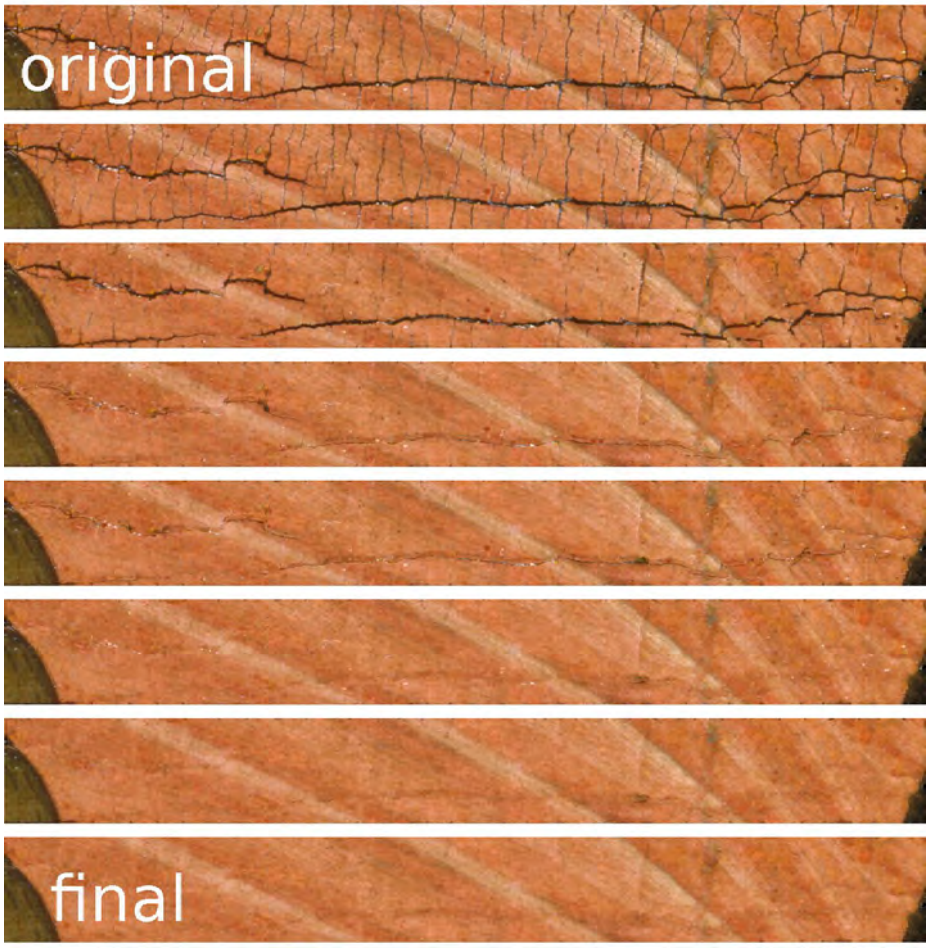
15th century, Flemish

Jan Van Eyck

Previous experience in doing this

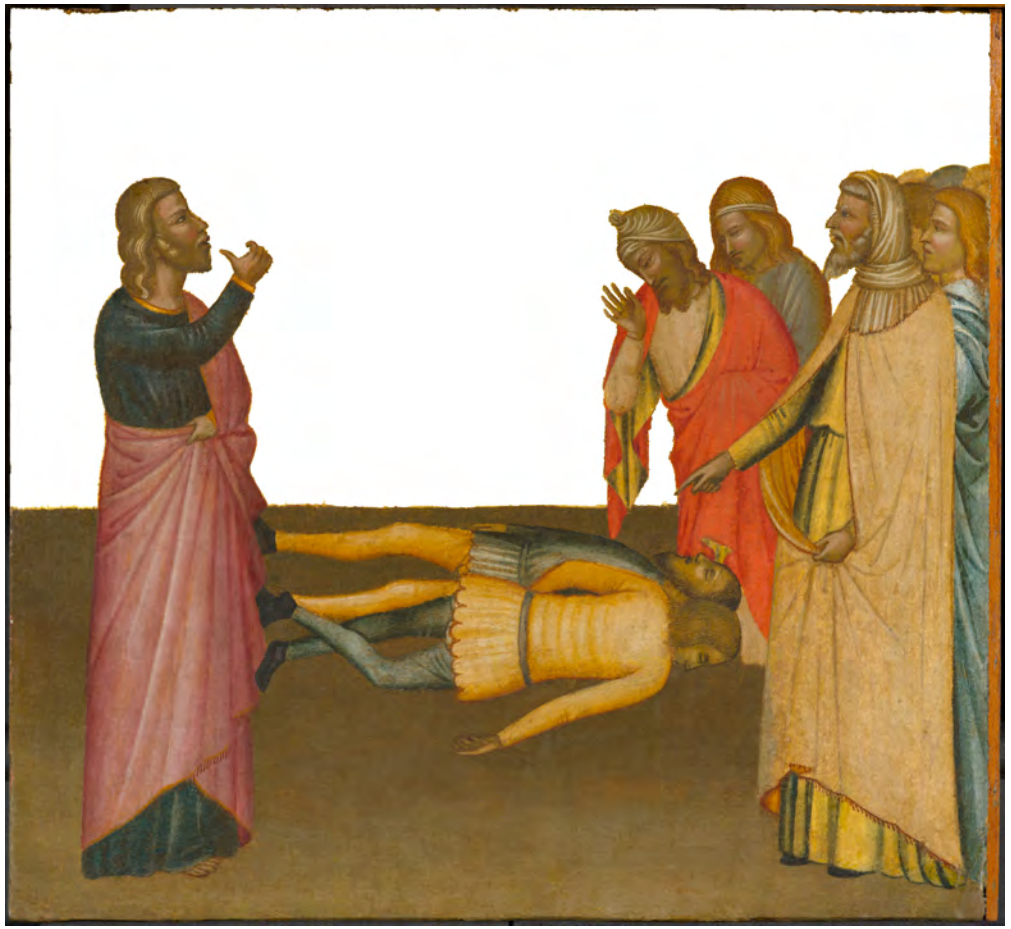
Previous experience in doing this

Previous experience in doing this

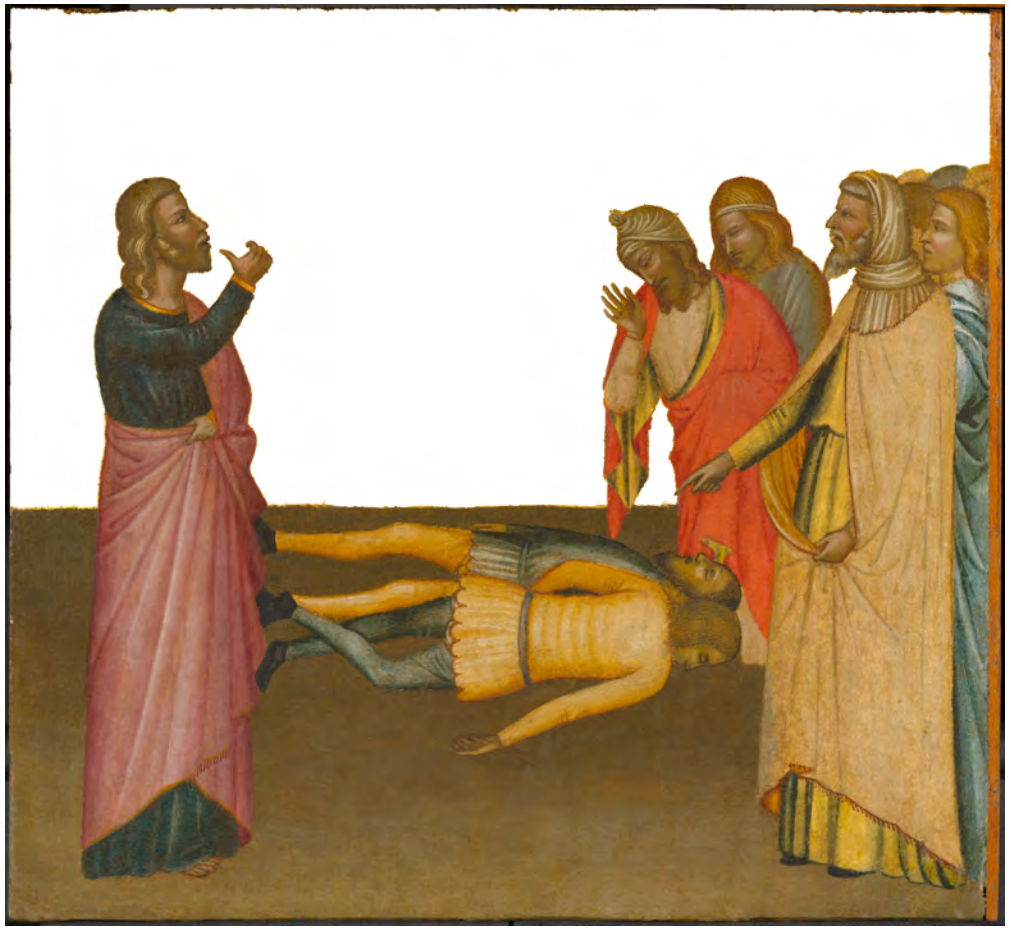

original
final

Color Remapping

Color Remapping



Color Remapping



Old colors

Rejuvenated colors

Color Remapping

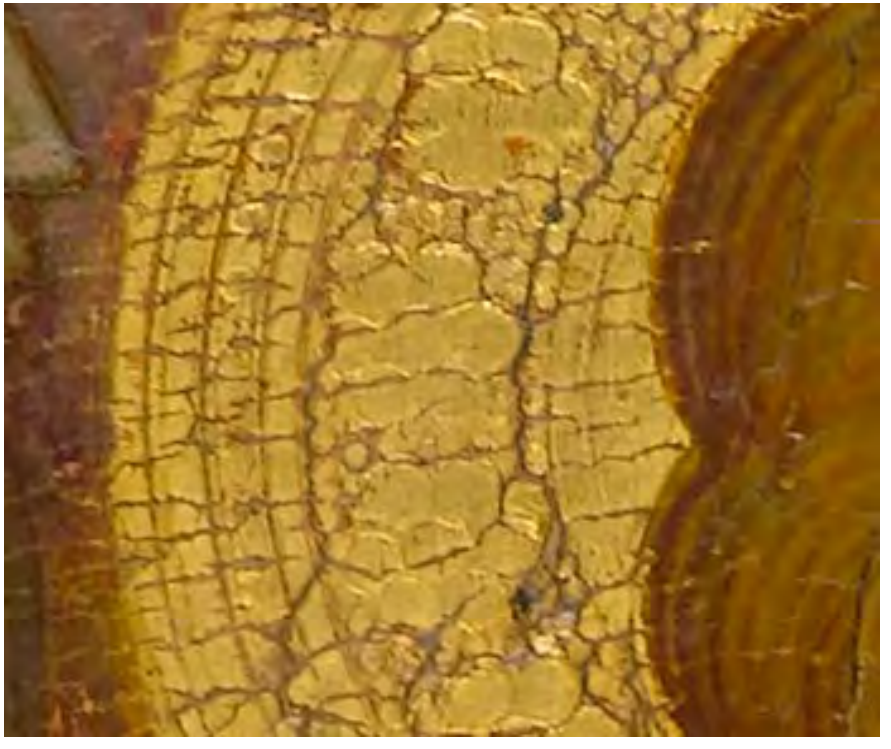
Aged colors

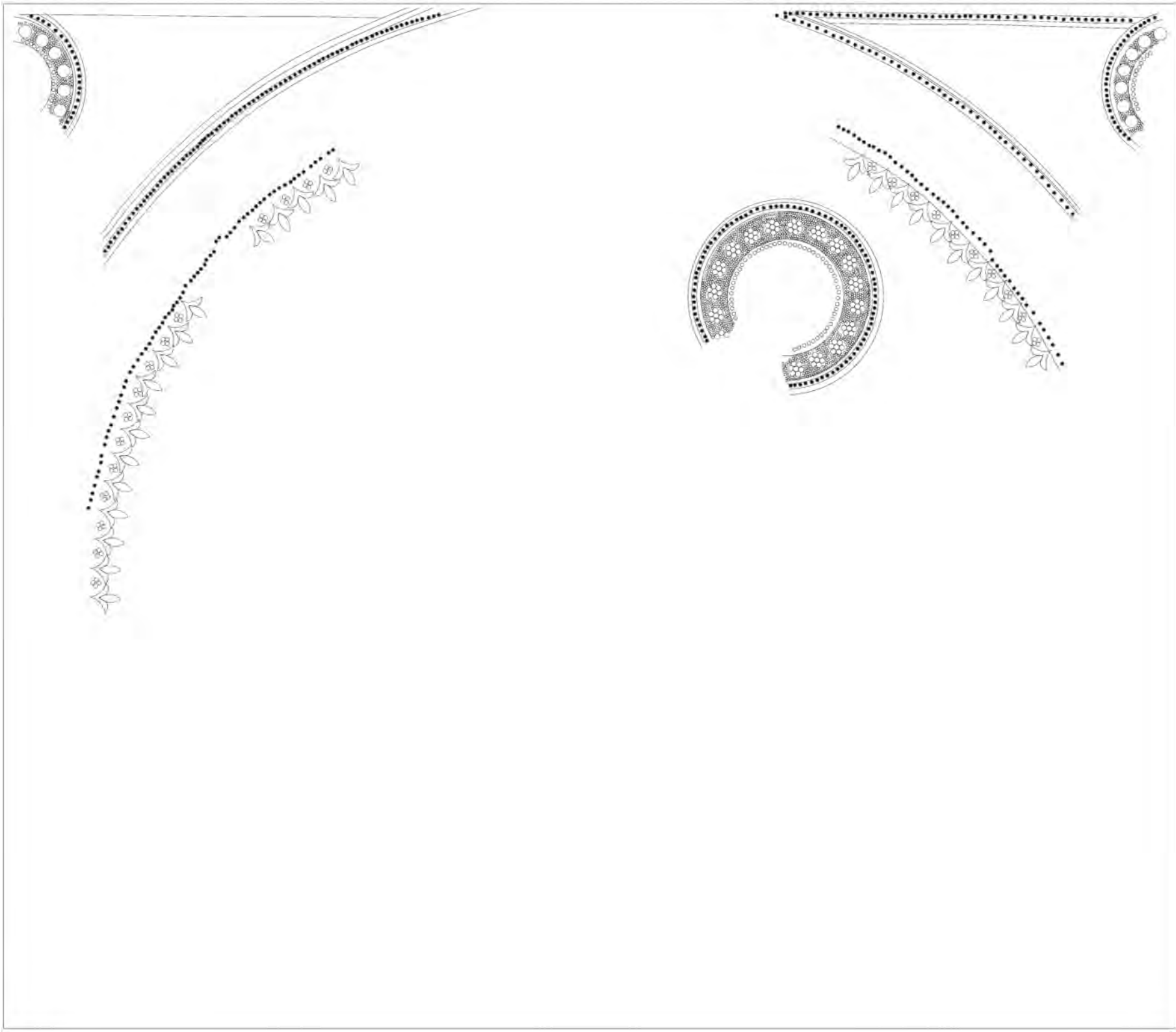
New, fresh colors

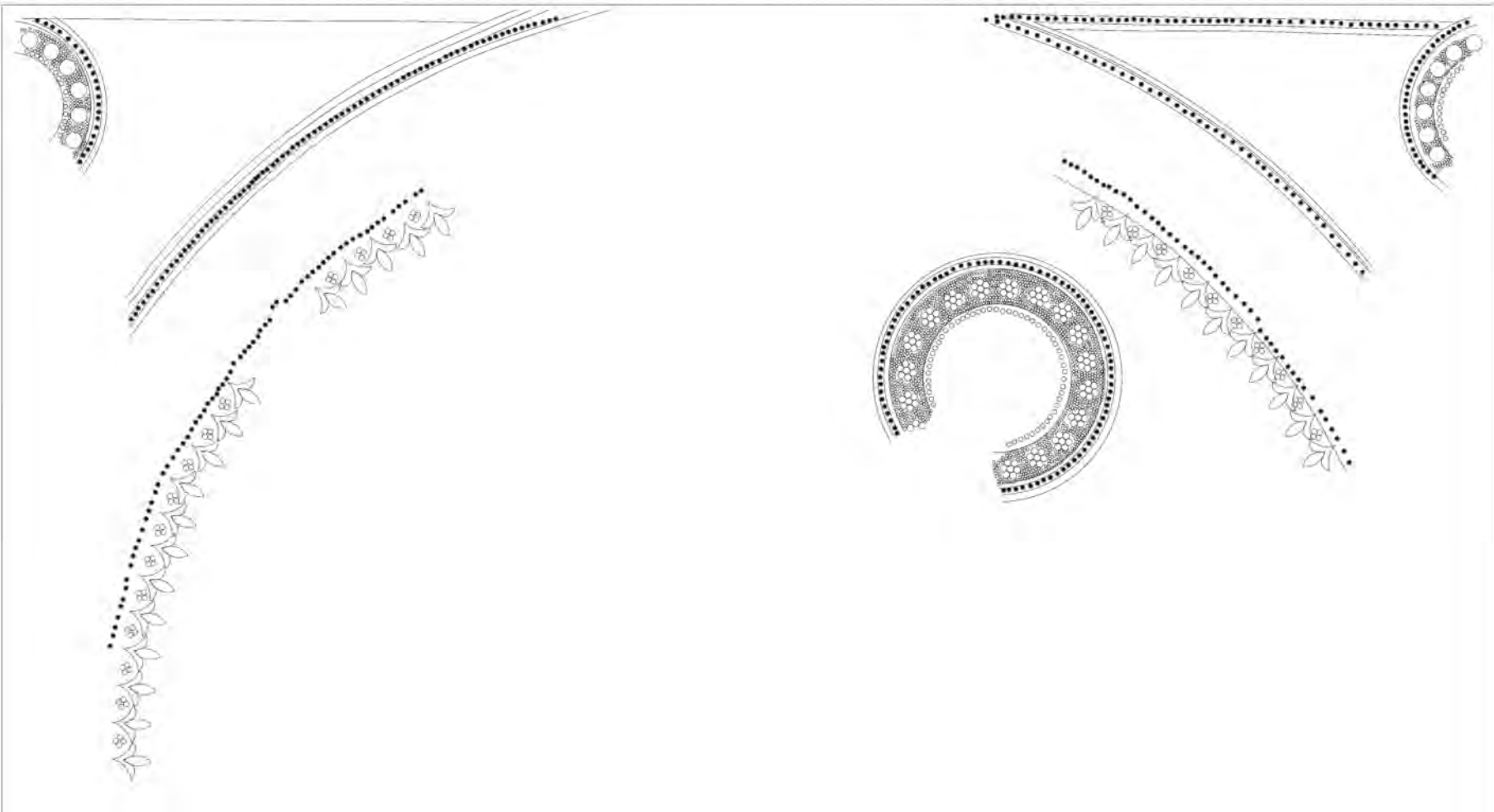
Crack Generation

Crack Generation

Putting “new” gilding on rejuvenated panels

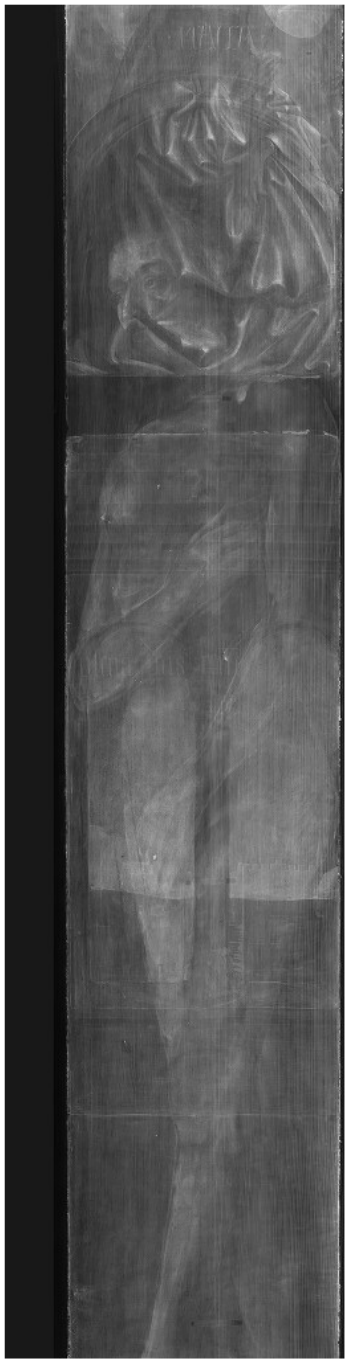






Computer graphics techniques were used to model and render the reflections of the gold background and off the punchmarks, once their locations were identified.

(show movie)




ADAM


Eva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