(EN) LASERING-PH: sustainable cleaning of Pictorial Heritage: optimization of laser ablation processes

(IT) LASERING-PH: Metodi di pulitura sostenibili per il patrimonio pittorico: ottimizzazione dei processi di ablazione laser

December 2023

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CONTEXT

1. Context

Background

- Laser ablation as **CLEANING METHOD**.
- **ADVANTAGES:** no mechanical contact, selectivity, graduality, no additional substances are incorporated.
- **DRAWBACKS:** photochemical and photothermal alterations, darkening, discolorations, etc.
- It has been deeply investigated for stone.
- Bibliography
  - PIGMENTS: effects on colour, morphology, etc.
  - PAINTINGS: effects of different lasers, comparisons of traditional and laser methods, removal of varnishes, etc.

→ **Er:YAG** the most researched → **EXPAND KNOWLEDGE**

OBJECTIVES

2. Objectives

GENERAL OBJECTIVE →

Advancing research on the effects of laser radiation on tempera and cave paintings.

SPECIFIC OBJECTIVES

i. to define the ideal conditions of laser radiation as a cleaning method.

ii. to know the effects that parameters exert on the pigments, binders and paintings.

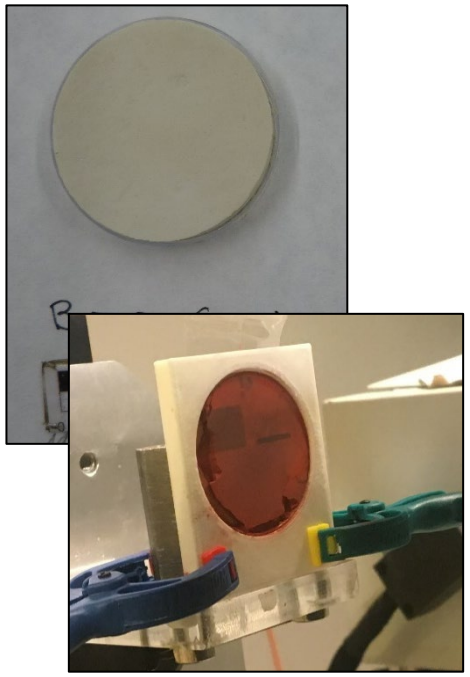
iii. to identify the parameters that allow the optimal removal of a layer of soiling without damages.

iv. to check the transferability of the results to a real intervention.

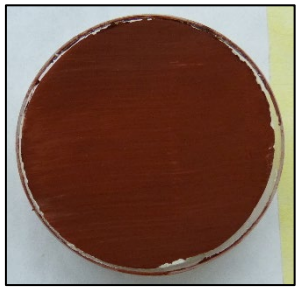
2. Objectives

- Systematic and step-by-step research.

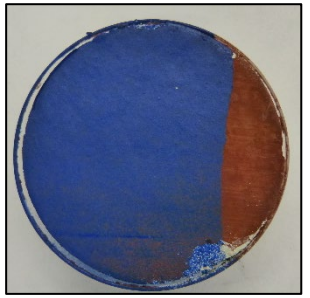
Individual components

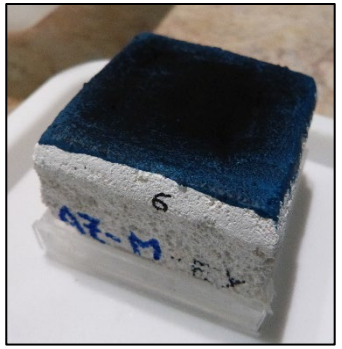


Mock-up



Mock-ups with soiling layer





Real artwork

Inner courtyard of Shine Albazyn Hotel in Granada (Spain)

MATERIALS AND ANALYTICAL TECHNIQUES

3. Materials and analytical techniques

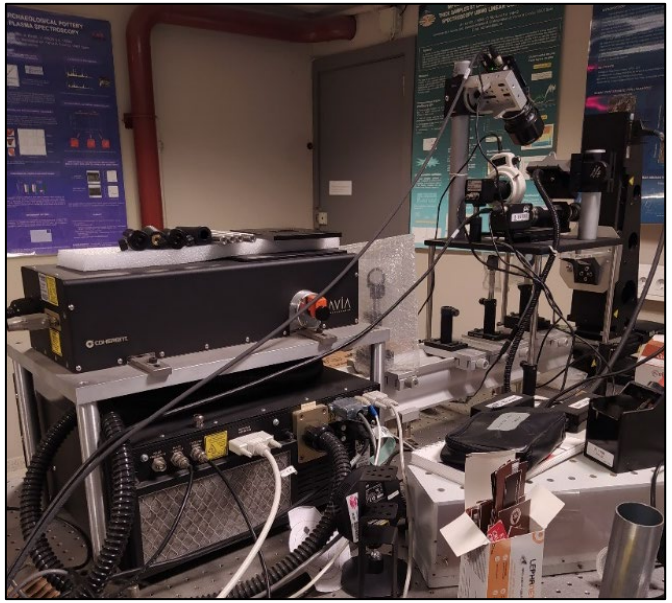
3.1. Materials

	TEMPERA PAINTINGS	CAVE PAINTINGS
PIGMENTS	Azurite (AZ)  Malachite (MA)  Cinnabar (CI)  Orpiment (OR)  White Kremser (WK) 	Hematite (HE)  Red Earth (RE)  Carbon Black (CB) 
BINDERS	Egg Yolk (EY)  Rabbit Glue (RG) 	Butter (Bu)  Casein+NH_3 (Cas) 
SUBSTRATES	 Intonaco (1/2): 1 slaked lime/ 1 silica sand + 1 marble powder Arriccio (1/3): 1 slaked lime/ 2 silica sand + 1 coarse sand	 Kaolin + butter  Quartzite

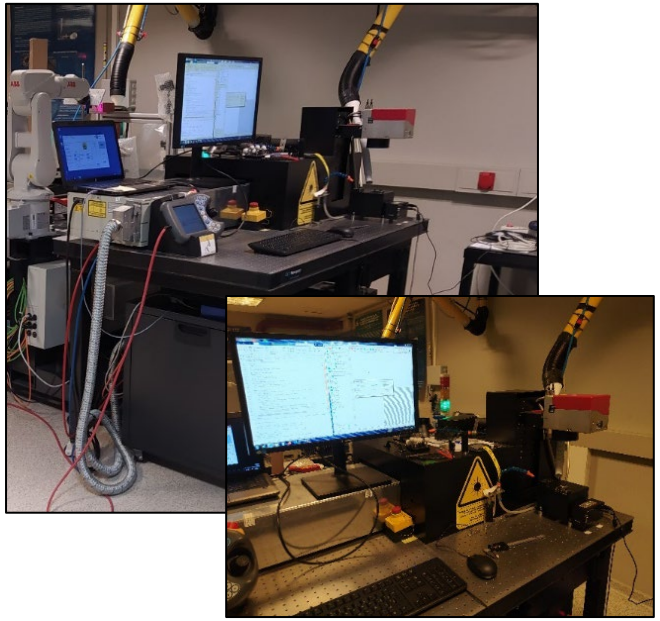
3.1. Materials

PULSED LASERS

Nd:YVO_4 ($FYVO_4$)
λ: 355 nm (UV)
Pulse duration: 25 ns
CITENI of Ferrol (Spain)

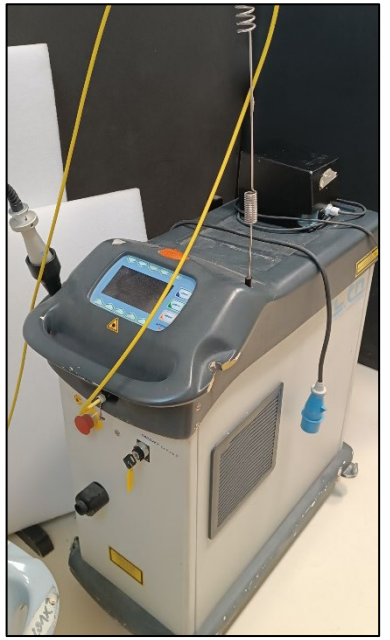


Spectra Physics Spirit (FSPS)
λ: 1040 nm (near IR)
Pulse duration: 380 fs
CITENI of Ferrol (Spain)



Er:YAG (LB2)
λ: 2940 nm (IR)
Pulse duration: 150 ,250, 400μs
Università di Pisa (Italy)

3.1. Materials

PULSED LASERS		
Nd:YAG Long Q-Switch mode (LQS) λ: 1064 nm (IR) Pulse duration: 100 ns La Venaria Reale (Italy)	**Nd:YAG Q-Switch mode (QS)** λ: 1064 nm (IR) Pulse duration: 8 ns La Venaria Reale (Italy)	**Nd:YAG Short Free Running mode (SFR)** λ: 1064 nm (IR) Pulse duration: 110 μs La Venaria Reale (Italy)
		

3.1. Materials

SOILING LAYER

Diesel powder

Spray paint

CLIMATIC CHAMBER

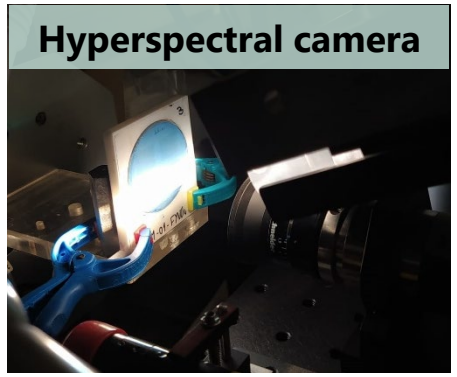
Climatic Chamber Fitoclima 300 EDTU, ARALAB with gases exposure.

Instituto Tecnico of Lisboa

3.2. Analytical Techniques

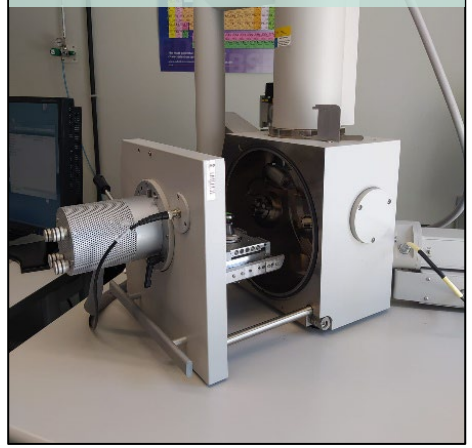
FTIR

Hyperspectral camera



CHARACTERISATION OF THE RAW MATERIALS	CHARACTERISATION OF THE MOCK-UPS
Mineralogical-chemical: SEM-EDS (texture and composition) XRD (mineralogy) FTIR (functional groups) <u>Binders:</u> Py/GC-MS (fatty acids and proteins) HPLC-MS (triglycerides) **Physical:** Stereomicroscopy (appearance) Spectrophotometry (colour coord. meas.) Hyperspectral stereomicroscopy (reflectance curves)	**Mineralogical-chemical:** SEM-EDS (texture and composition) XRD (mineralogy) FTIR (functional groups) Py/GC-MS (fatty acids and proteins) HPLC-MS (triglycerides) **Physical:** Stereomicroscopy (appearance) Spectrophotometry (colour coord. meas.) Hyperspectral stereomicroscopy (reflectance curves)

Scanning Electron Microscopy



Stereomicroscopy

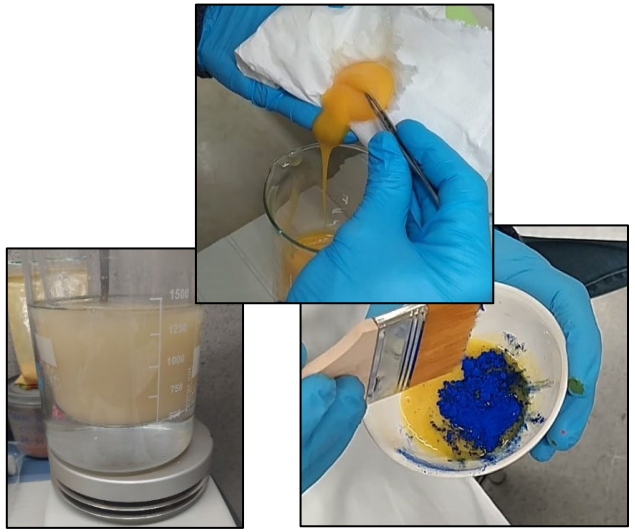
CINTECX Universidade Vigo · CACTI Centro de Apoio Científico e Tecnolóxico á Investigación Universidade Vigo · Centro de Instrumentación Científica · ugr Universidad de Granada · Università di Pisa

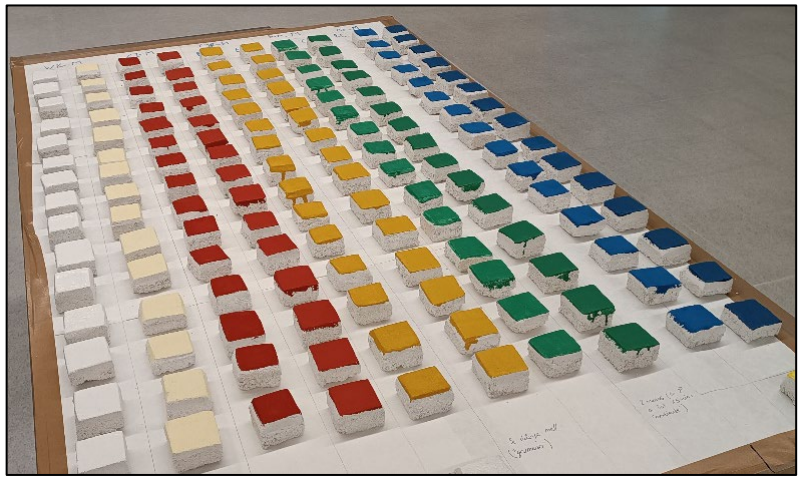
CURRENT STATUS

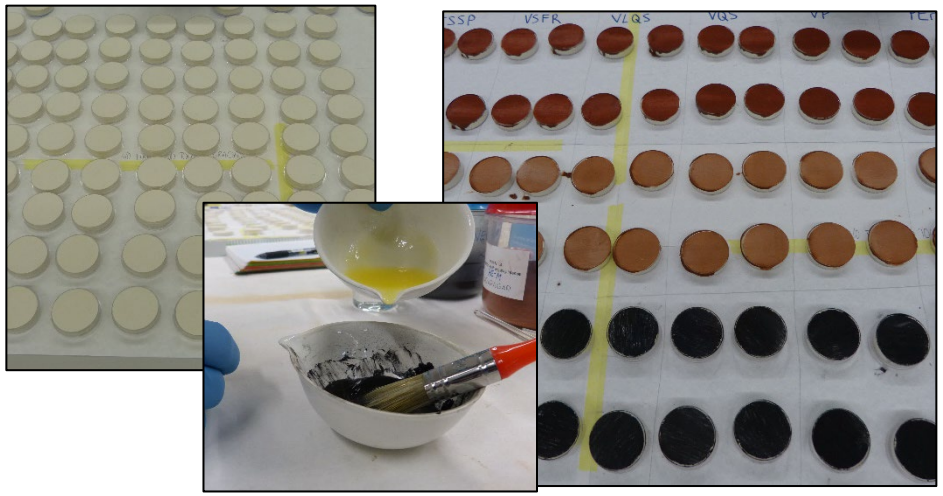
4. Current status

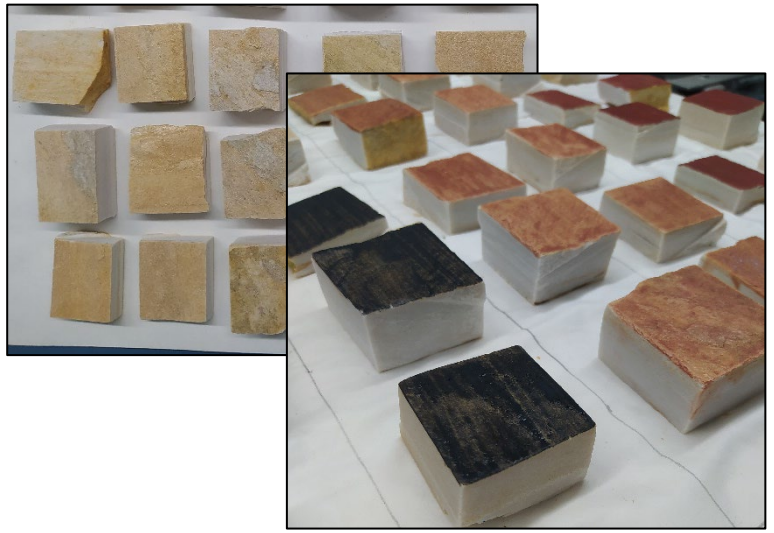
4.1. Preparation of mock-ups

Following Old's Master recipes.





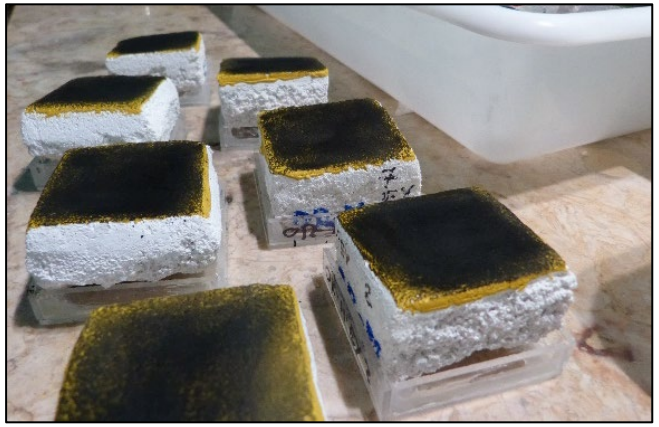


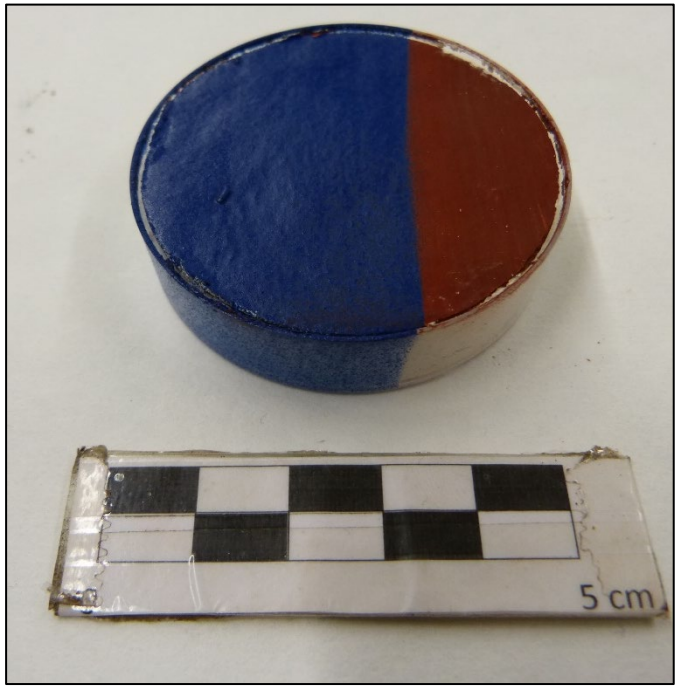


4. Current status

4.1. Preparation of mock-ups

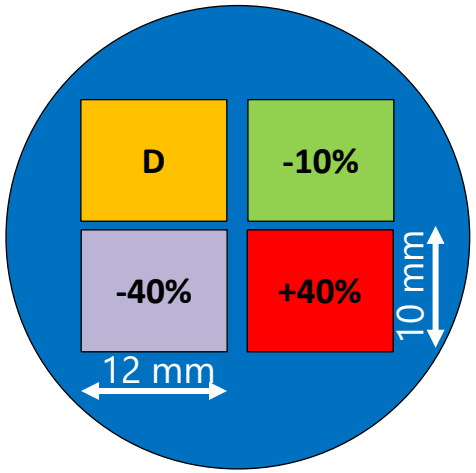
Generating a soiling layer.





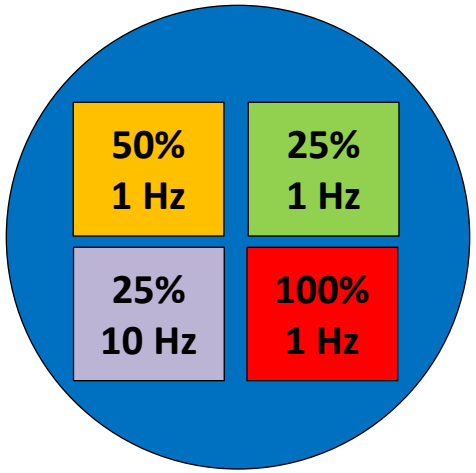
4.2. Methodology of irradiation

Looking for the fluence at which alterations began to appear under naked eye



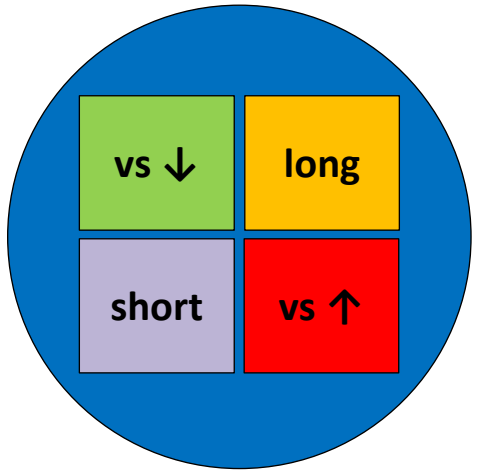
ns
fs

Setting parameters of irradiation



QS
LQS
SFR

LB2

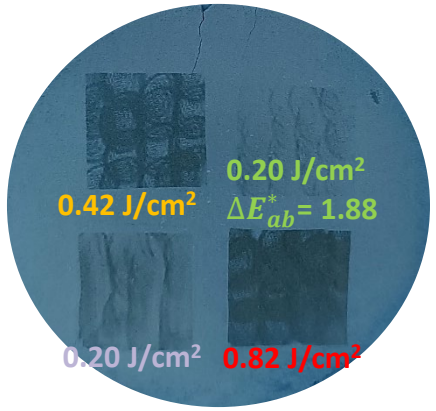


RESULTS

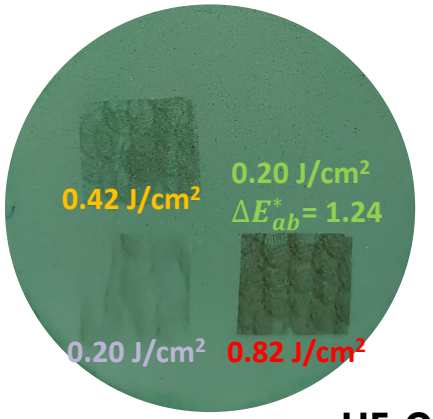
5.1. Influence of the pulse duration

1. La Venaria Reale: Nd:YAG in Q-Switched mode (QS)

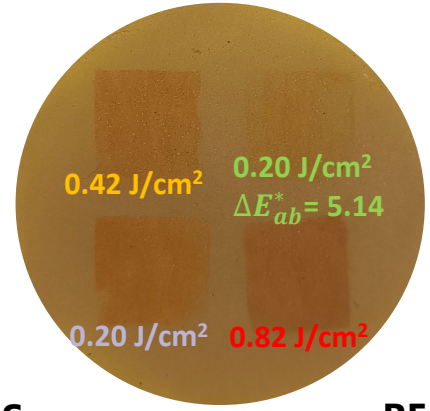
AZ-QS



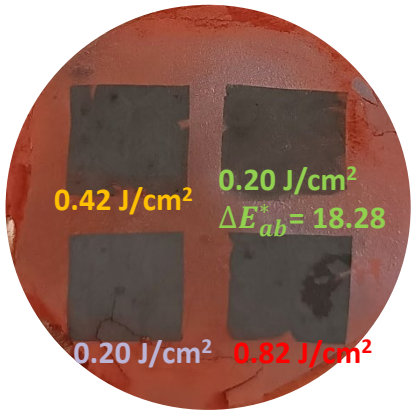
MA-QS



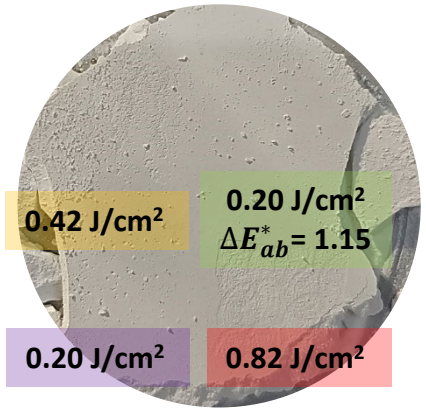
OR-QS



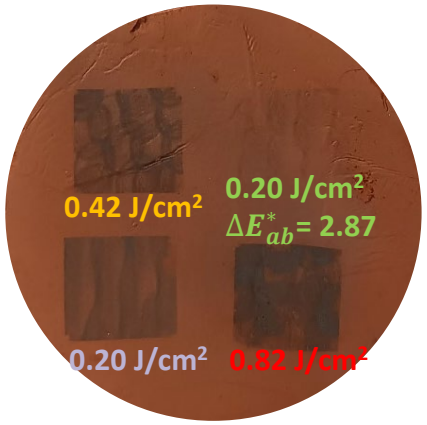
CI-QS



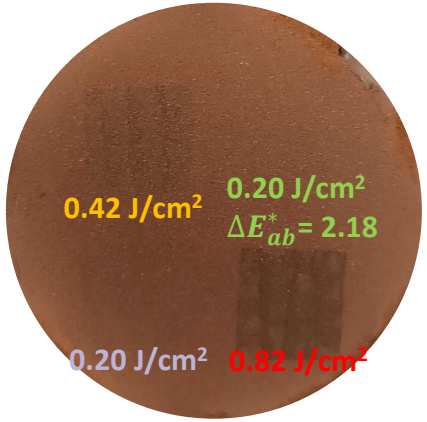
WK-QS

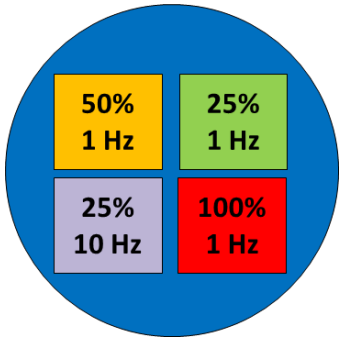


HE-QS



RE-QS





Naked eye observations

Darkening
Saturation (OR)
Blackening (CI)

Susceptibility:

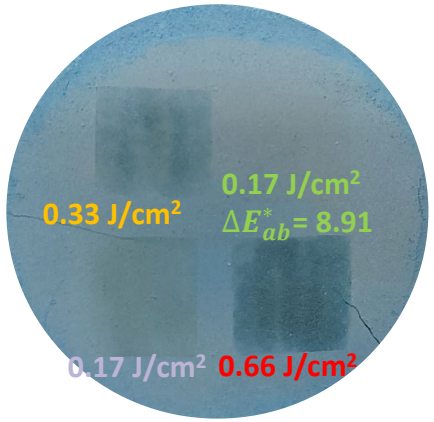
WK
RE
MA
HE
AZ
OR
CI

aplar applicazioni laser nel restauro analisi critica e confronti 8 LASERING

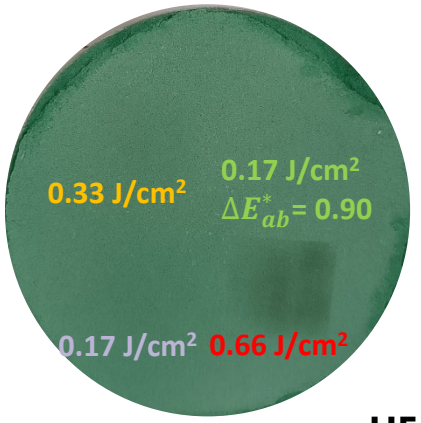
5.1. Influence of the pulse duration

2. La Venaria Reale: Nd:YAG in Long Q-Switched mode (LQS)

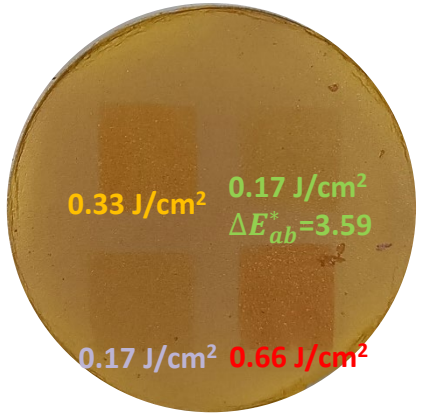
AZ-LQS



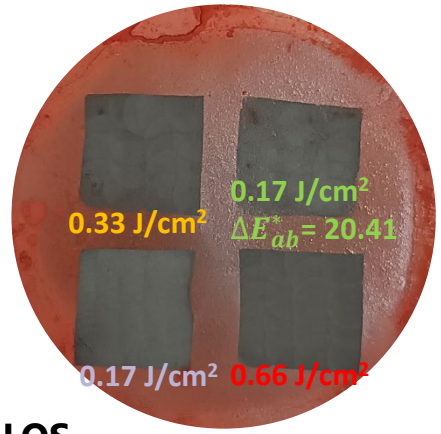
MA-LQS



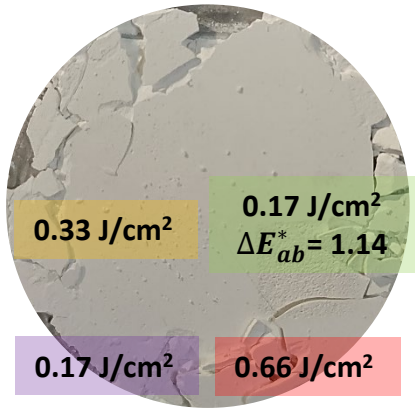
OR-LQS



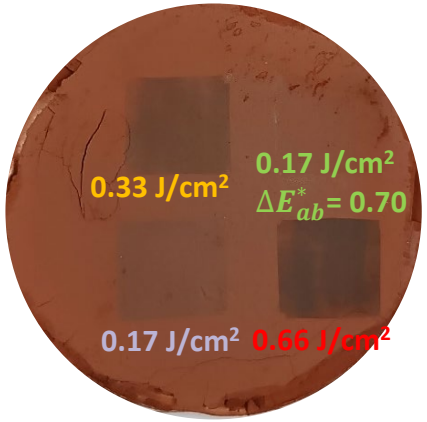
CI-LQS



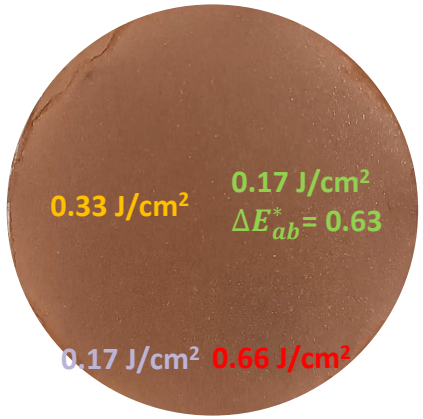
WK-LQS

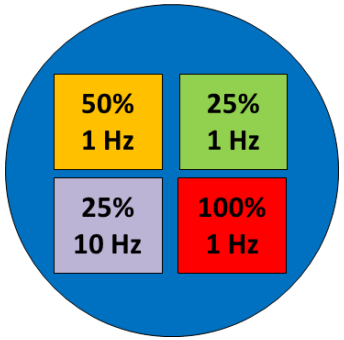


HE-LQS



RE-LQS





Naked eye observations

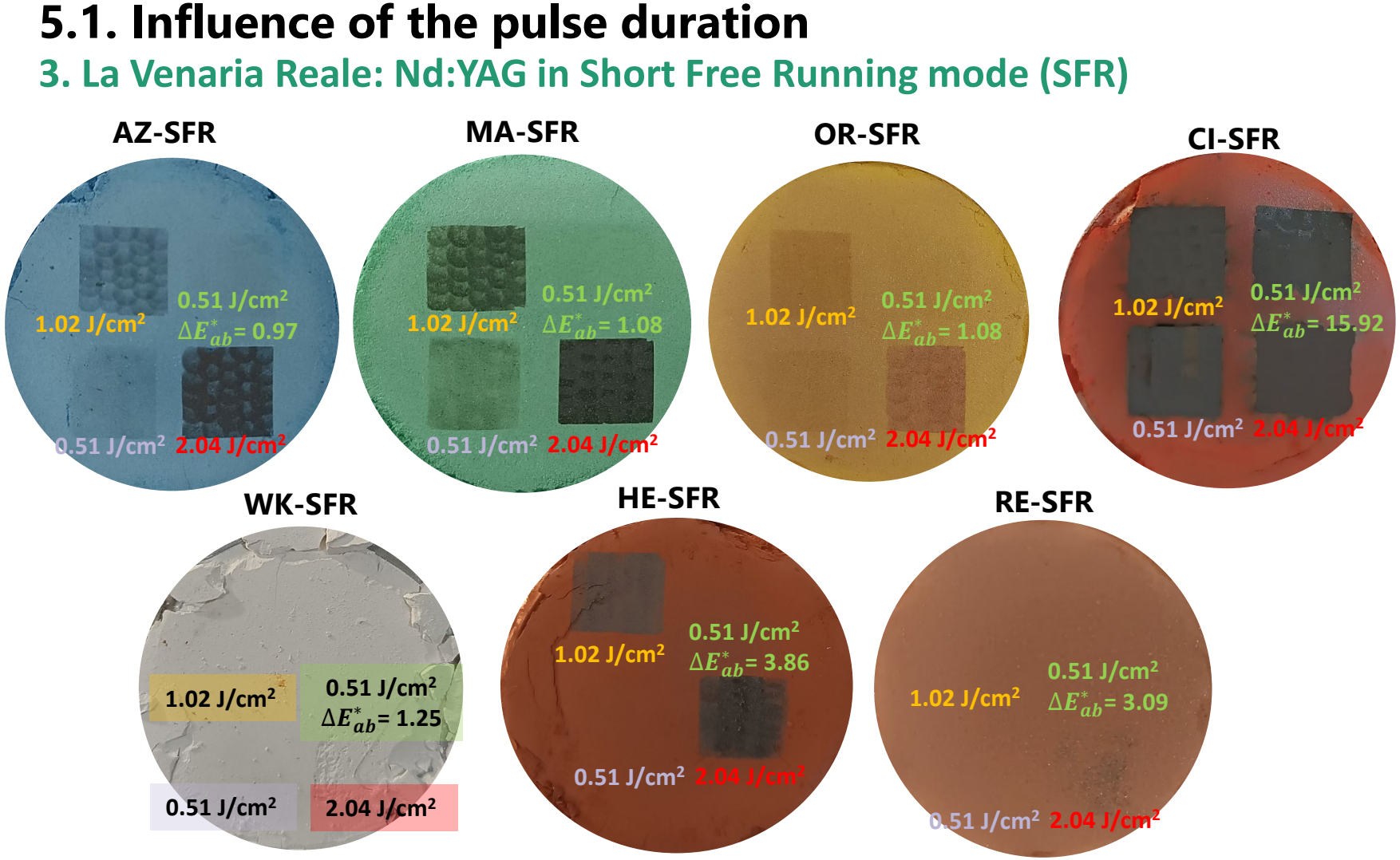
Darkening
Saturation (OR)
Blackening (CI)

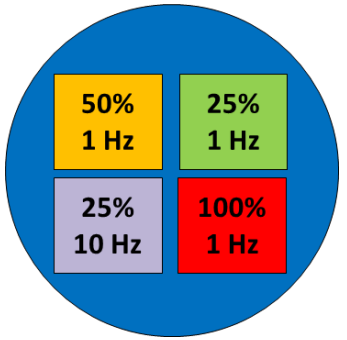
Susceptibility:

WK
RE
MA
HE
AZ
OR
CI

5.1. Influence of the pulse duration

3. La Venaria Reale: Nd:YAG in Short Free Running mode (SFR)





Naked eye observations

Darkening (RE)
Saturation (OR)
Blackening (CI)

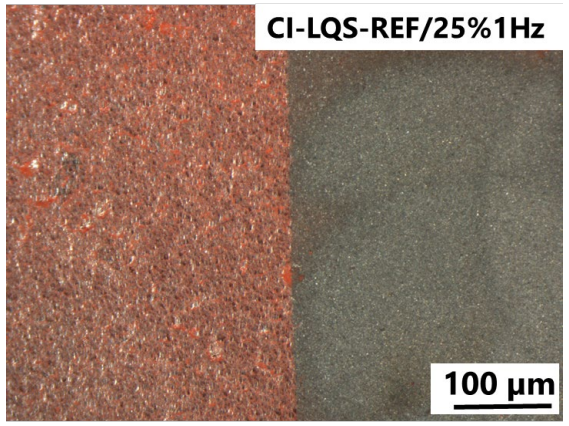
Susceptibility:

WK-RE
HE-AZ-MA-OR
CI

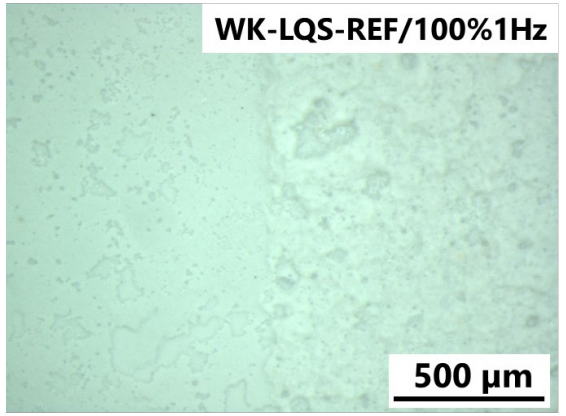
5. Results

5.1. Influence of the pulse duration

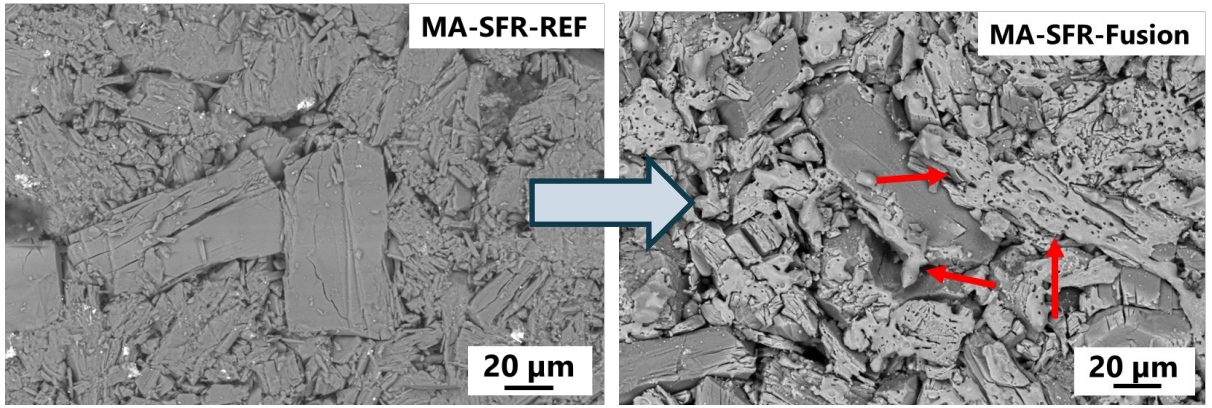
Laser QS	Laser LQS	Laser SFR
WK	WK	WK-RE
RE	RE	HE-AZ-MA-OR
MA	MA	CI
HE	HE	
AZ	AZ	
OR	OR	
CI	CI	



Blackening



Remove of material

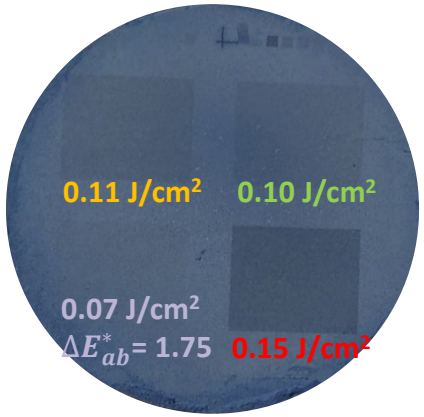


Melting crusts

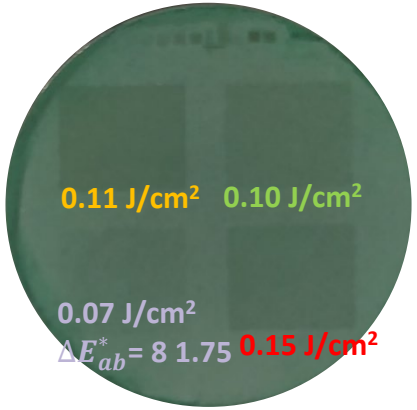
5.2. Influence of the pulse duration, active medium and wavelength

4. Ferrol: $Nd:YVO_4$ (ns, 355 nm)

AZ-ns

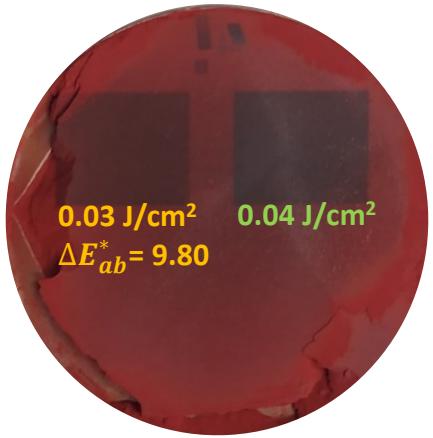


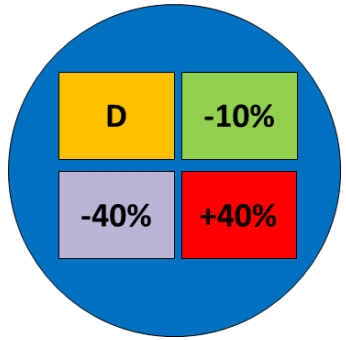
MA-ns



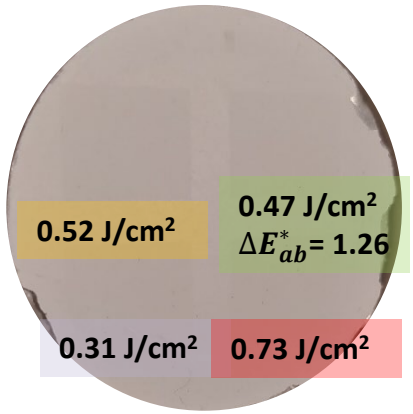
OR-ns

CI-ns

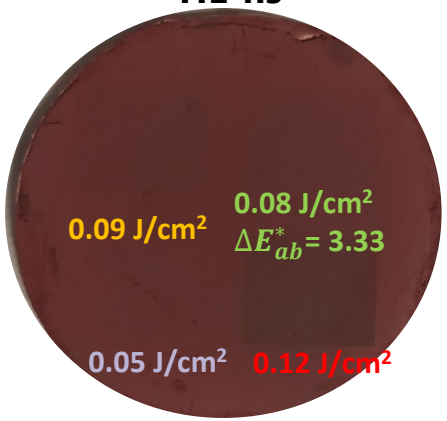




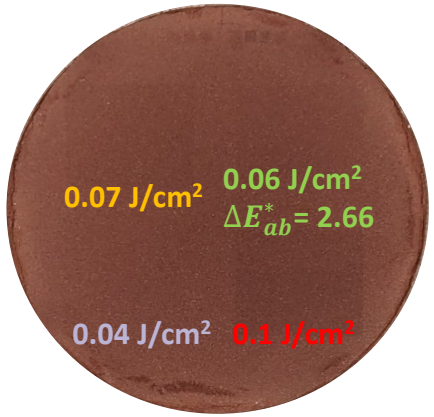
WK-ns



HE-ns



RE-ns



Naked eye observations

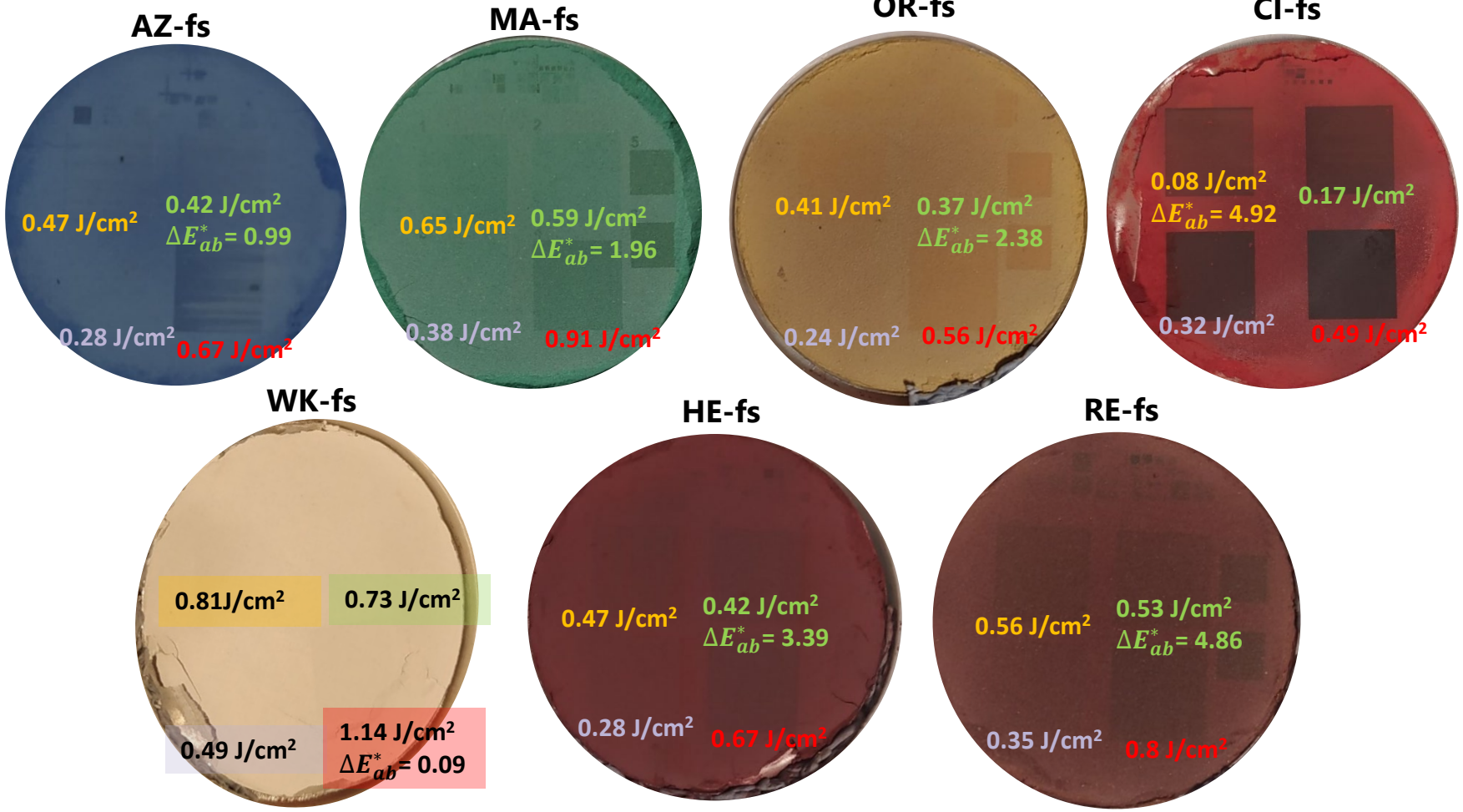
Darkening
Saturation (OR)
Blackening (CI)

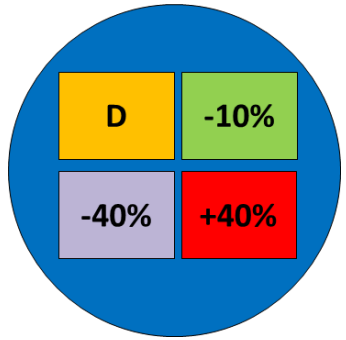
Susceptibility:

WK
AZ-MA
HE
RE
CI

5.2. Influence of the pulse duration, active medium and wavelength

5. Ferrol: Spectra Physics Spirit (fs, 1040 nm)

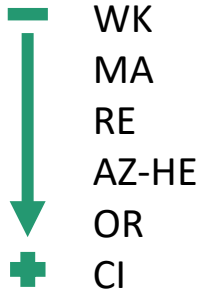




Naked eye observations

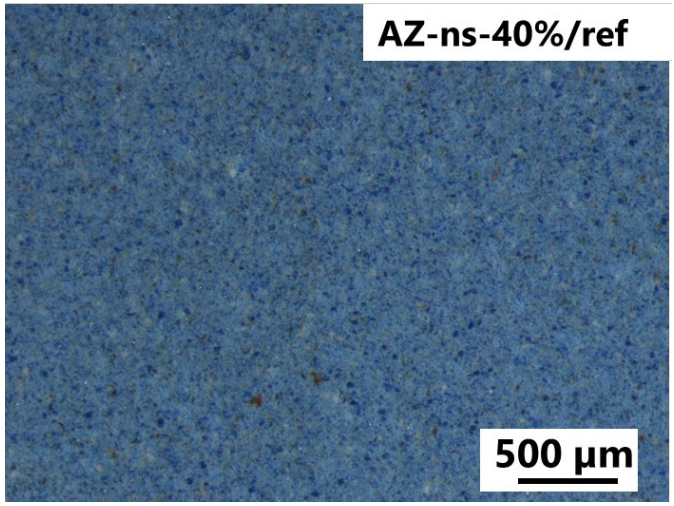
Darkening
Saturation (OR)
Blackening (CI)

Susceptibility:

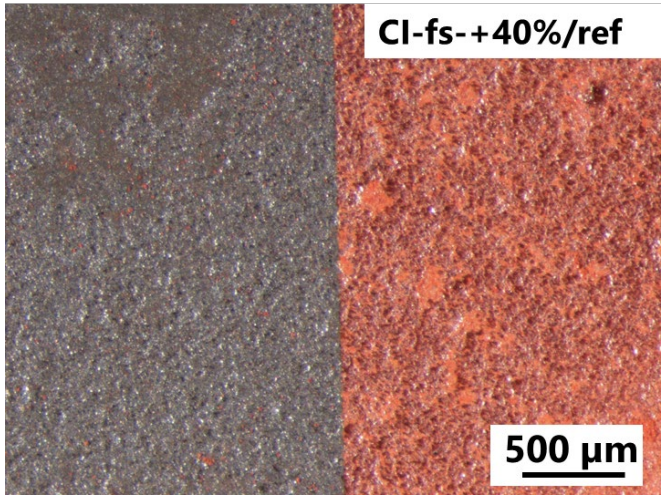


5.2. Influence of the pulse duration, active medium and wavelength

Laser fs	Laser ns
WK	WK
MA	AZ-MA
RE	HE
AZ-HE	RE
CI	CI



No differences

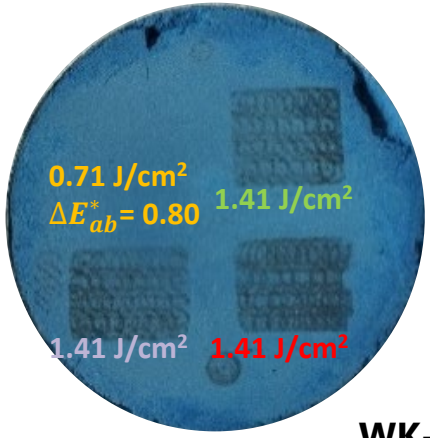


Blackening

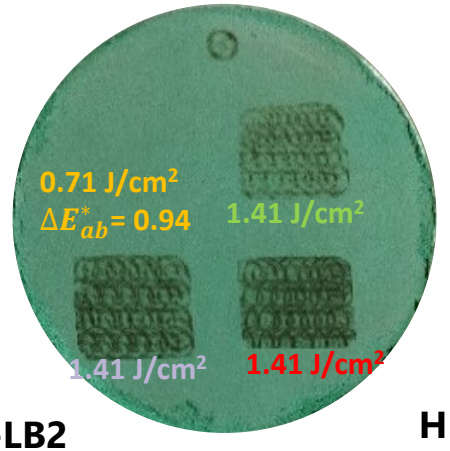
5.3. Influence of the pulse duration

8. Pisa: Light Brush 2 Er:YAG (LB2)

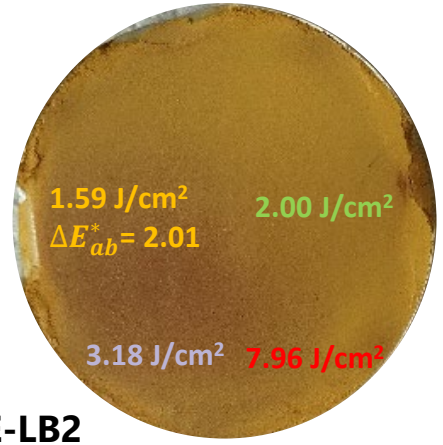
AZ-LB2



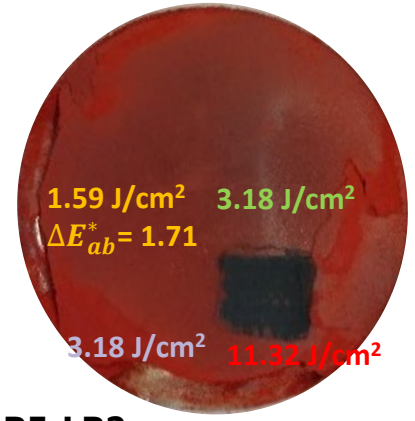
MA-LB2

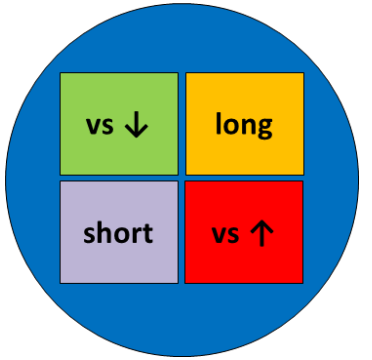


OR-LB2

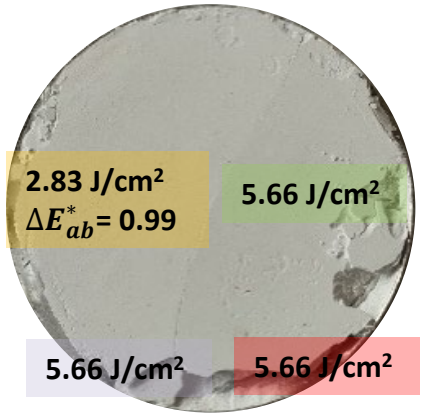


CI-LB2

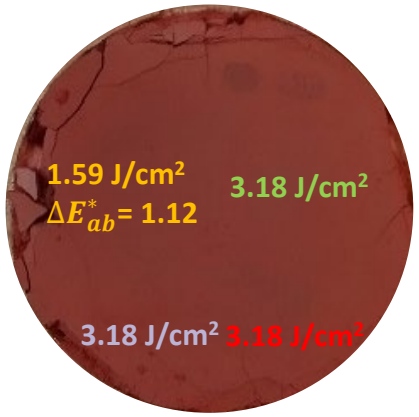




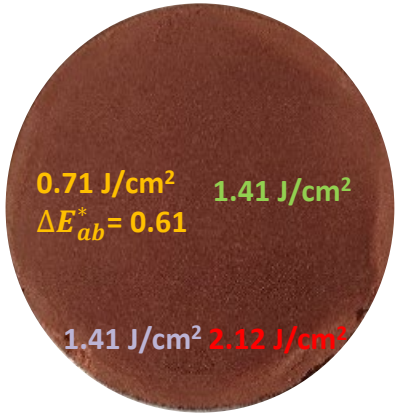
WK-LB2



HE-LB2



RE-LB2



Naked aye observations

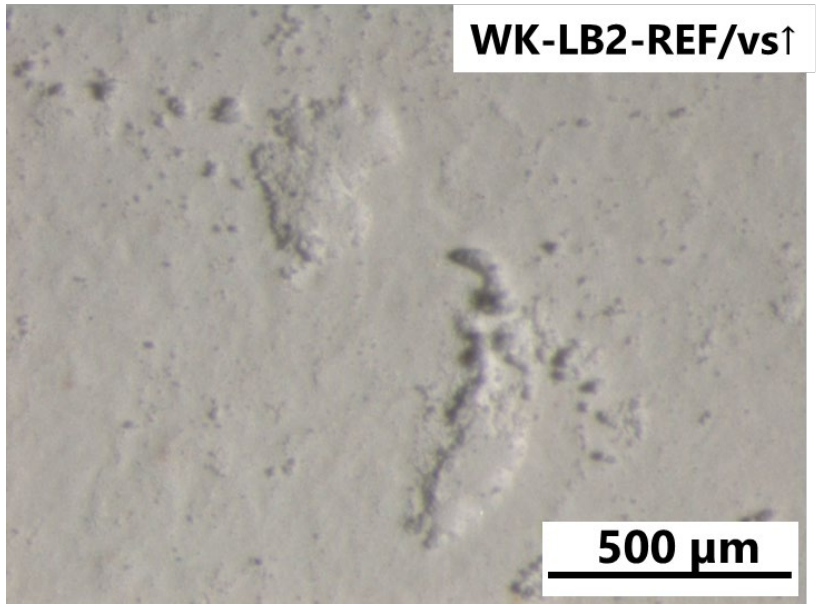
Darkening
Blackening (CI)

Susceptibility:

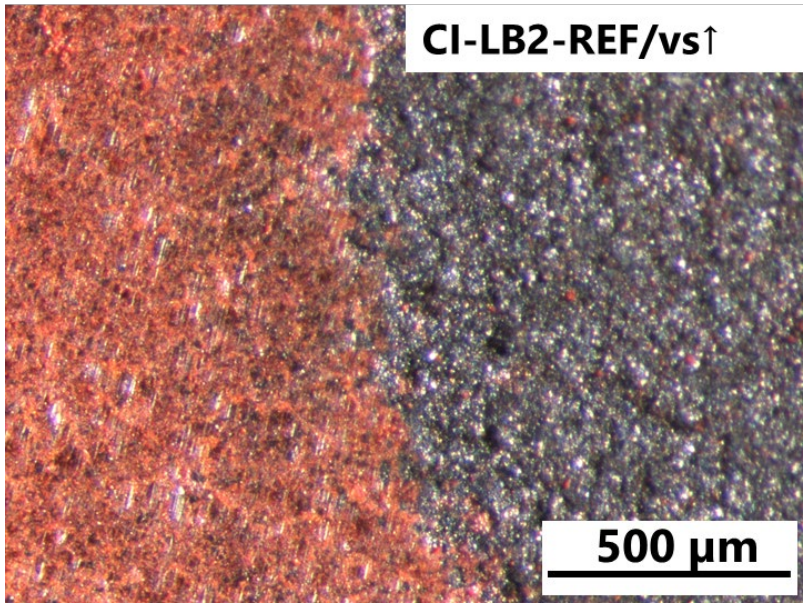
OR-RE-HE-WK
CI
AZ-MA

5.3. Influence of the pulse duration

Laser LB2
OR-HE-HE-WK
CI
AZ-MA



Remove of material



Blackening

NEXT STEPS

7. Next steps

2024:

- Comparative among the effects on the pigment tablets after irradiation with different lasers.
- Comparative among the effects on painting mock-ups after irradiation with different lasers.

2024-2025:

- Irradiation and analysis of mock-ups after removing the soiling layer with different lasers.
- Transference of the results to a real artwork.

WHAT WILL THE LEAST AGGRESSIVE CONDITION?

Chromatic changes?

Discolorations?

Mineralogical transformations?

Photochemical and photothermal changes?

WE WILL SEE!

Thank you for your attention!

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December 2023

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THE 1st BIANNUAL MEETING. Specialized Group of Chemistry for the Study and Conservation of Cultural Heritage of the Spanish Royal Society of Chemistry

29th February, 2024
Abstract submission deadline

Paraninfo of the Faculty of Geography and History
Praza da Universidade, 1

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