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ITALIAN STUDIES AT OXFORD
UNIVERSITY OF OXFORD

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Italian Embassy in London and by Italian Studies at Oxford in collaboration with the Department of the History of Art of the University of Oxford and the Oxford e-Research Centre

LASER ABLATION IN CONSERVATION OF ARTWORKS

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IFAC

BRIEF HISTORY

<u>Seventies</u> (Proposal)

- J. Asmus in Venice
- Technological limits, high costs

<u>Eighties</u> (Incubation)

- A few active researcher (Asmus and pupils)
- Lack of systematic studies
- Conservators manifest their mistrust
- High cost

<u>Nineties</u> (Turn)

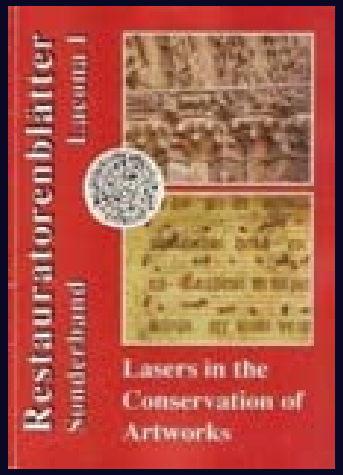
- Several dedicated research projects (I, F, GR, UK, G)
- Development of dedicated laser systems
- Discussion about irradiation parameters
- Important applications
- The problem of the yellow appearance of stones

<u>Third millenium</u> (Dissemination of the rigorous approach)

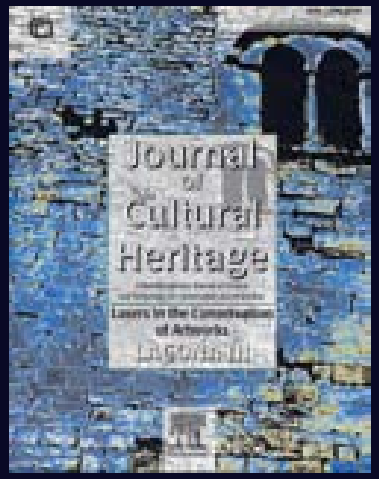
- Definite picture for stones (a number of conservation works)
- Systematic study and application to metals
- First applications on polychromies
- At an experimental level: paper, parchment, glasses, and other

LITERATURE: LACONA

1995, Herklion

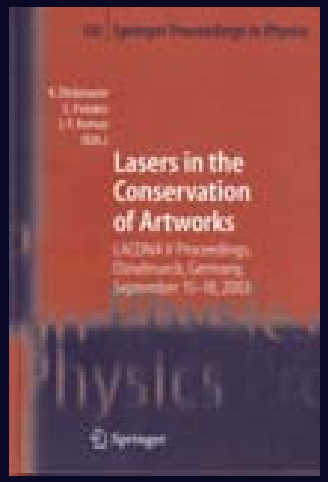


1997, Firenze

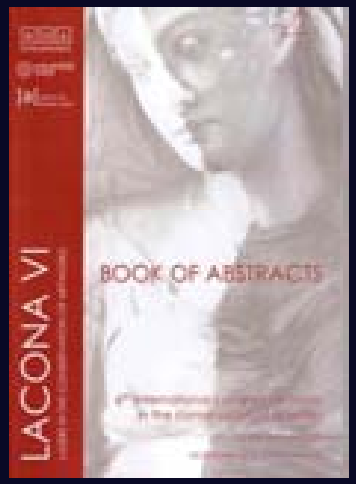


2001, Paris

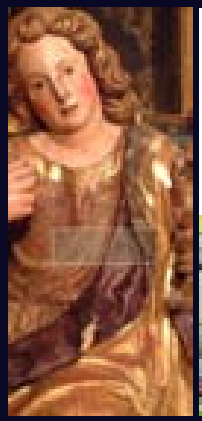
2003, Osnabrueck



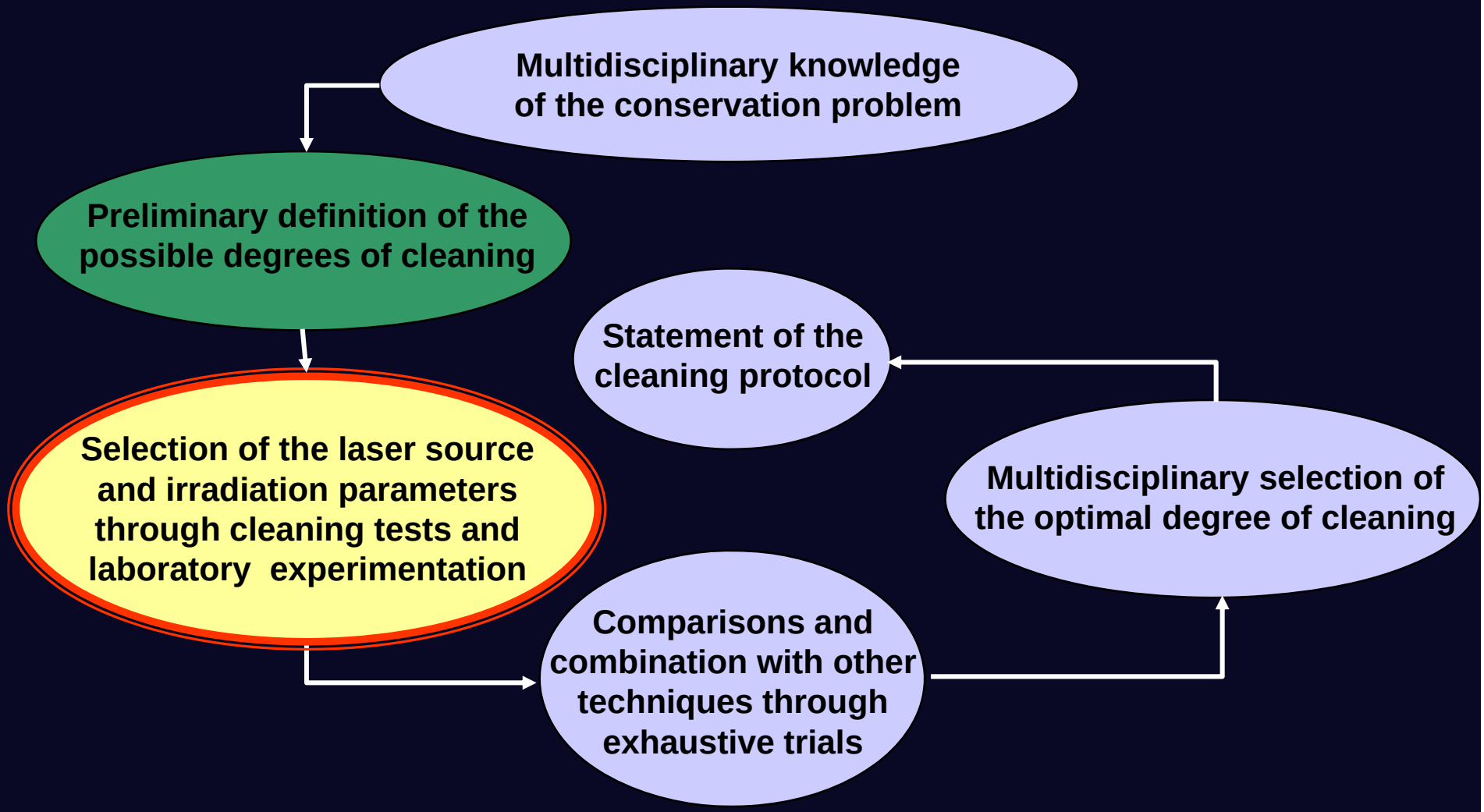
2005, Vienna



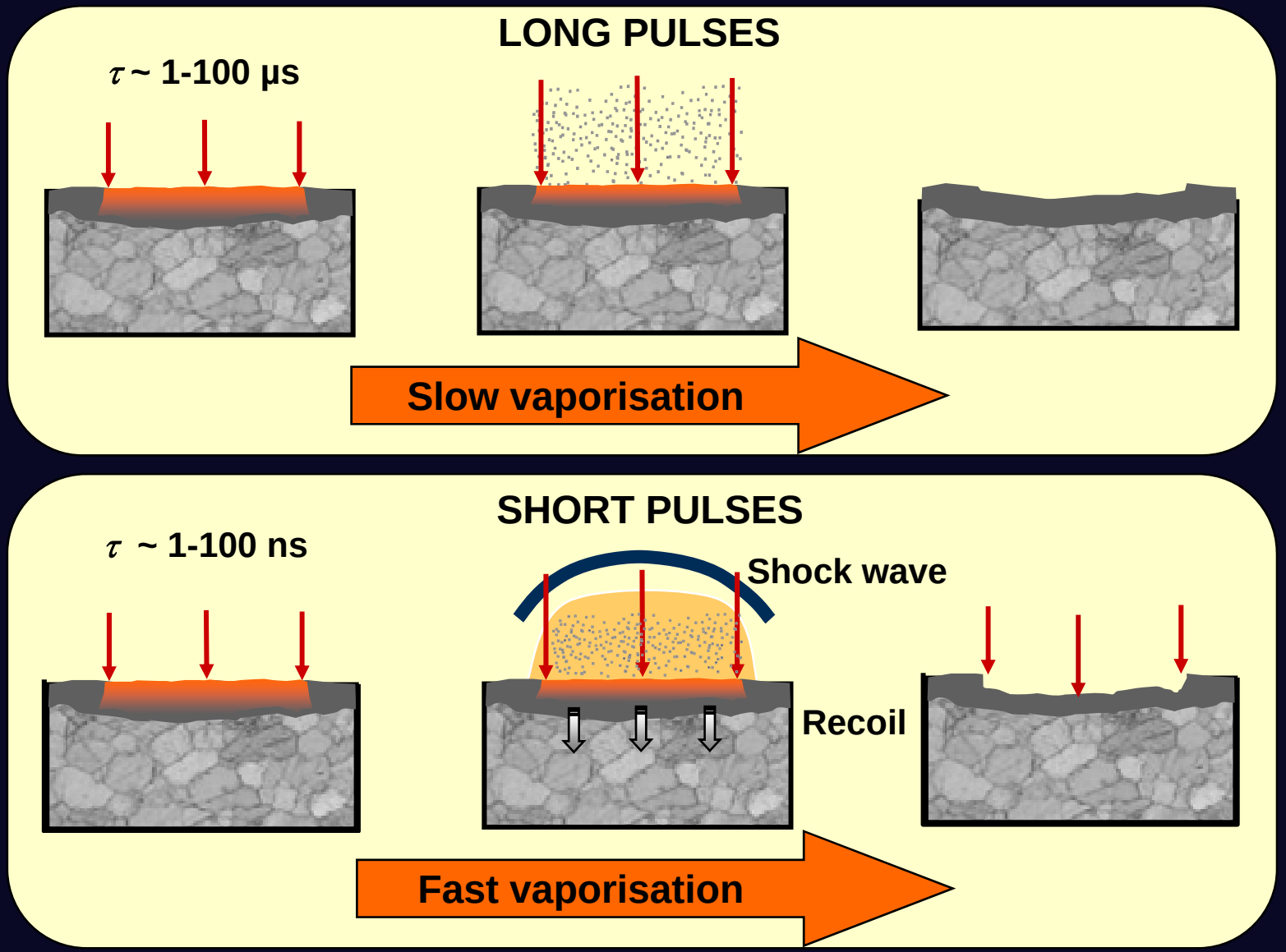
2007, Madrid



LASER CLEANING OPTIMISATION

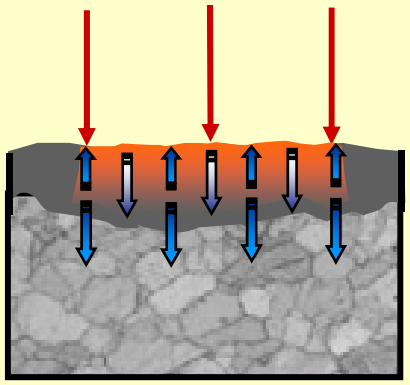


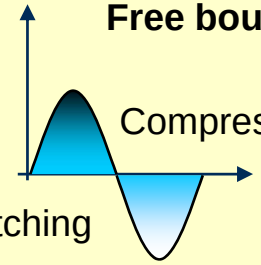
ABLATION BY VAPORISATION



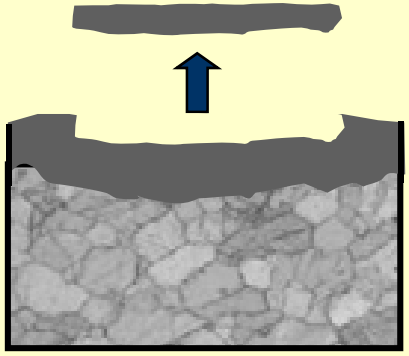
ABLATION BY SPALLATION

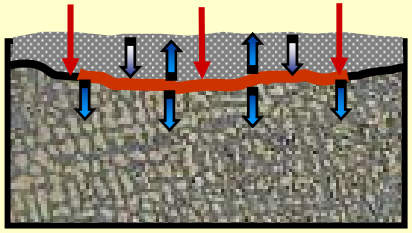
$10^6 < I < 10^8$ W/cm^2, τ=10-100 ns





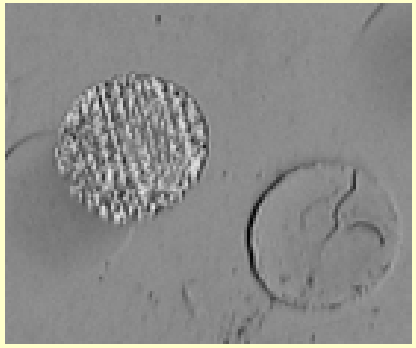
Primary spallation





***I* > critical threshold, any τ**

Secondary spallation



SELECTION OF THE LASER SOURCE

CHOICE OF THE IRRADIATION CONDITION

- No assists
- Liquid-assists
  - Humid surface
  - Thin water film
  - Immersion
- Gas-assists
- Liquid-solid mixtures

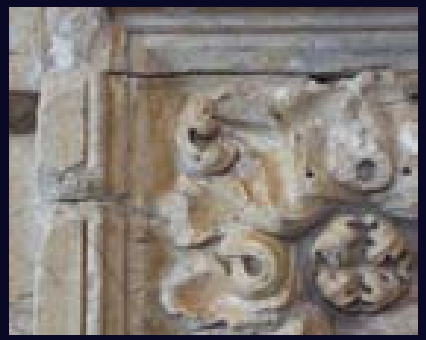
DEFINITION OF THE IRRADIATION FLUENCE RANGES (J/cm^2)

STONES

SUCCESSFUL APPLICATIONS ON MASTERPIECES

2001 - Profet Abacuc by Donatello
OPD. Restorer: Carlo Biliotti

2002- The Fonte Gaia by Iacopo Della Quercia
Restorers: Stefano Landi et al.



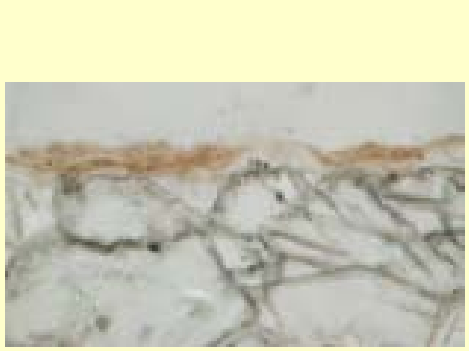
SUCCESSFUL APPLICATIONS ON MASTERPIECES

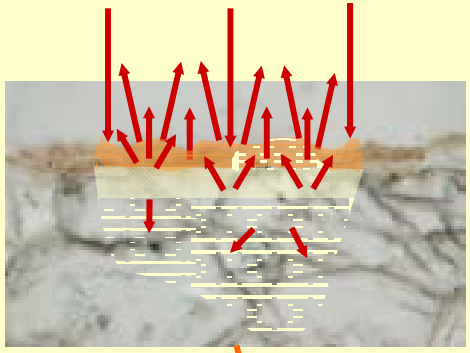
2003 - *Ratto delle Sabine* by Giambologna
Meridiana Restauri , restorer: Alberto Casciani

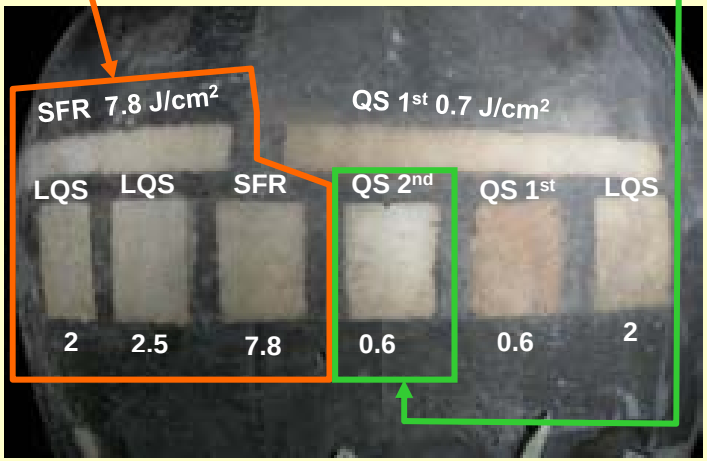
YELLOW APPEARANCE PROBLEMS ASSOCIATED WITH PIGMENT LOADS

Long pulse duration solutions:
high fluence
high penetration

Wavelength solutions:
low fluence
low optical penetration

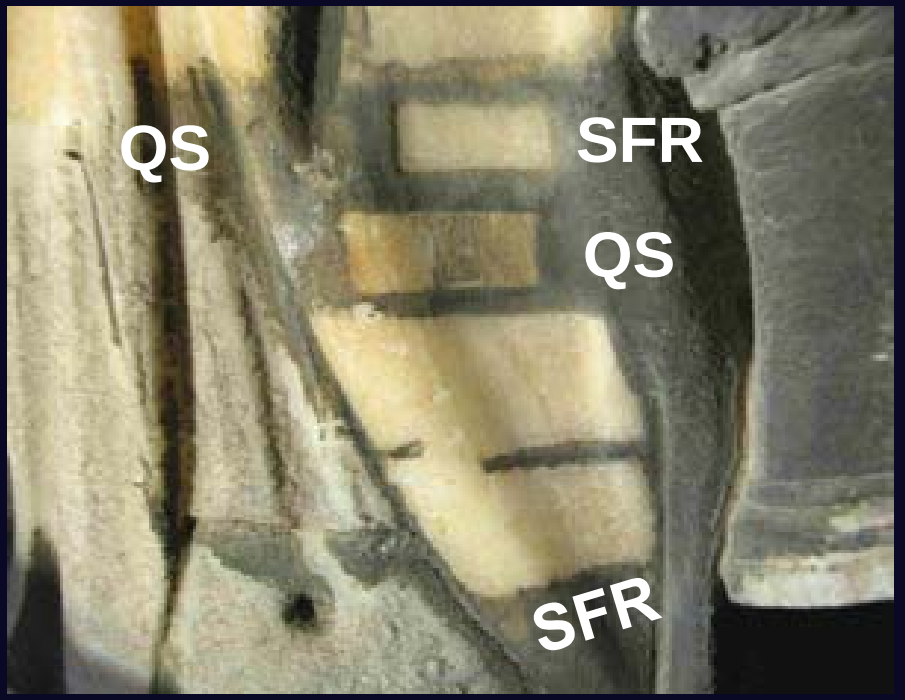


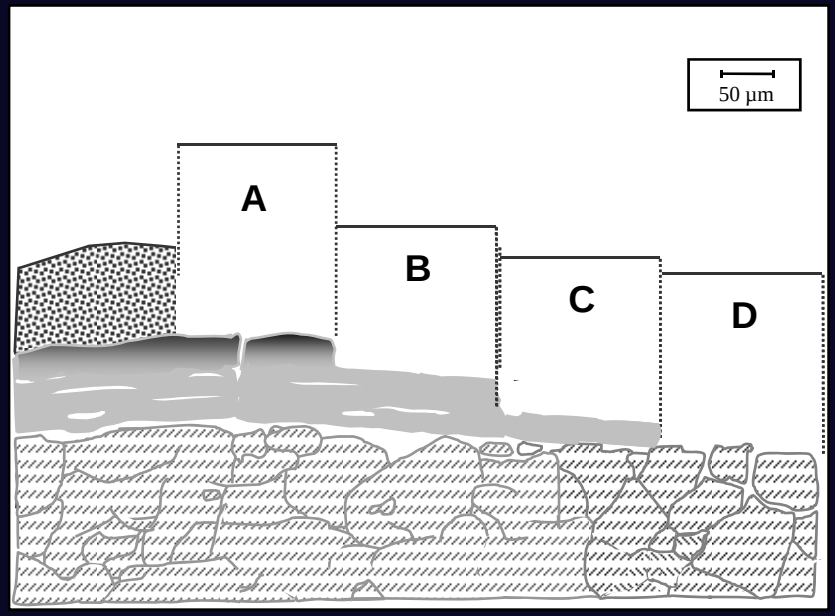




QS
(by single pulse)

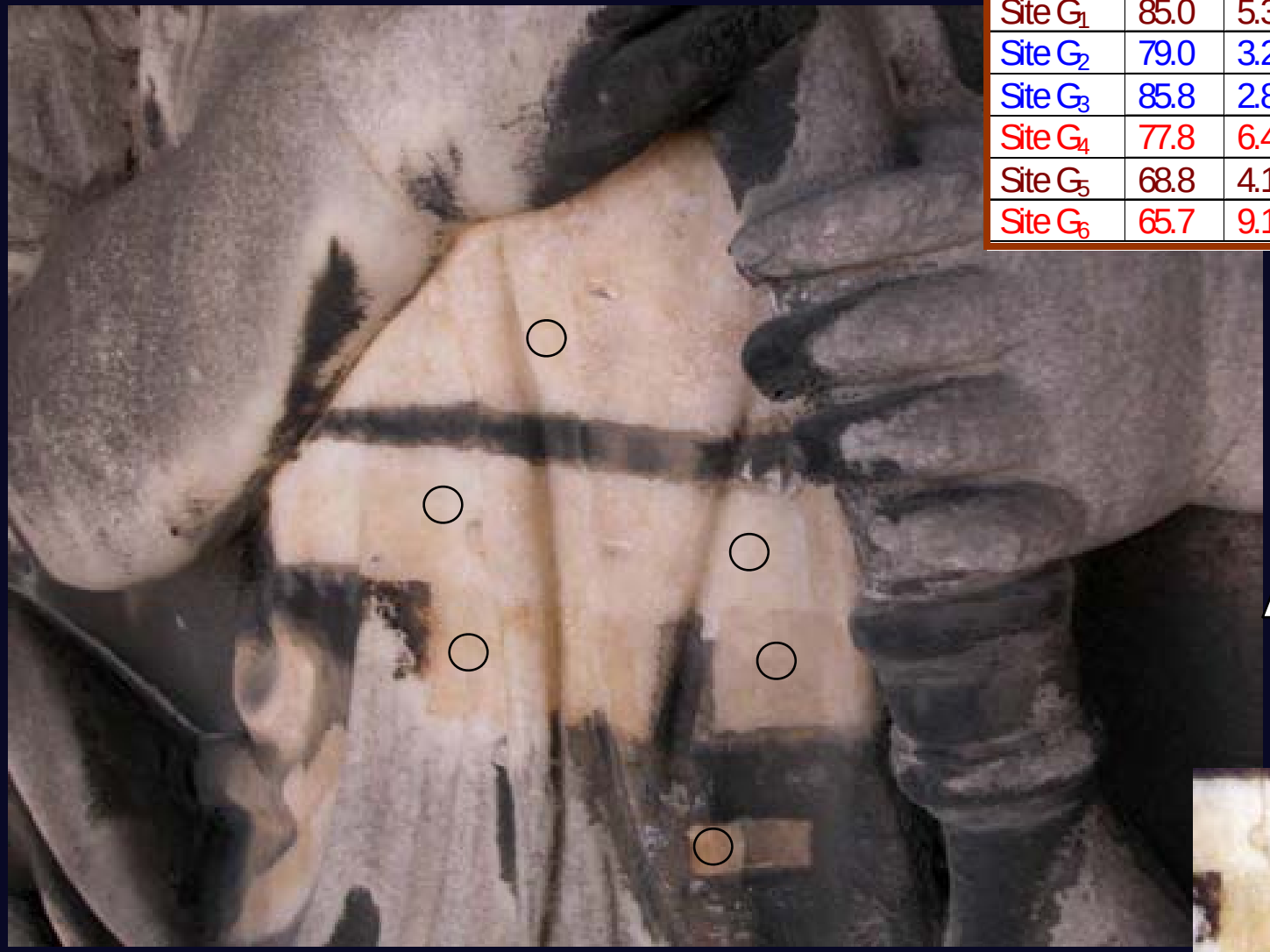
Mechanical abrasion using silicon wheel

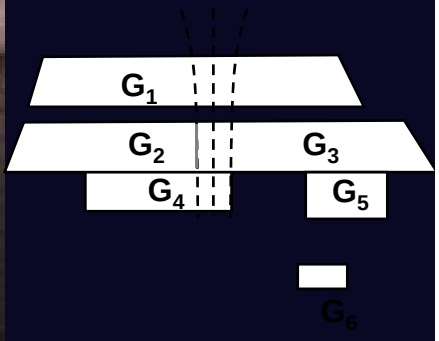




A DOUBLE WAVELENGTH SOLUTION

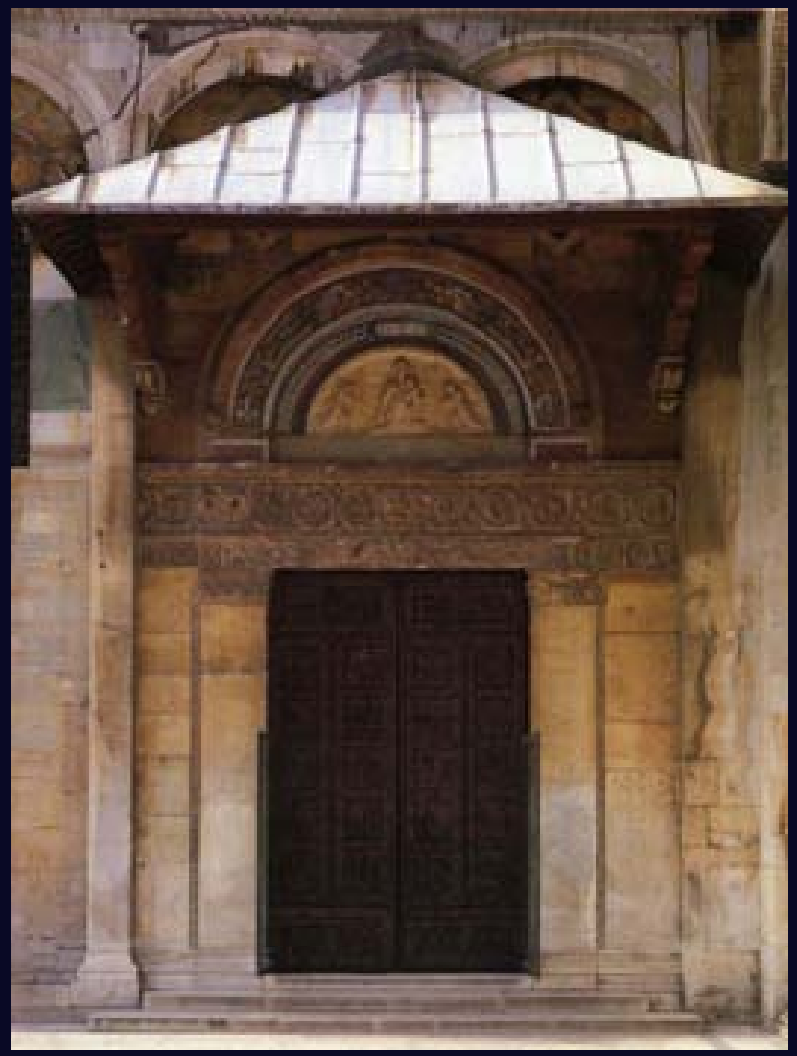
Site	L*	a*	b*	C_{ab}	h_{ab}
Site G_1	85.0	5.3	26.6	27.0	1.37
Site G_2	79.0	3.2	21.1	21.4	1.42
Site G_3	85.8	2.8	18.2	18.4	1.42
Site G_4	77.8	6.4	27.3	28.0	1.34
Site G_5	68.8	4.1	20.6	21.0	1.38
Site G_6	65.7	9.1	30.8	32.1	1.28





G_1) Palladio 1st (close to dam. thr.). G_2) Palladio 1st then 2nd then silicon wheel. G_3) Palladio 1st then 2 nd. G_4) Palladio 1st. G_5) EOS (high fluence); G_6) Art light II

PORTAL OF SAN RANIERI
CATHEDRAL OF PISA



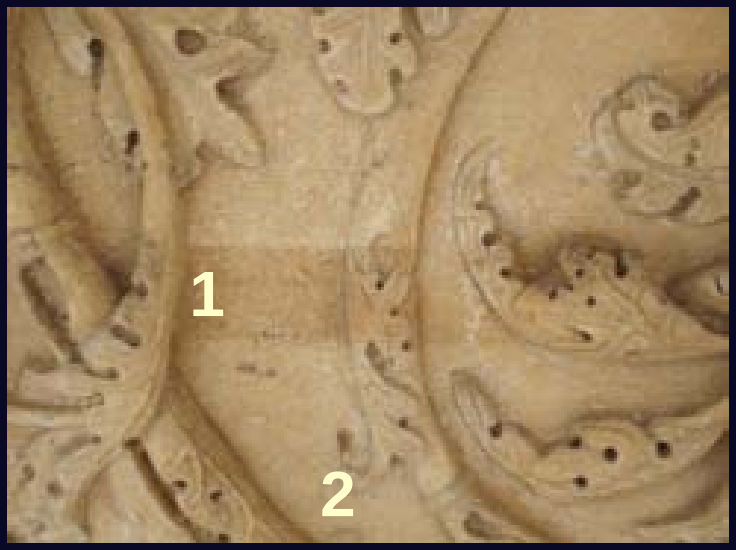
2

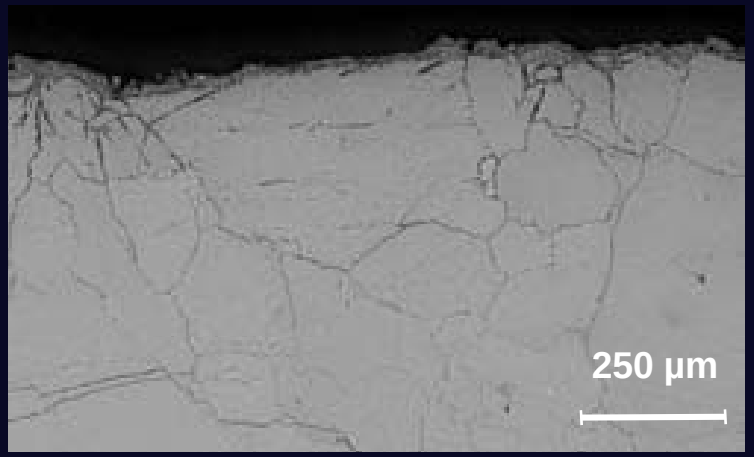
1

2

FINAL CLEANING DEGREE

Restorer: Sabina Vedovello





GILDED BRONZES

The *Porta del Paradiso*

Baptistery of Florence

THE CONSERVATION PROBLEM

1429-1453 - **Crafted by L. Ghiberti**

Conservation treatments (since 1475**)**:

- periodical washing by water
- protection with oil and wax

1946-48 Chemical cleaning intervention

1966 - Flood damages and the following restoration

1980- Starting of the present conservation intervention

1990- Removal to the OPD laboratory

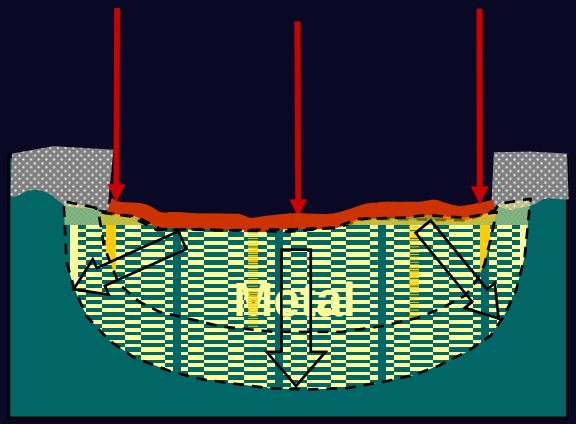
THE CHEMICAL CLEANING PROTOCOL

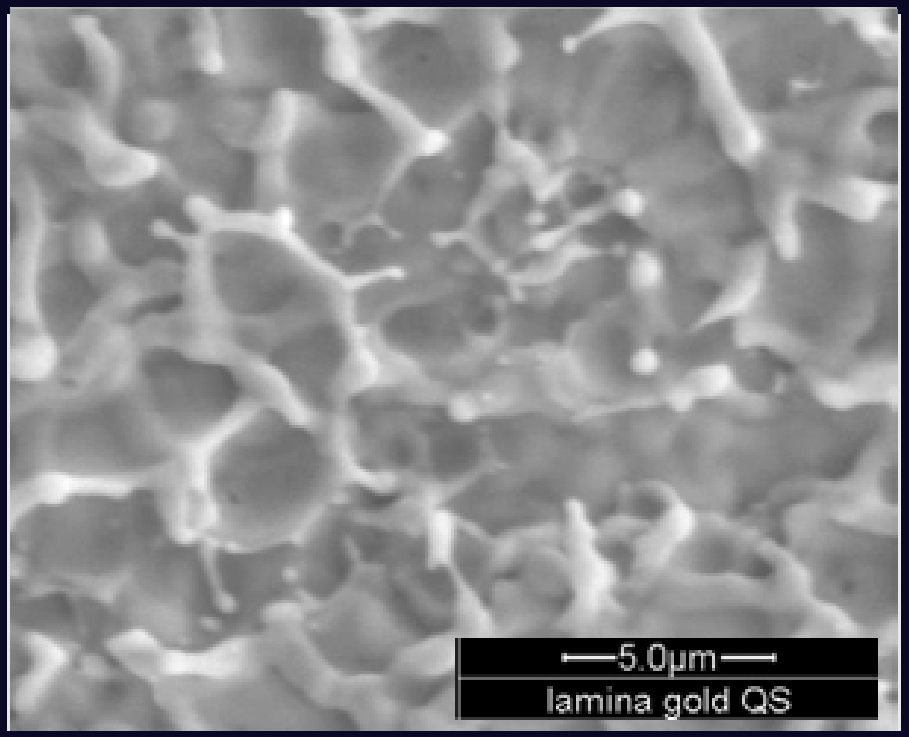
0) <u>Dismounting of the sculptural element</u>
1) Removal of soluble fatty substances by acetone
3) Preliminary removal of hydrosoluble compounds and dust by distilled water
4) <u>Removal of deposits and corrosion products by sodium potassium tartrate (Rochelle salt) neutral solution</u>
5) Careful rinsing in distilled water up to reduce the residual conductivity at 10-15 µS
6) Temporary drying by a warm air flow (40-50 °C)
7) Localised manual finishing
8) Final rinsing in distilled water
9) Drying as above
10) Final drying
11) Preservation in a controlled microclimate

METAL SUBSTRATE

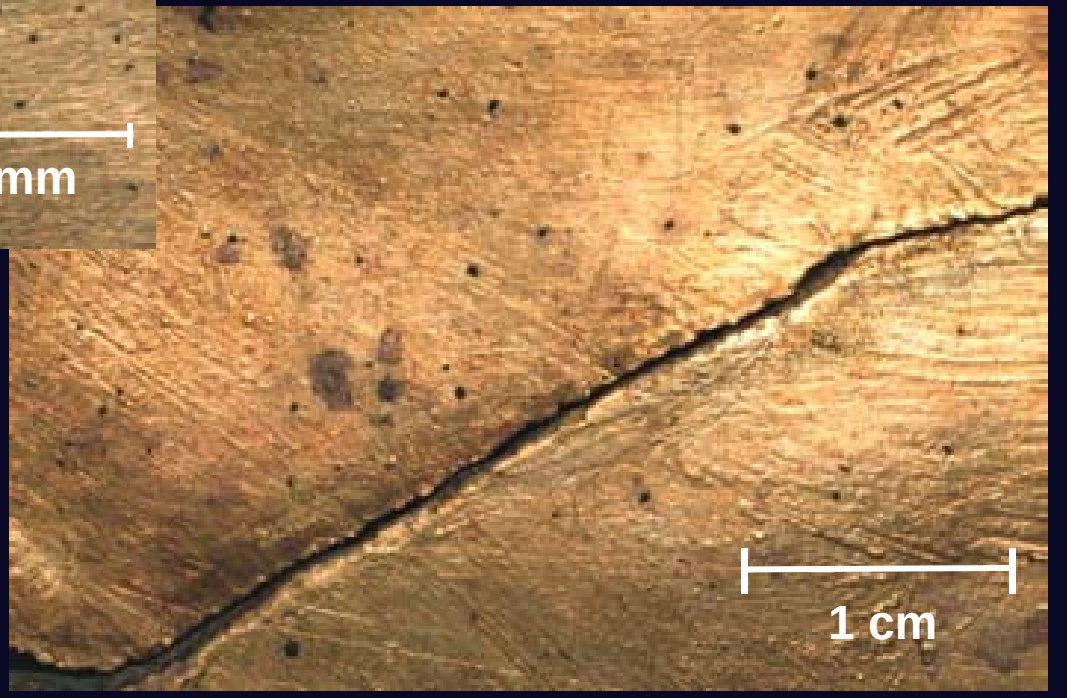
Tests on pure gold film standards 5-20 μm thick with <u>SHORT PULSES</u>

τ=8 ns, surface micro-melting F=900 mJ/cm^2 (Fa=63 mJ/cm^2)

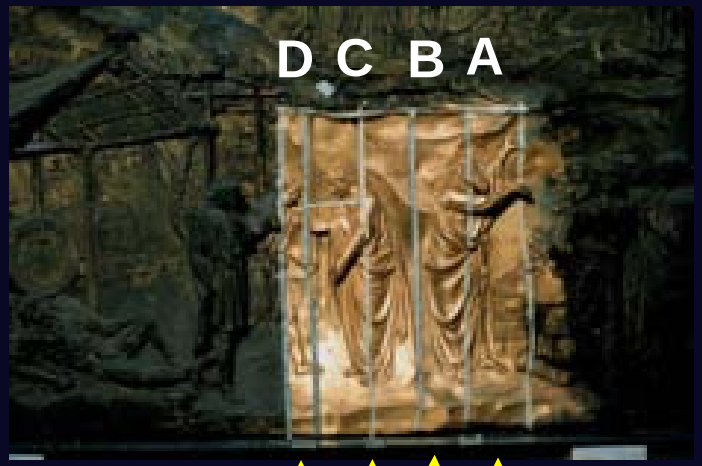




COMPLETE SAFEGUARD OF THE NATURAL TEXTURE AND COLOUR HUES



COMPARISON AND INTEGRATION



Laser+RS poultice (10%)

Laser

RS poultices (35%)

Atomised RS (35%)

C

Laser

LASER CLEANING OF THE FRIEZE

Restorers: S. Agnoletti, A. Brini

OPTIMISED PULSE DURATION FOR OIL GILDING

Treatable problem: removal of organic binder patinations
Exploitable ablation process: slow vaporisation

QS and LQS at 0.7 J/cm^2 (cleaning threshold)

No discrimination, aggressiveness

SFR (50 µs), 1.5-2 J/cm^2

Preservation of the gilding

VERROCCHIO'S DAVID

THE CLEANING INTERVENTION

(by Ludovica Nicolai)

VERROCCHIO'S DAVID RESTORED

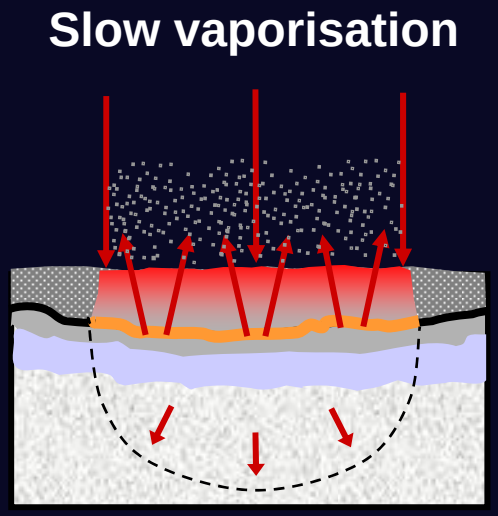
2003

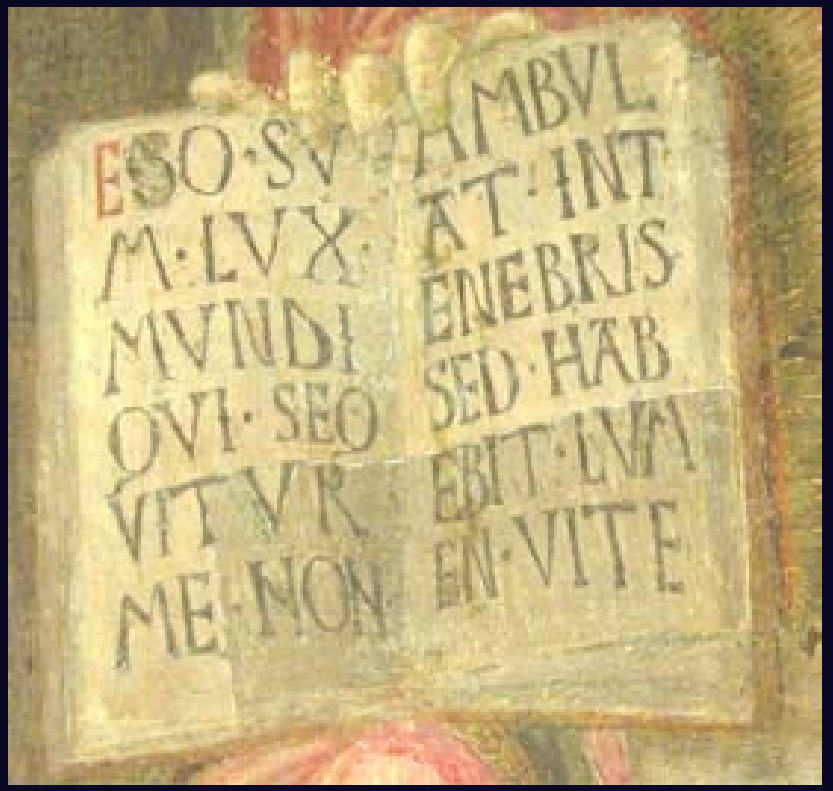
SFR Nd:YAG
Laser, 2 J/cm^2

Restorer:
Ludovica Nicolai

WALL PAINTINGS

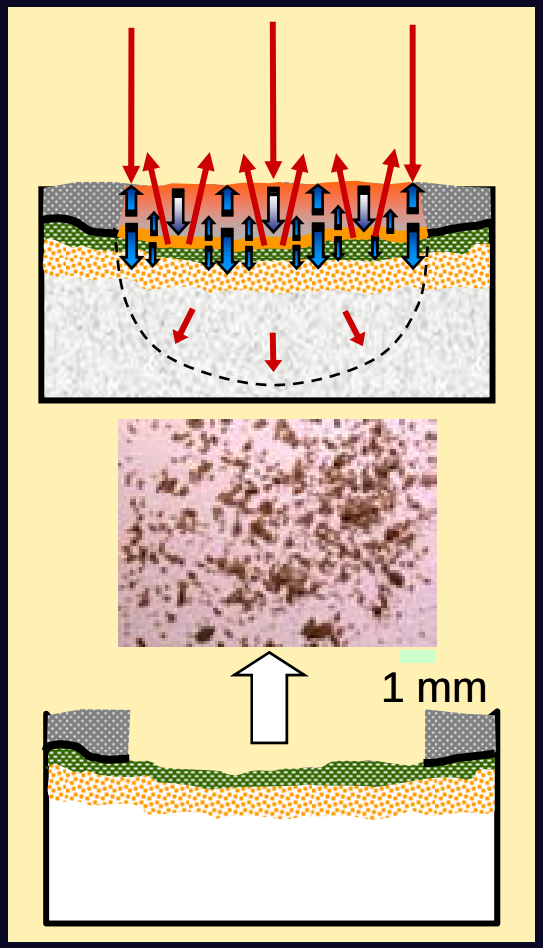
GRAY HUE AREAS : SFR Nd:YAG laser (2-3 J/cm^2)





Restorer: Anna Brunetto

EXTENSIVE TESTS:
LQS Nd:YAG laser (120 ns, 0.7 J/cm^2)



Restorer: Anna Brunetto