Reading the Invisible: the role of optical investigations in the Study of the Herculaneum Papyri

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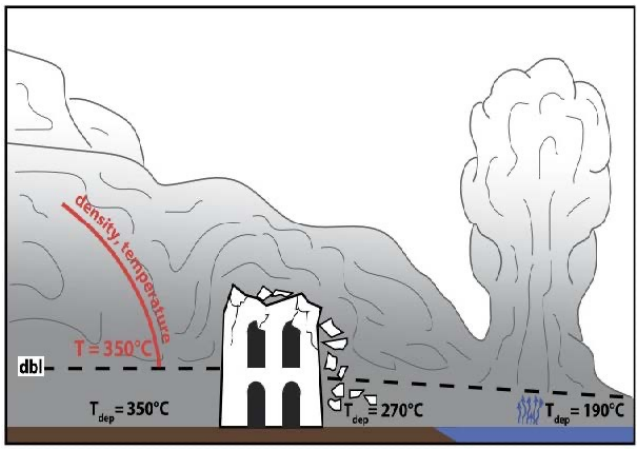
Congresso Nazionale AIAr, 19-21 Aprile 2023 Messina

Herculaneum Papyri



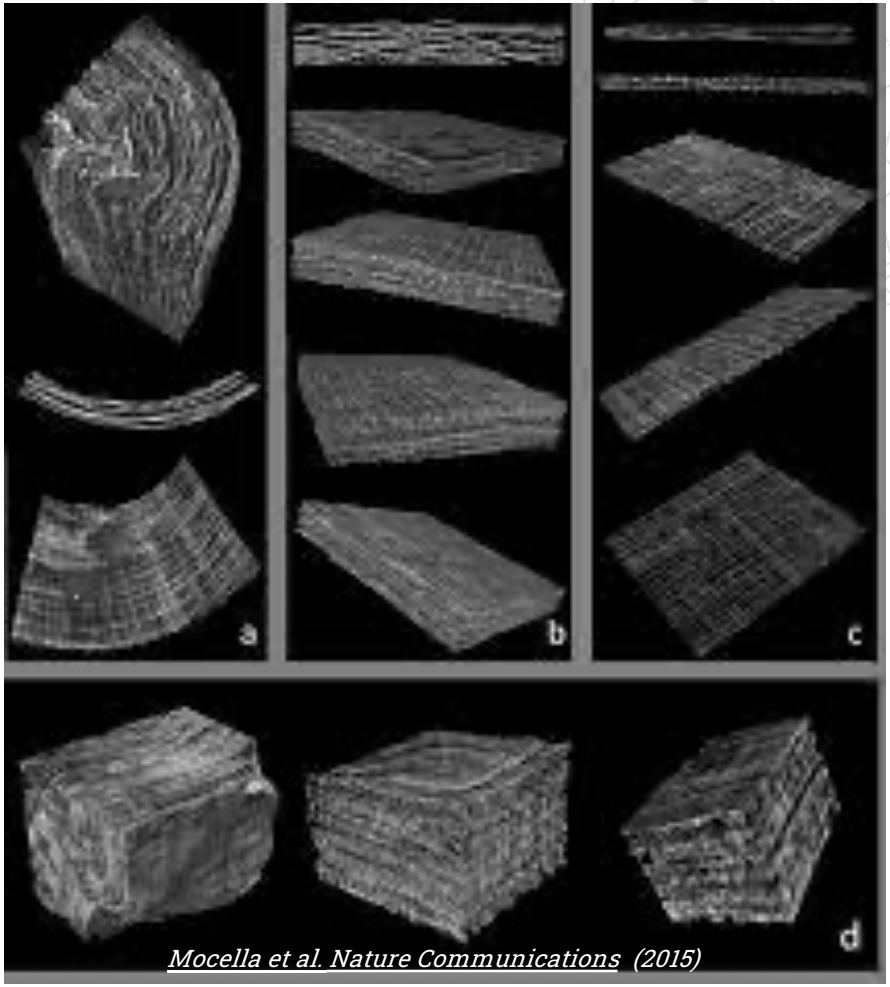
>1,800 papyrus scrolls found, carbonized by the heat of the eruption in 79 AD

Previous Studies

1. Mocella V. et al.,
Revealing letters in rolled Herculaneum papyri by X-ray phase-contrast imaging
Nature Communications (2015)
X-ray phase-contrast tomography (XPCT)

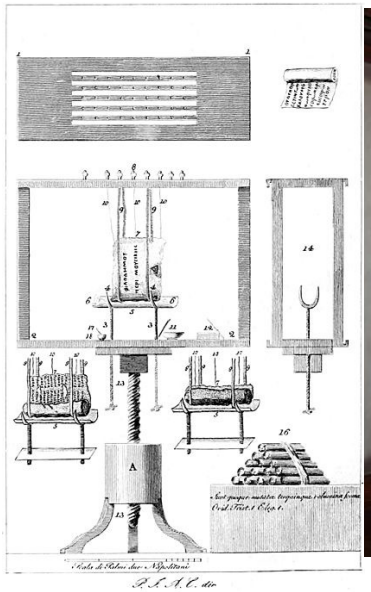
2. Bukreeva I. et al.
Virtual unrolling and deciphering of Herculaneum papyri by X-ray phase-contrast tomography
Scientific Reports (2016)
X-ray phase-contrast tomography (XPCT) & unrolling algorithms

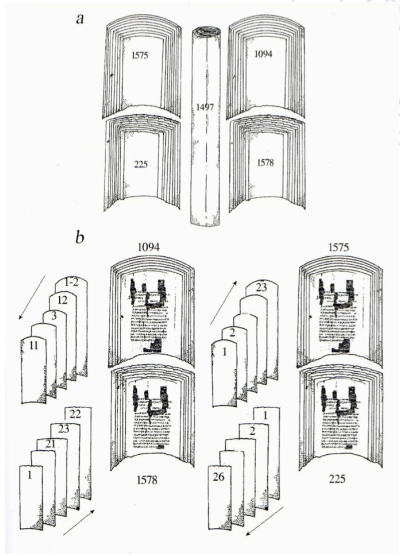
3. Parker CS et al.
From invisibility to readability: Recovering the ink of Herculaneum.
PLoS ONE (2019)
Micro-CT & AI



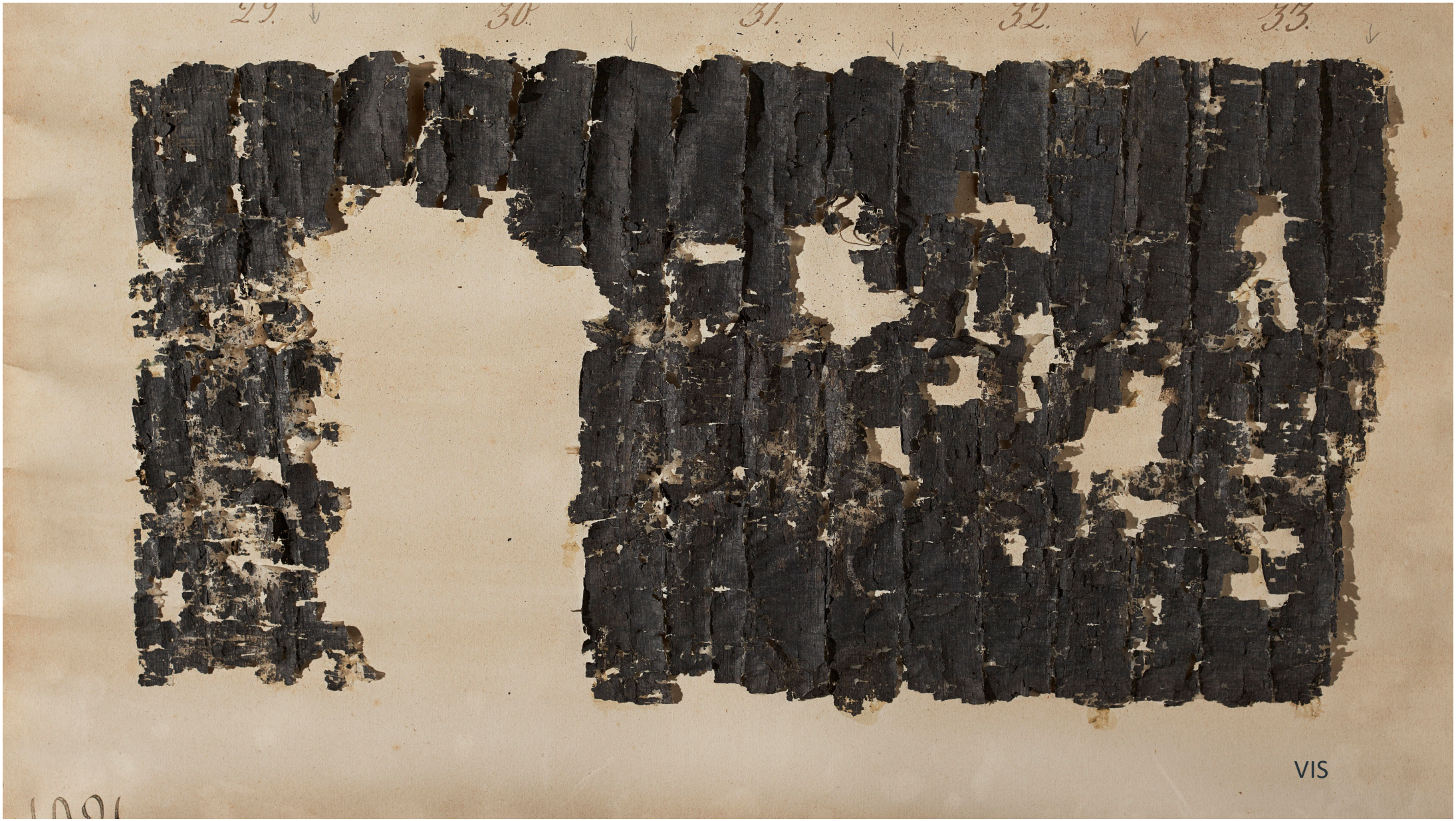
Mocella et al. Nature Communications (2015)

Piaggio's machine (1756-1906)



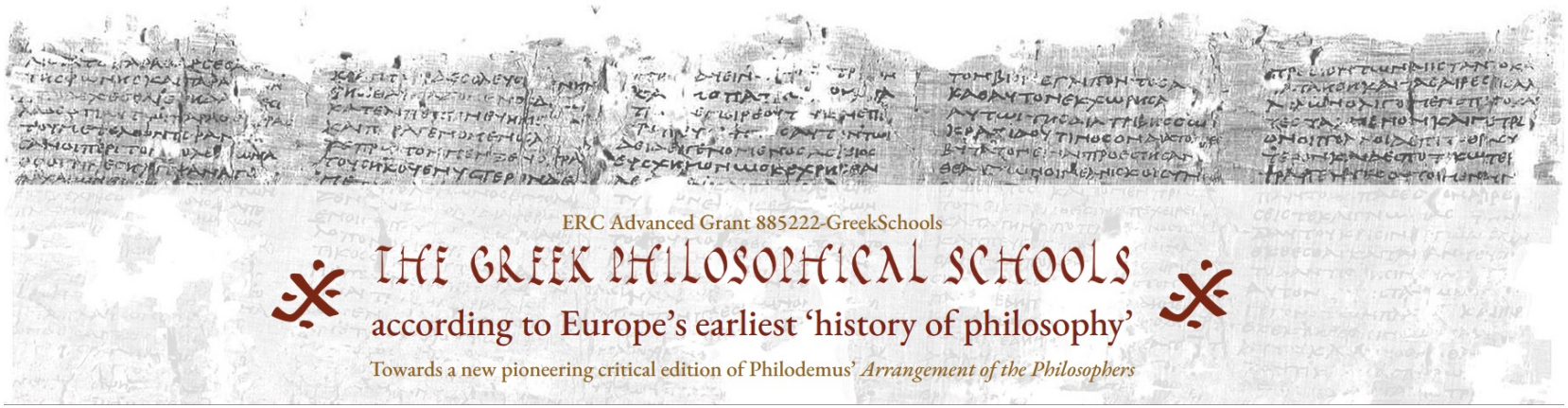


Papyrological practices


29.
30.
31.
32.
33.
VIS


NIR

The Greekschools Project



The main aim of the project is the application of non-invasive advanced techniques to Herculaneum papyri belonging to Philodemus' *Syntaxis* in order to:

(a) read the text hidden on the *verso*,
(b) detect, classify, and replace overlapping layers
(c) read the text concealed inside them
(d) produce a more reliable and improved critical text

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THz imaging

Technical photography

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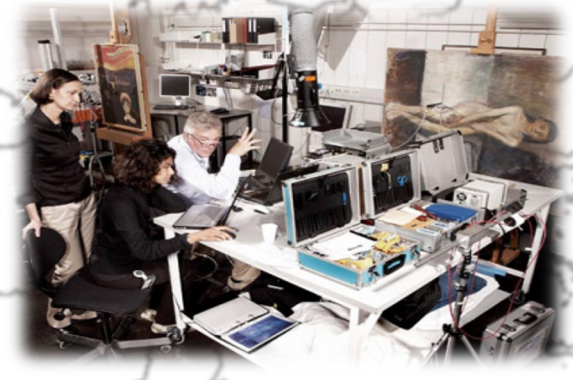
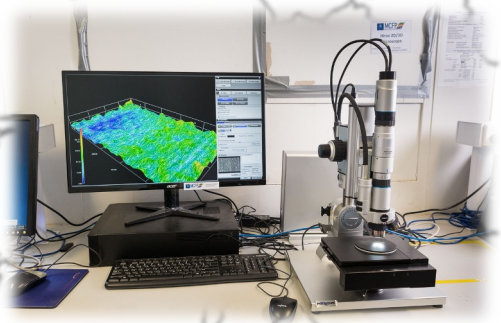
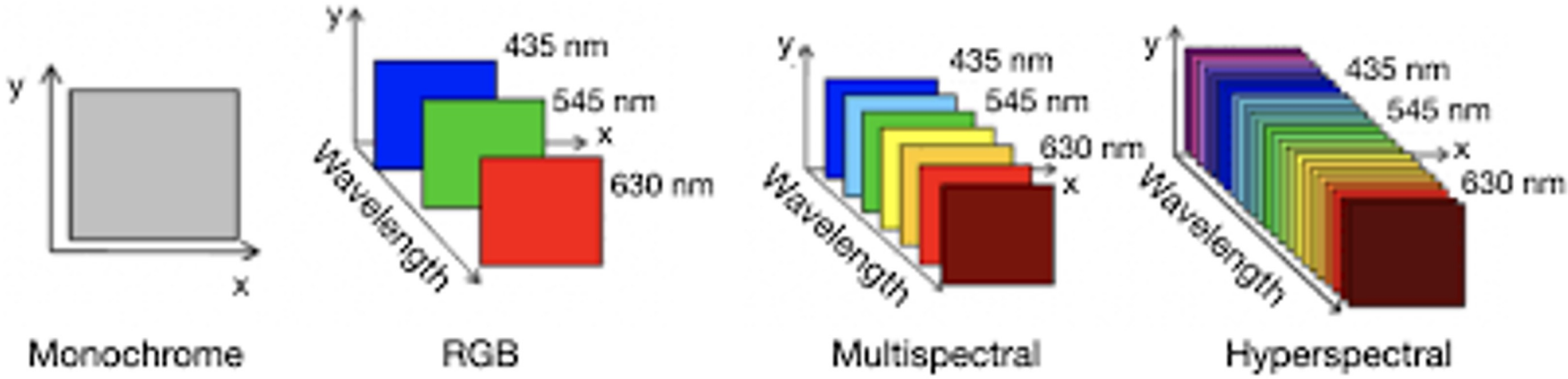
Molecular Spectroscopies /Hyperspectral imaging



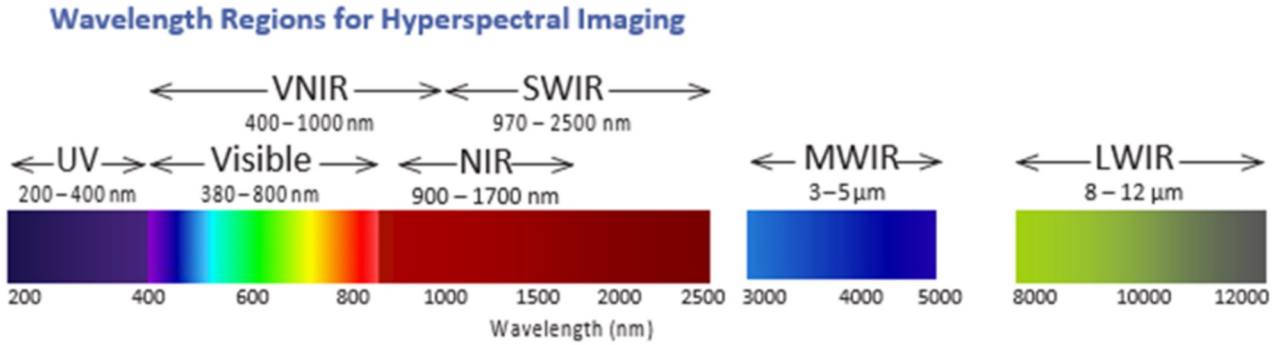
3D Digital Microscope



Hyperspectral Imaging



X-ray



Hyperspectral Imaging

PHerc 1021 Cr1

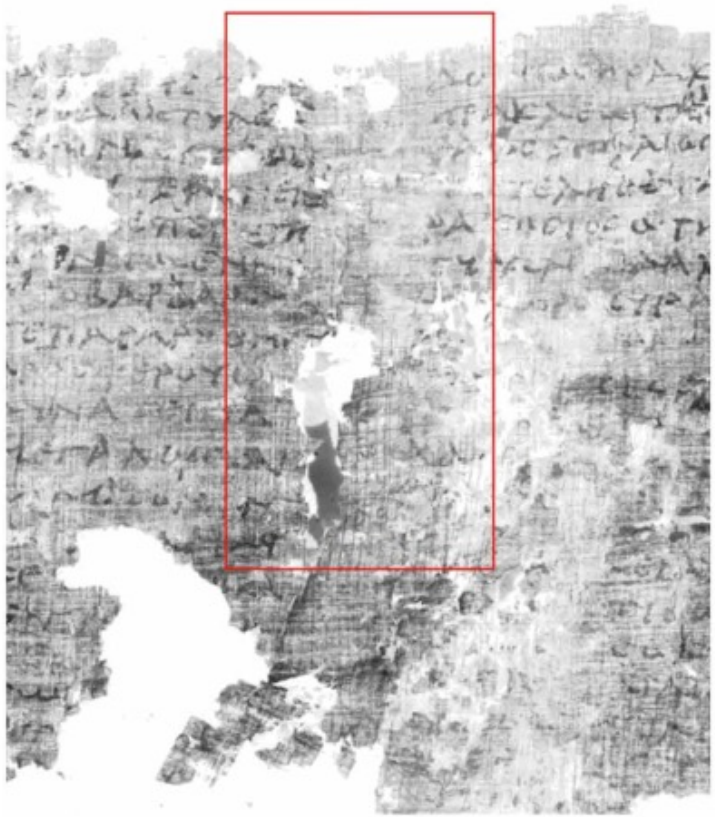
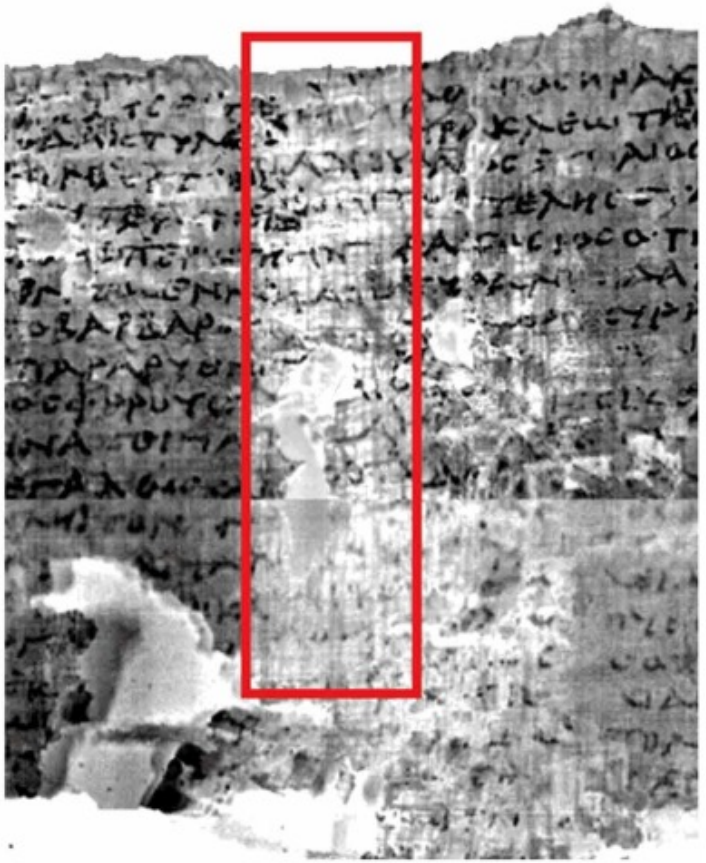


Image at 950 nm
No text visible from the verso between the column



PC3 SWIR hyperspectral images
Showing text from the verso

Hyperspectral Imaging

PHerc 1021 Cr1

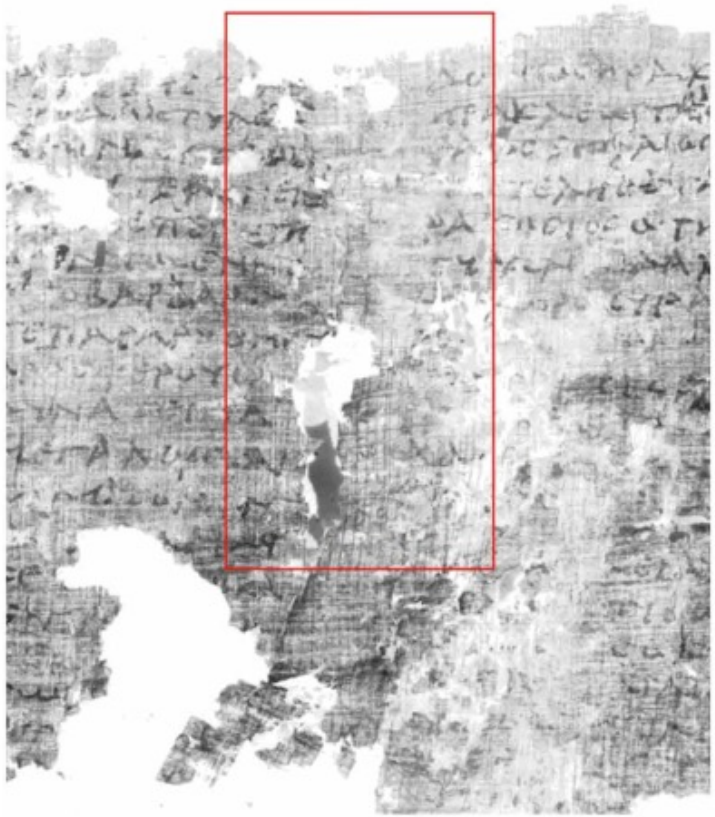
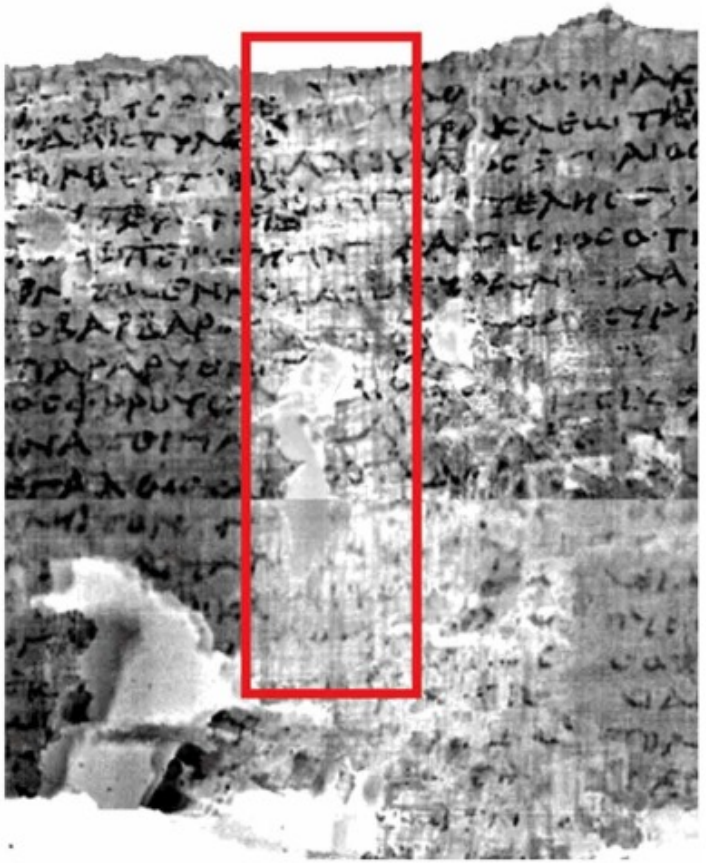


Image at 950 nm
No text visible from the verso between the column



PC3 SWIR hyperspectral images
Showing text from the verso

Hyperspectral Imaging

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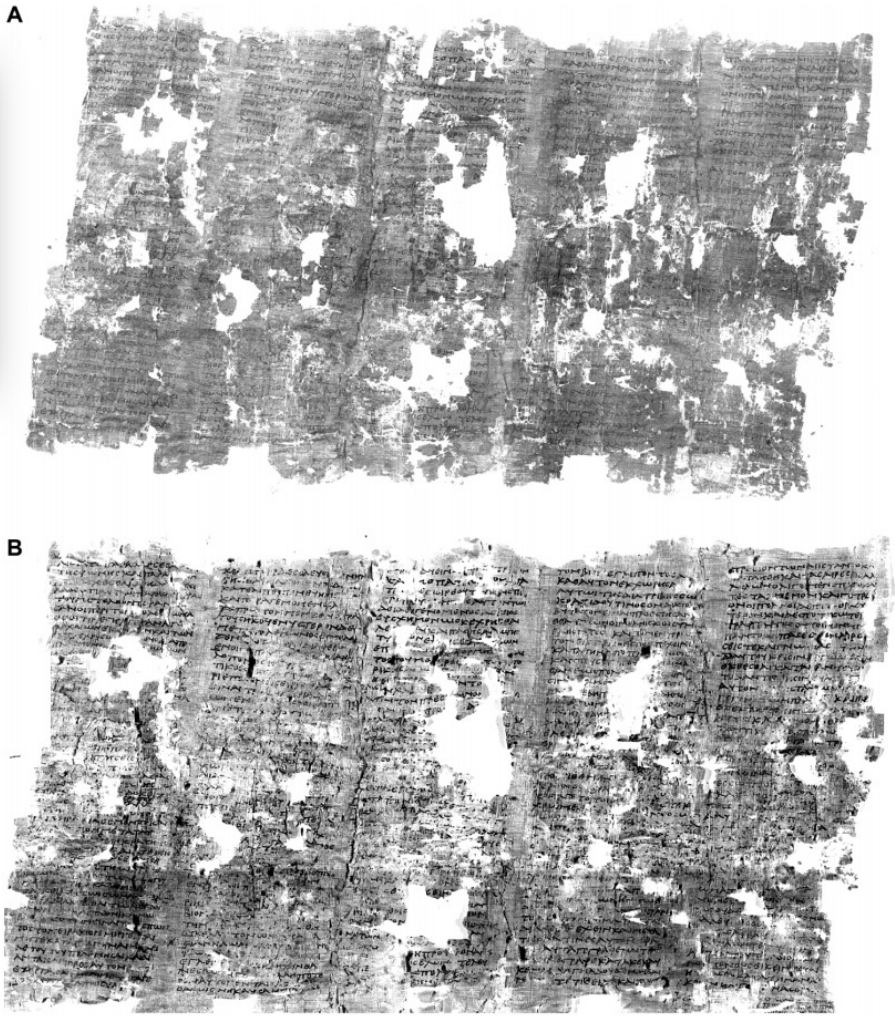
Text readability increased by 20%.

Enhancement of the recto



A/ Image at 950 nm
No text visible from the verso between the colomn

B/ PC1 SWIR hyperspectral images
Showing text from the recto

PHerc 1021 Cr 4, general view

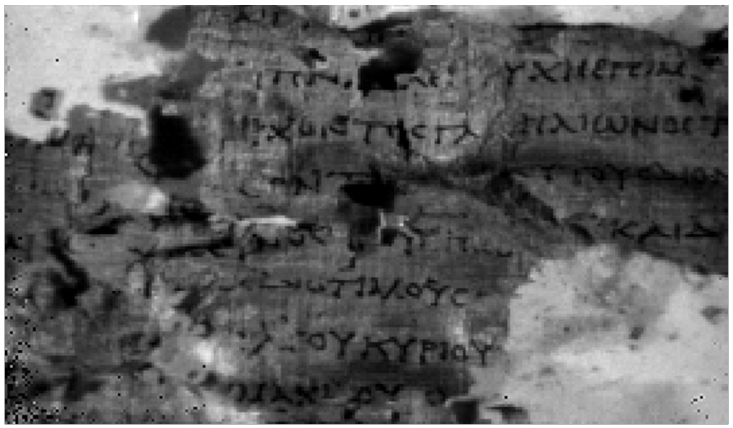
Sci Adv ***5*** *(10)*
DOI: 10.1126/sciadv.aav8936

Hyperspectral Imaging: single wavelength image

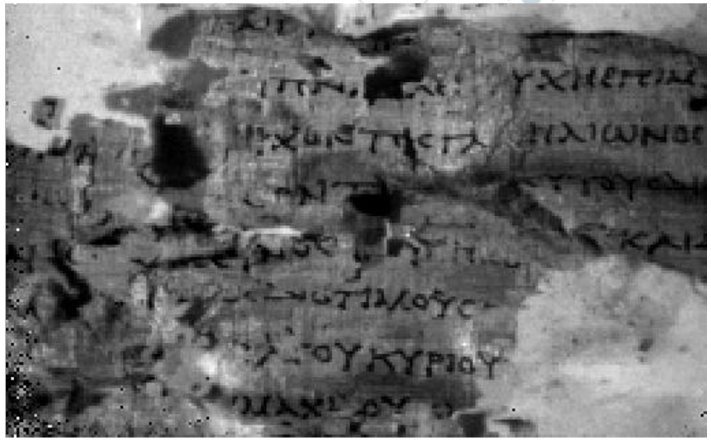
PHERC_1780_Cr1 Cubo 19

1020 nm

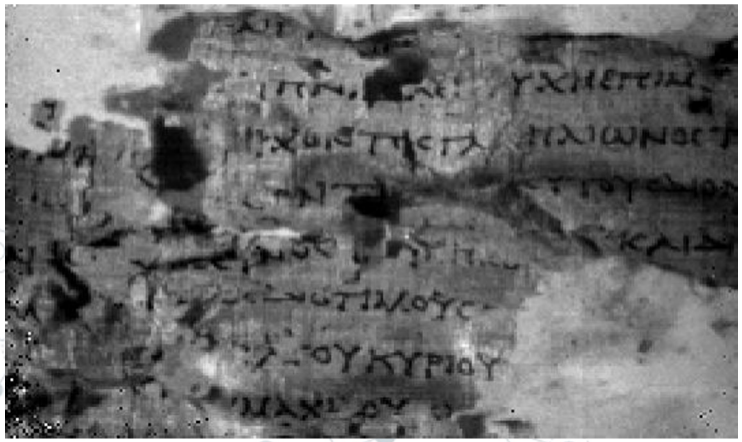
1460 nm



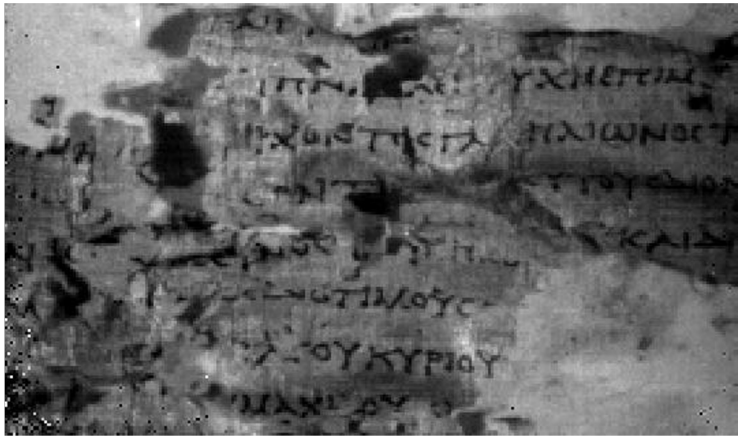
1630 nm



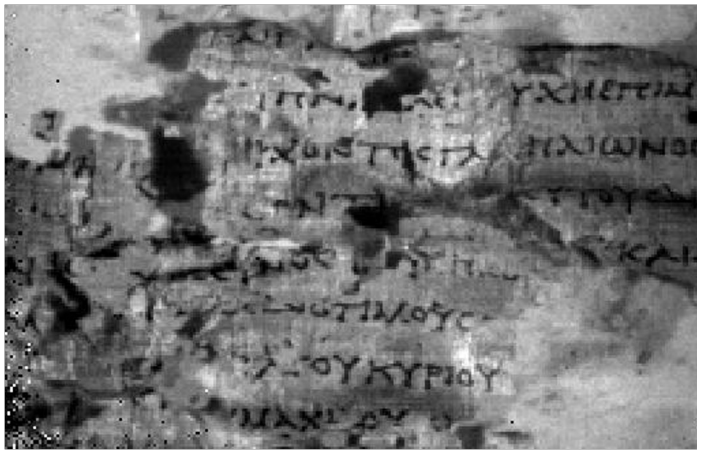
1735 nm



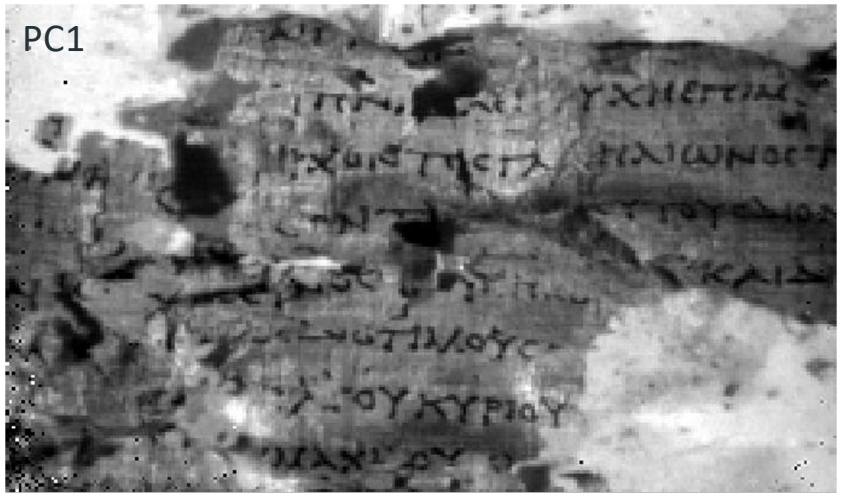
1865 nm

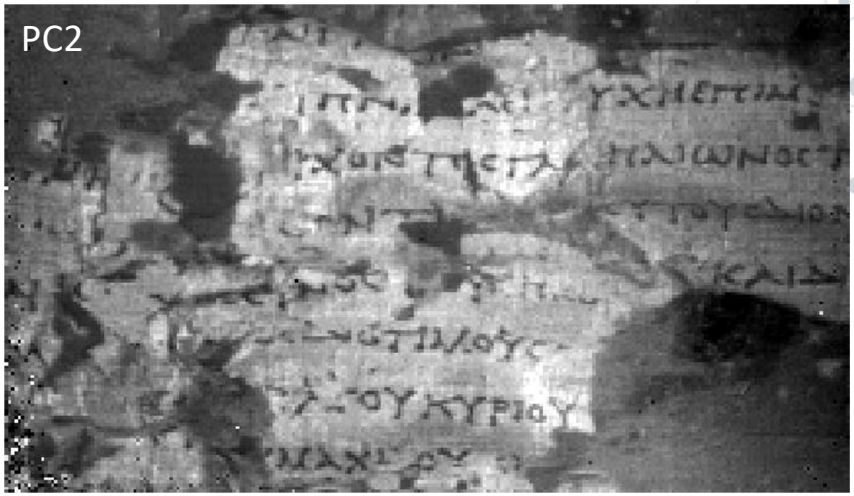


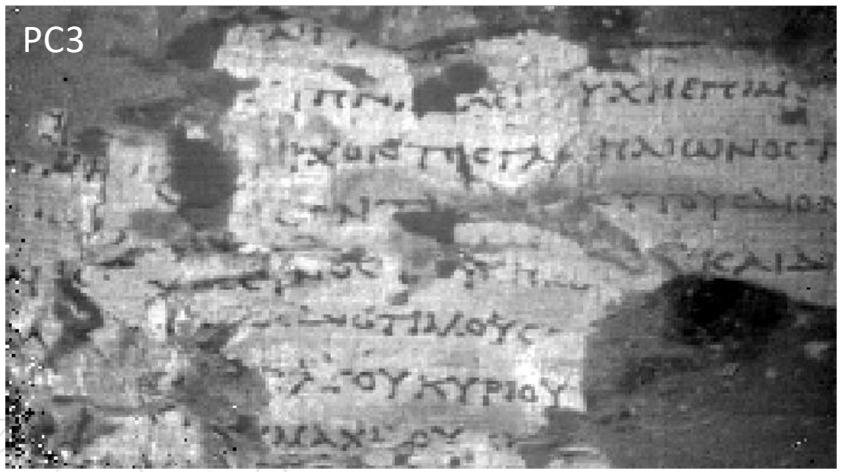
2000 nm

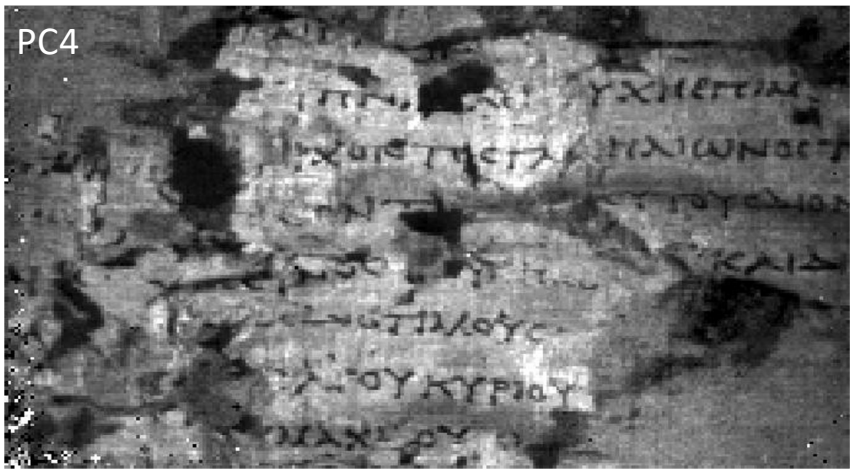


Hyperspectral Imaging: machine learning for image processing









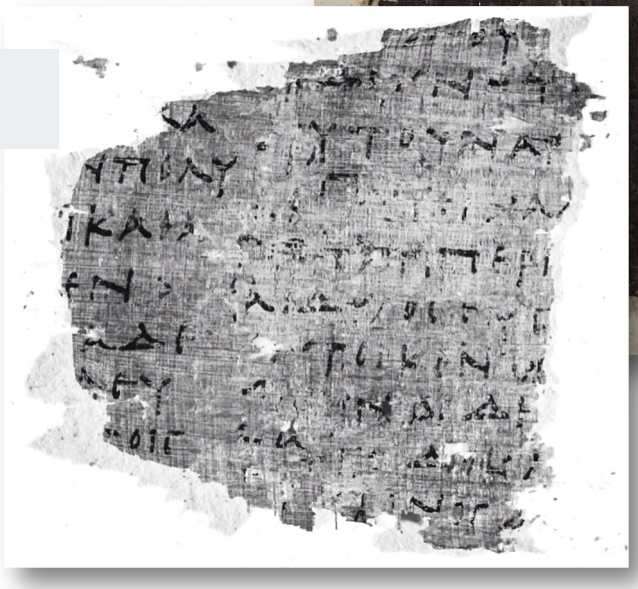
Technical photography

- Spettro Visibile (VIS) 400-700 nm
- Radente Spettro Visibile (VISr) 400-700 nm
- Infrarosso (NIR) 1000 nm

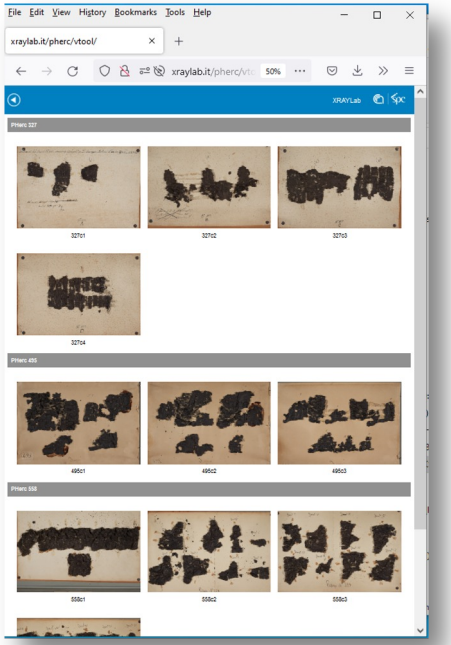
VISr

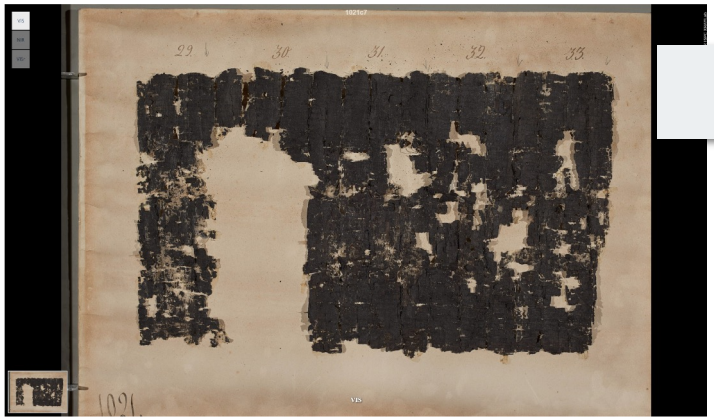
VIS

NIR



Web-based Viewer





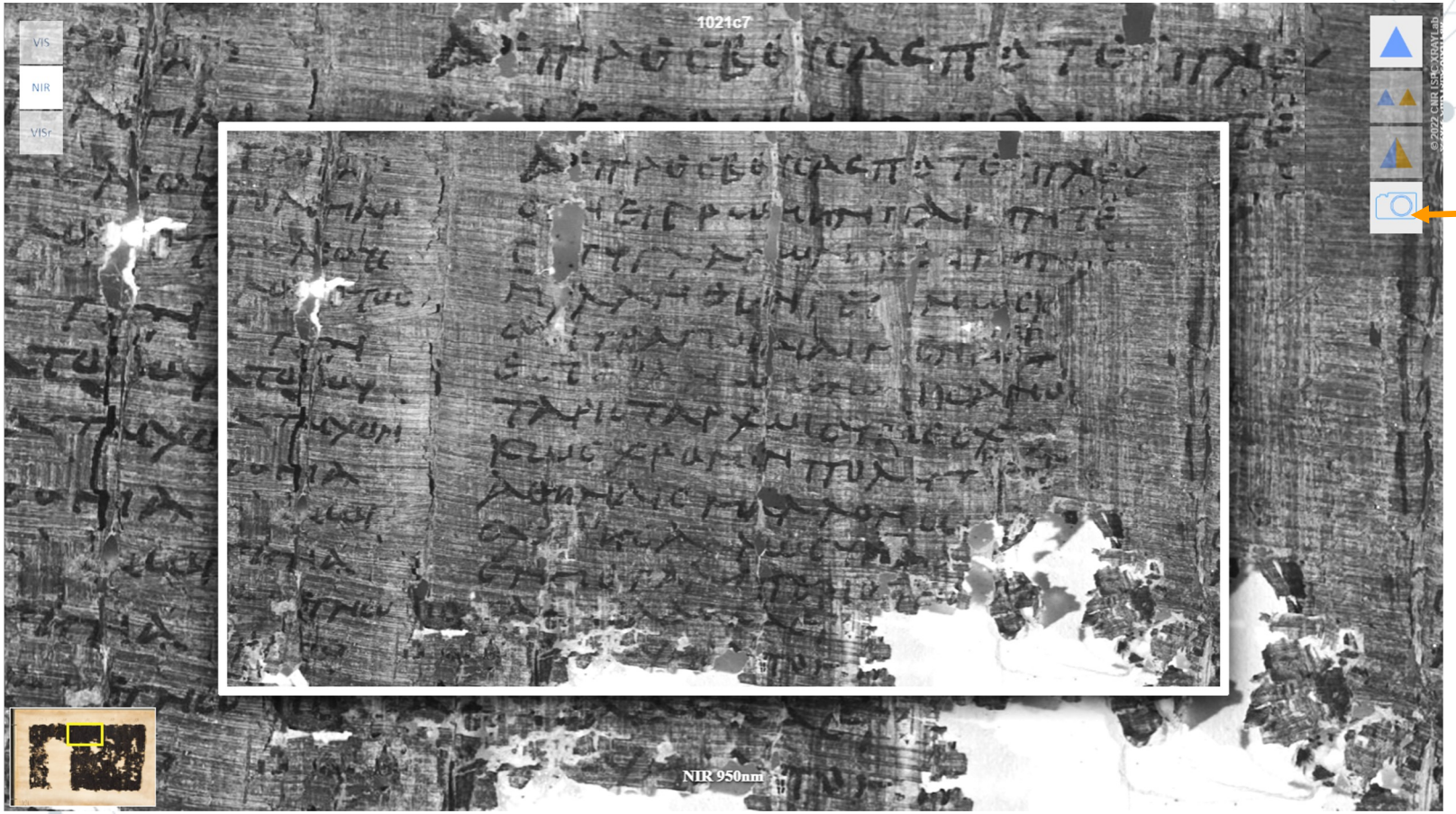
Full View

Side by Side

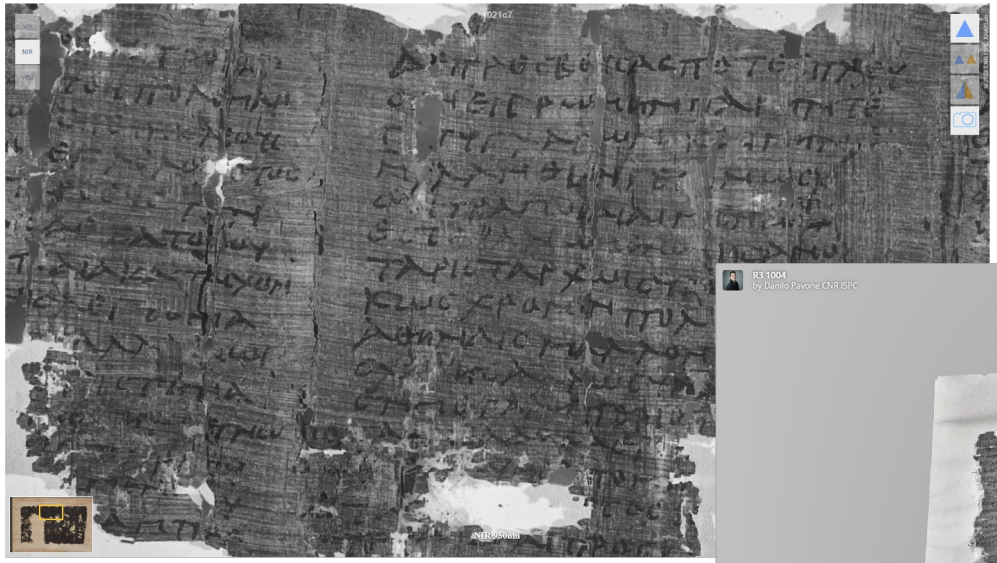
Split View

Web-based Viewer: side by side

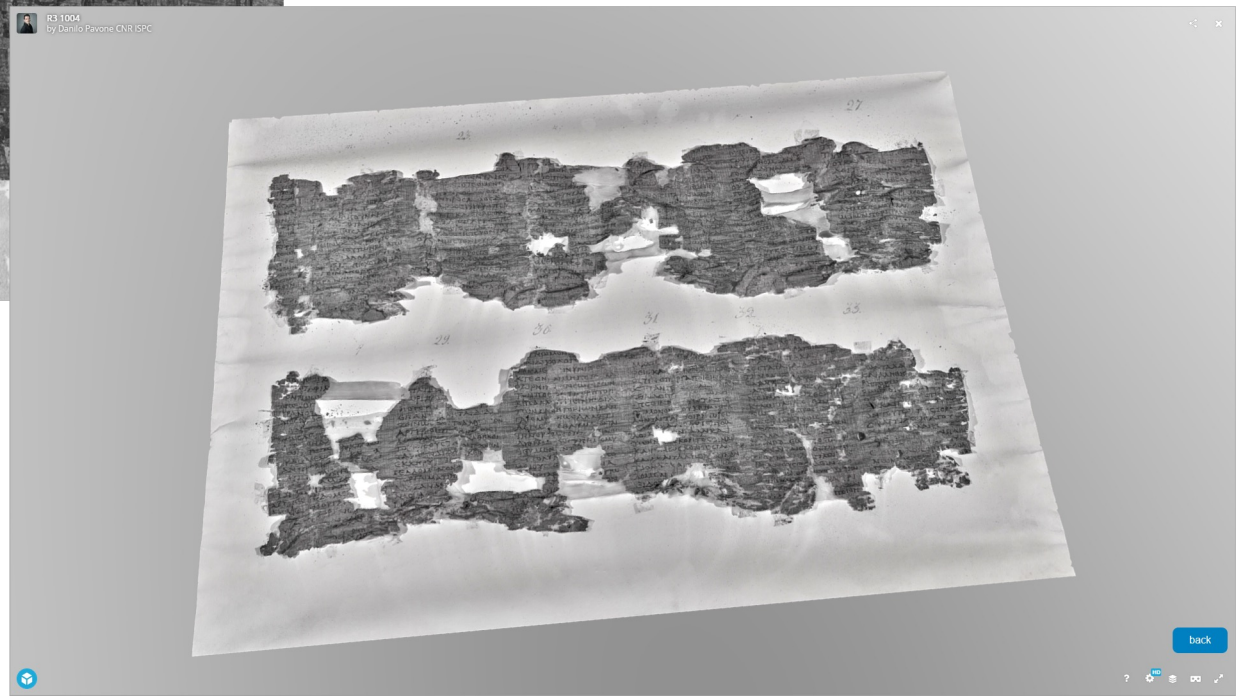
Web-based Viewer: screenshot



Web-based Viewer: photogrammetry



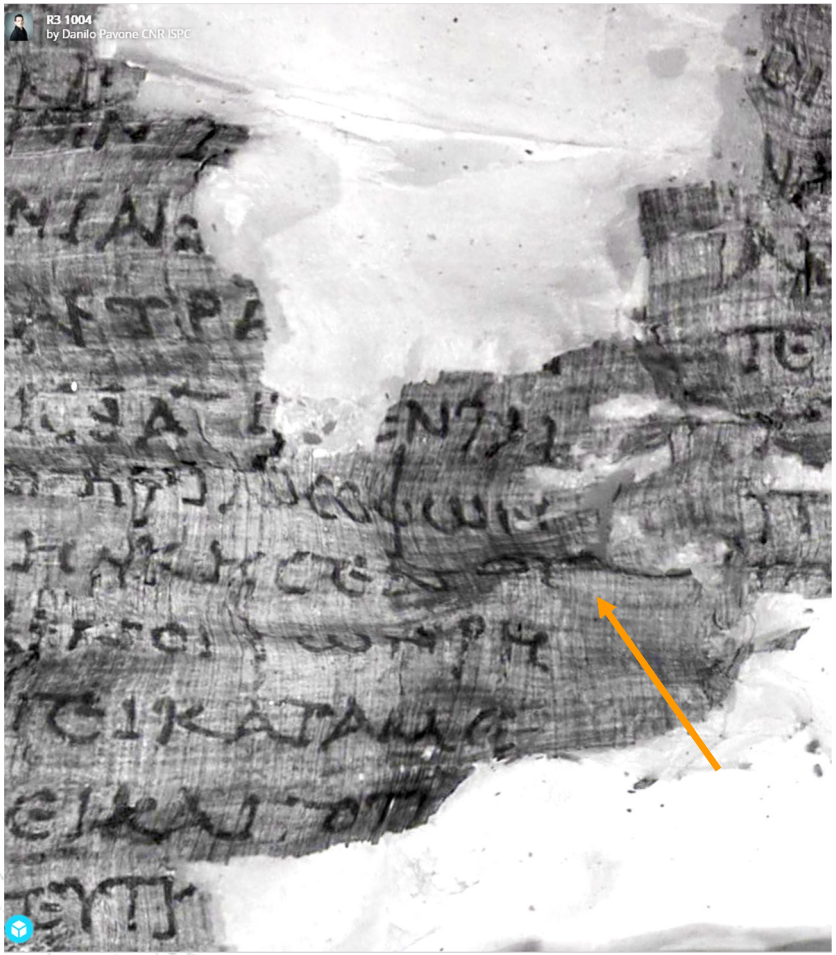
2D

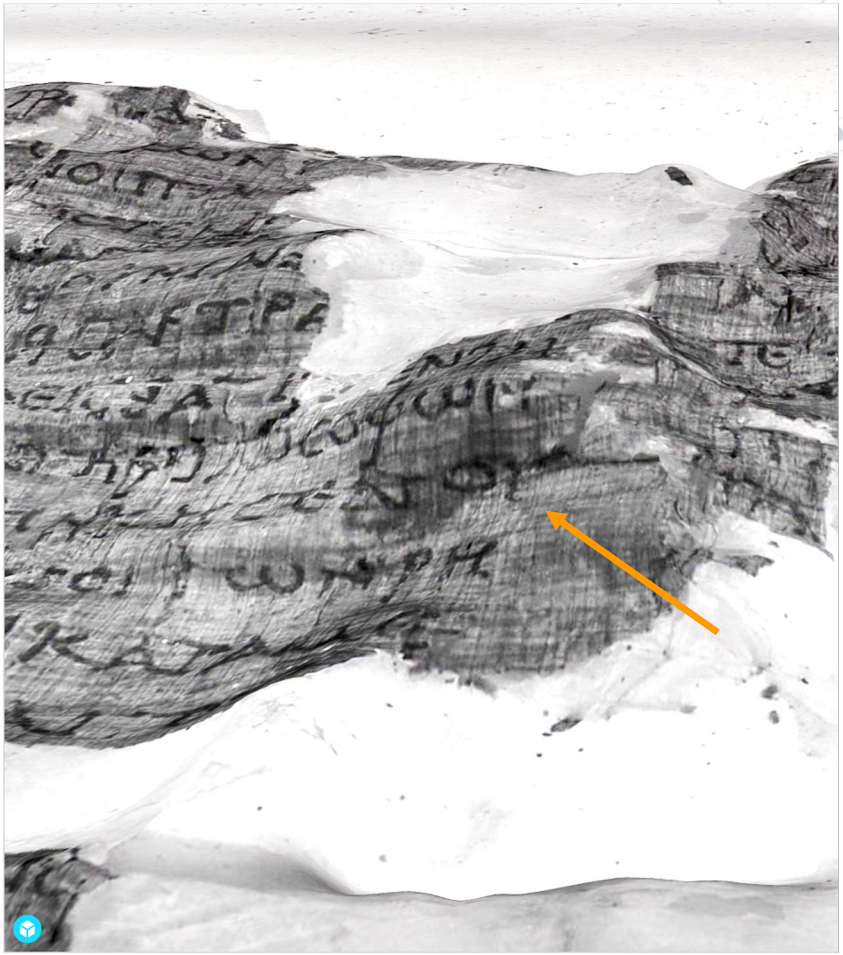


3D

Web-based Viewer: photogrammetry

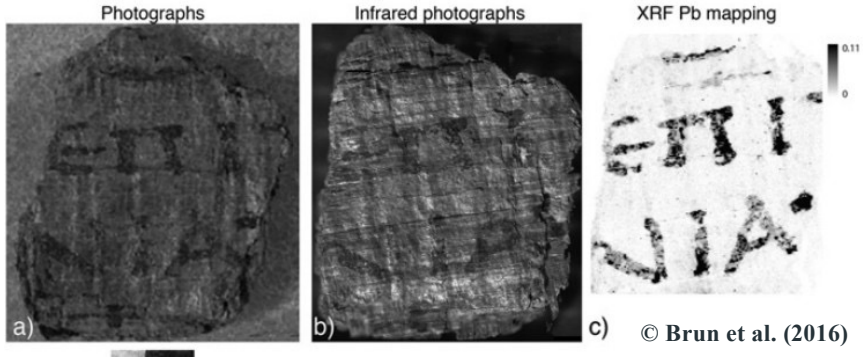
Web-based Viewer: photogrammetry





Papyri Inks

- First chemical analysis by Davy in 1821[1]: **C-based + gum –** *(confirmed with IR-rifl.)*.
- **Pb** evidences in *Brun et al. (2016)*[2].

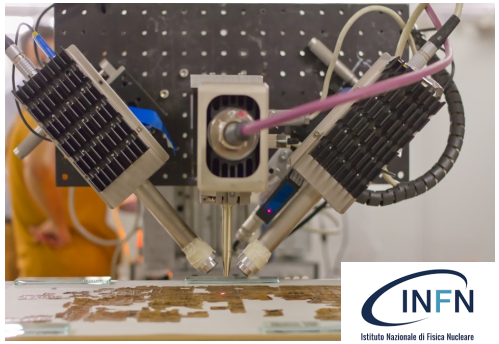


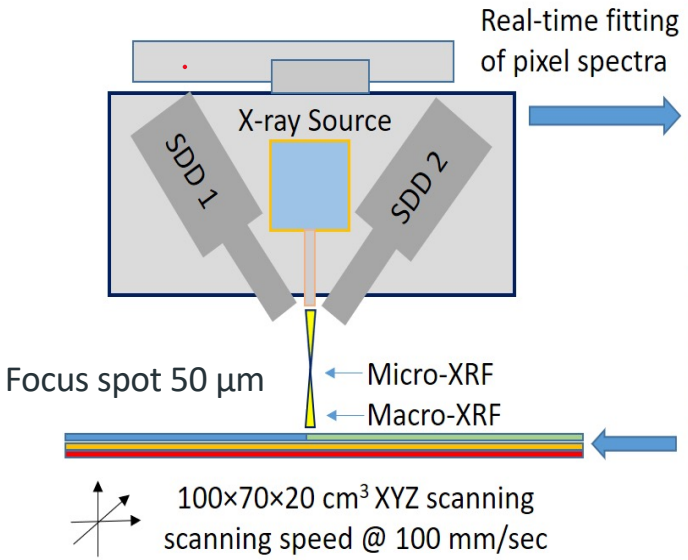
© Brun et al. (2016)

- Carbon inks are based on C compound from burning or macerating of organic and inorganic materials (wood, oil, earth)[3].
  - Pliny the Elder: *exudation as salts or sulphur compounds*.
- Amorphous C in the form of soot, charcoal or bone black[4].
- Pliny, Vitruvius and Dioscorides indicate a certain type of fine soot, considered the best for both writing and painting was procured through the careful **pyrolysis of resin or pitch** in factories[3].

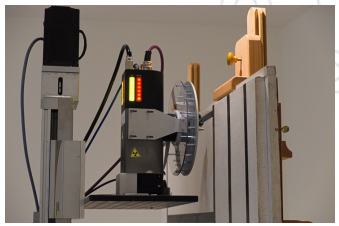
[1]Basile (1994) I papiri carbonizzati di Ercolano: la temperatura dei materiali vulcanici e le tecniche di manifattura dei rotoli. Quaderni del Museo del papiro, Siracura: Istituto internazionale del papiro, 1 ed.
[2]Brun et al. (2016) Revealing metallic ink in Herculaneum papyri. PNAS, 113(14): 3751-3754.
[3]Christiansen (2017) Manufacture of black ink in the ancient Mediterranea. Bulletin of the America Society of Papyrologists, 54: 167-195.
[4]Di Stefano and Fuchs (2011) Characterization of the pigments in a Ptolemaic Book of the Dead papyrus. Archaeological and Anthropological Science, 3:231.

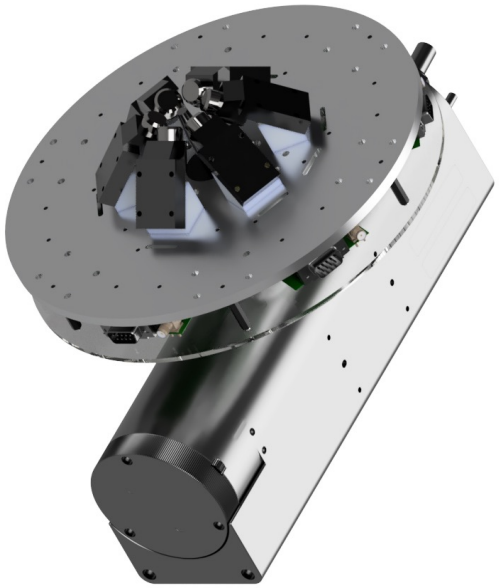
MA-XRF scanning system: new developments





Romano et al. Journal of Analytical Atomic Spectrometry 32.4 (2017): 773-781.





high-throughput 3D Array detection system

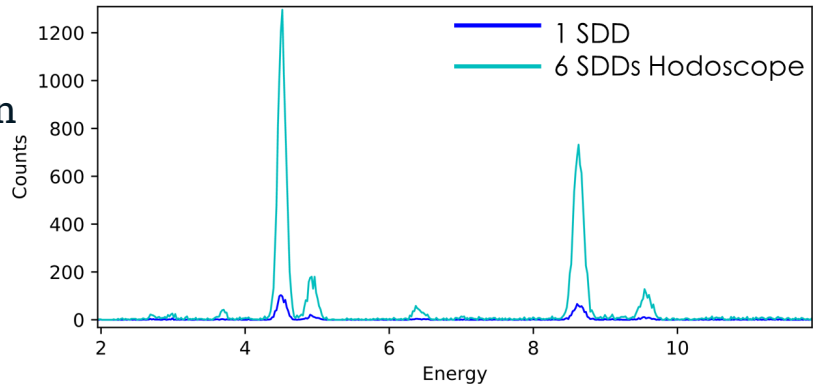
Hodoscope with 6 SDD detectors operated in parallel in a fast-mapping mode

high-performing mechatronics

scanning area 120x90x20 cm^3

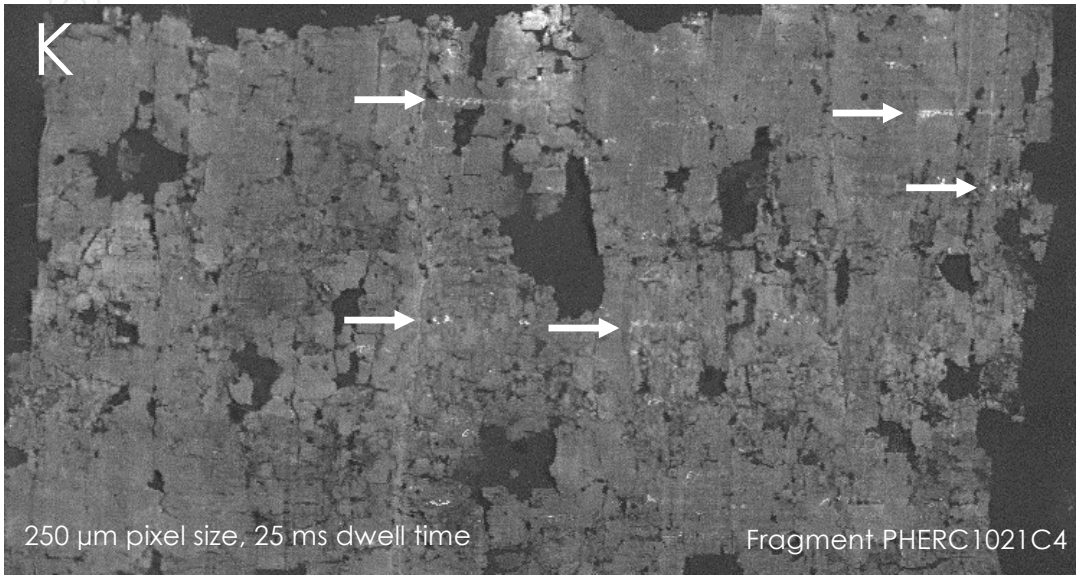
scanning speed up to 150 mm/sec

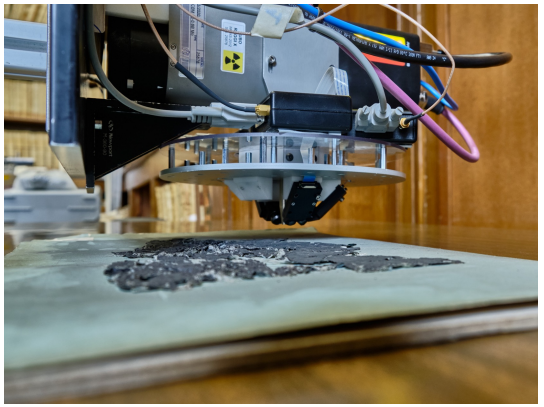
CPU with high computing capabilities



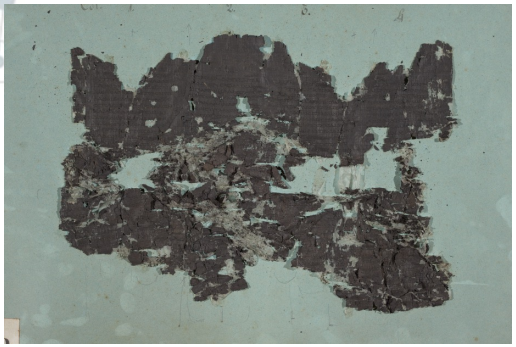
MA-XRF mapping

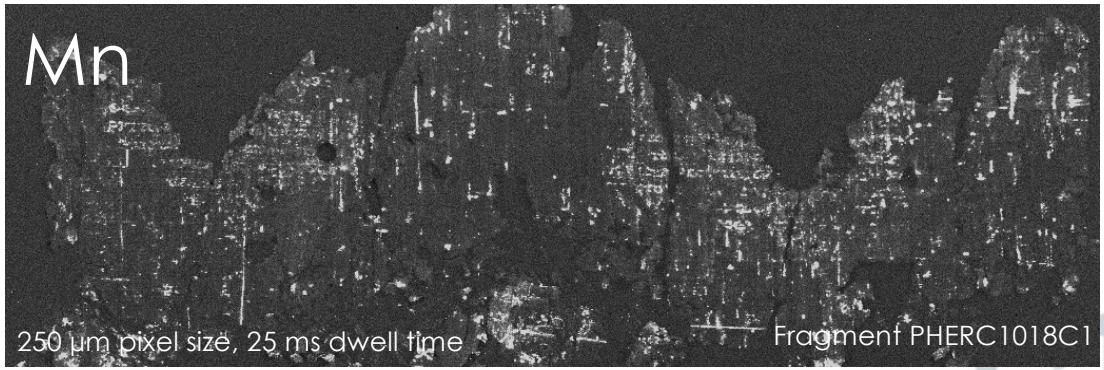
Detecting low residues of an organic ink





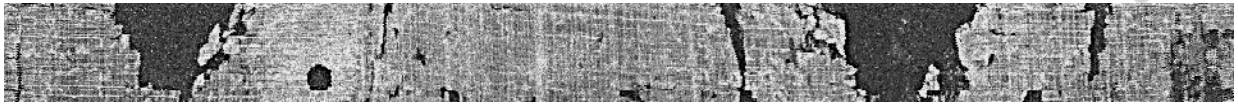
Detecting low residues of a metallic ink



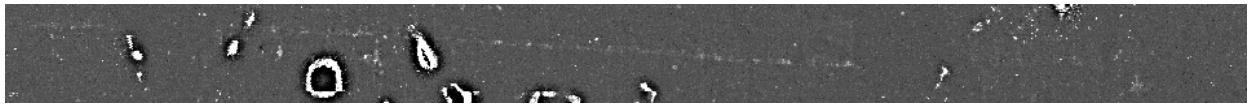


Carbonized papyri from Herculaneum: despite the strong degradations of the materials, the large detection efficiency allows the detection of low trace elements characterizing the nature of the residual inks.

Ca



Pb (L)



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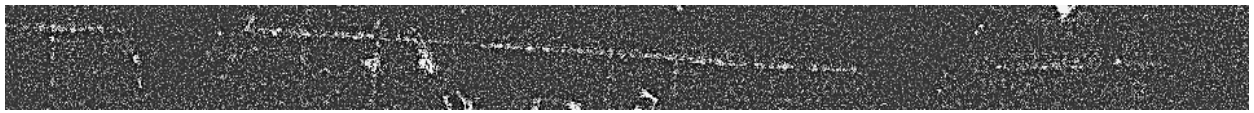

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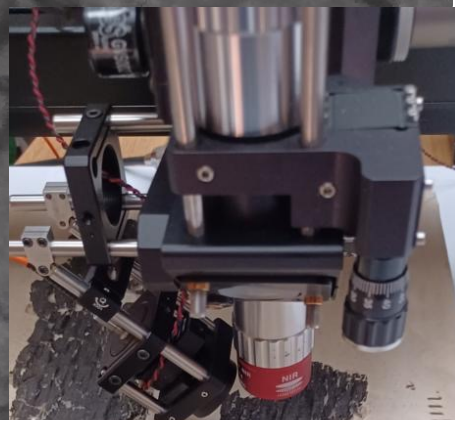

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THANKS!

Does anyone have any questions?

sveva.longo@ispc.cnr.it
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