Tecnologie non invasive integrate per la diagnostica e la conservazione del patrimonio culturale

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The first scientific investigations on works of art or archaeological objects go back to the XVIIIth century

- Winckelmann (1717-1768) underlines the importance of the knowledge of the object for the art history.
- Development of chemistry.

Among the first investigations the following ones can be mentioned:

- Gmelin:
  - studies on glass tesserae (1779)
  - paintings on Egyptian sarcophagi (1781)
- Chaptal: studies on Pompeian pigments (1809)

Of course the first investigations were not particularly respectful of the object under study

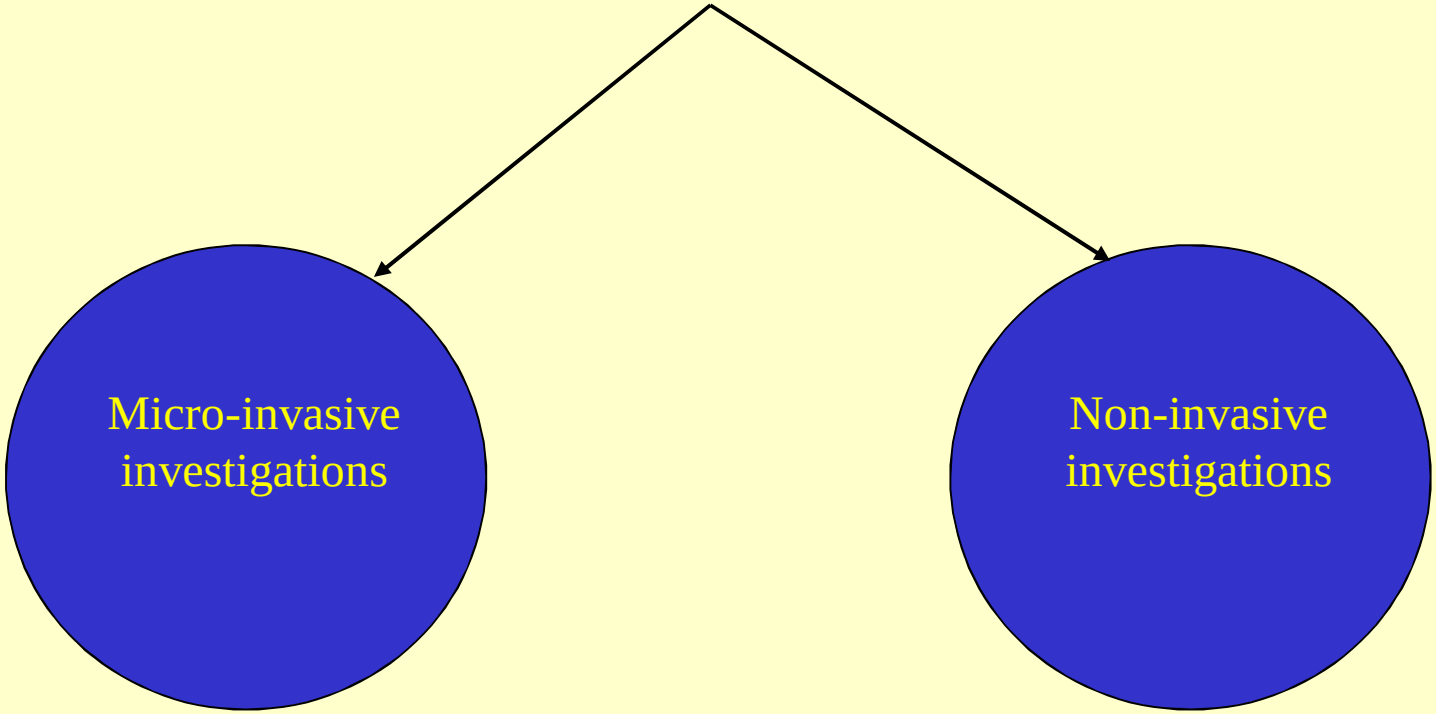
- ....Les acides muriatique, nitrique et sulfurique, font une légère effervescence avec cette couleur; ils paroissent lôaviver, même par une ébullition prolongée....[M. Chaptal, Annales de Chimie, **70** (1809) 22].

- ...io non ho esitato a sacrificare alcune pagine di un manoscritto... per sossaporlo alla prova dei reagenti [A. Fabroni (1841), citato in J. Nadolny, Reviews in Conservation, **4** (2003) 39].

However, awareness of the necessity of avoiding any damage to the work of art was also present, at least in the most conscientious scientists

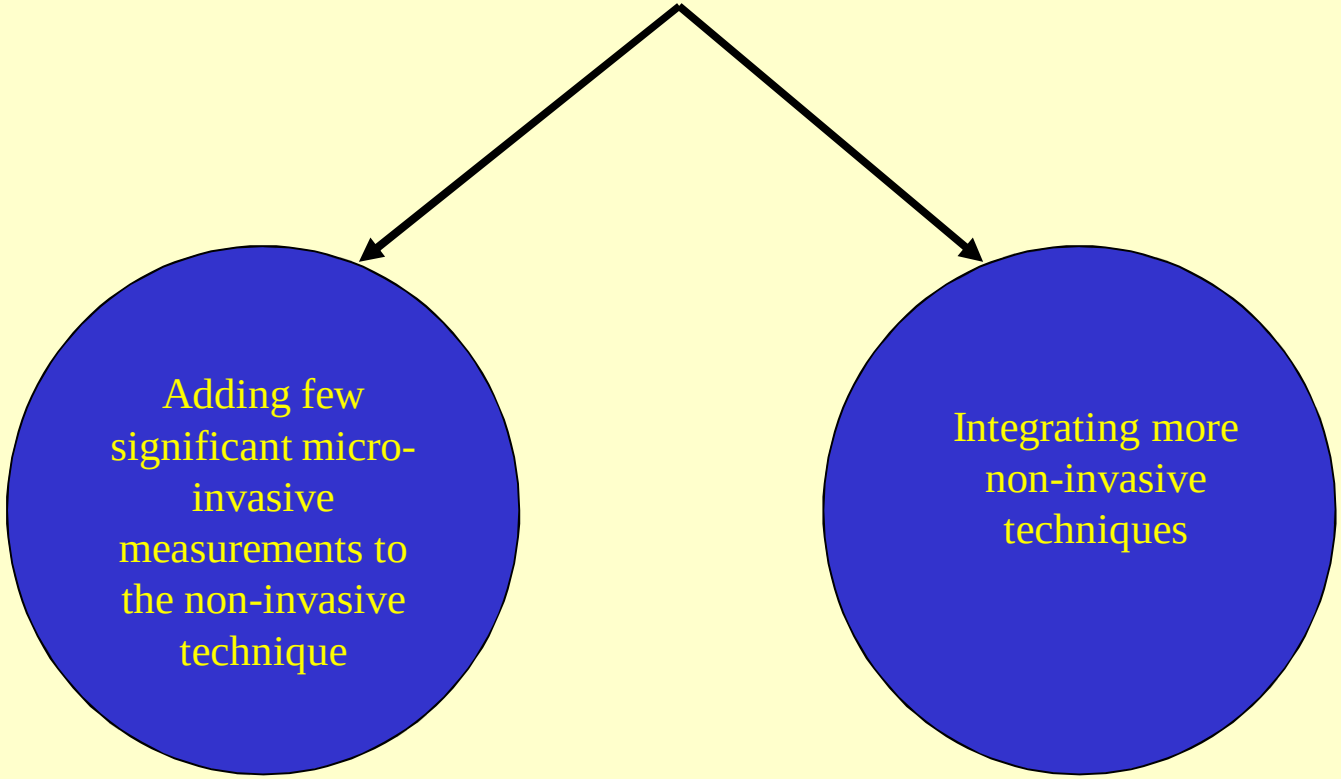
When the preservation of a work of art was concerned, I made my researches upon mere atoms of the colour, taken from a place where the loss was imperceptible: and without having injured any of the precious remains of antiquity, I flatter myself, I shall be able to give some information not without interest to scientific men as well as to artists, and not wholly devoid of practical applications. [H. Davy, Philosophical Trans., **105** (1815) 97]

Analytical data as complete as possible are required for both the knowledge of the work and the correct conservation



	Micro-invasive Investigations	Non-invasive Investigations
Pros	➢Very good characterization of the sample	➢Extensive sampling (statistical treatment) ➢Measurements can be repeated time after time ➢Many instruments are transportable for measurements *in situ*
Cons	➢Partial information (limited sampling) ➢Measurements on a given point cannot be repeated	➢The single technique is self-exhaustive only in lucky cases

Are there other choices?



Commonly used non-invasive techniques

* Single point information; § 2D or 3D information; ÀInformation on element composition; ÿ Information on molecular and/or crystal structure.

PIXE, PIGE * À

XRF * À

XRD * ÿ

X-ray Radiography §

Computer Assisted X-ray Tomography§

IR Reflectography §

Laser Micro-profilometry §

Fibre Optics Reflectance Spectroscopy * ÿ

Hyperspectral Image Spettroscopy§ ÿ

LIF * ÿ

Micro-Raman * ÿ

MRI * ÿ

IR Thermography §ÿ

Neutron Tomography §

Neutron Diffraction* Àÿ

As a case study some of the previous techniques were applied to an actual case by a team of researchers belonging to different laboratories (IFAC-CNR, INOA, Perugia Sect. ISTM-CNR, ENEAï Casaccia, Physics Dept.-Firenze, ISTI-CNR, SIEMENS SpA) and coordinated by Opificio delle Pietre Dure, Firenze (Cecilia Frosinini, Roberto Bellucci).

Madonna of the yarn winder
(Leonardo da Vinci, attr.)

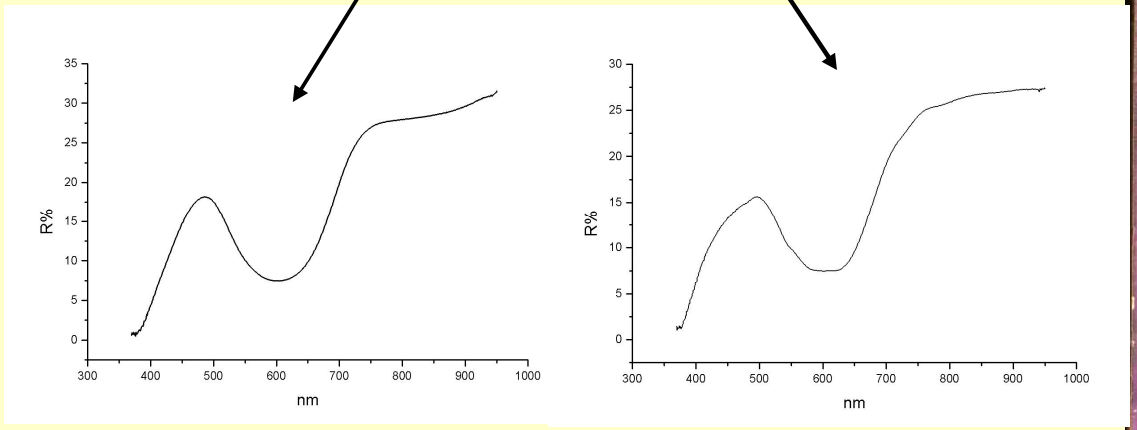
The integrated use of the different techniques made it possible to get information on:

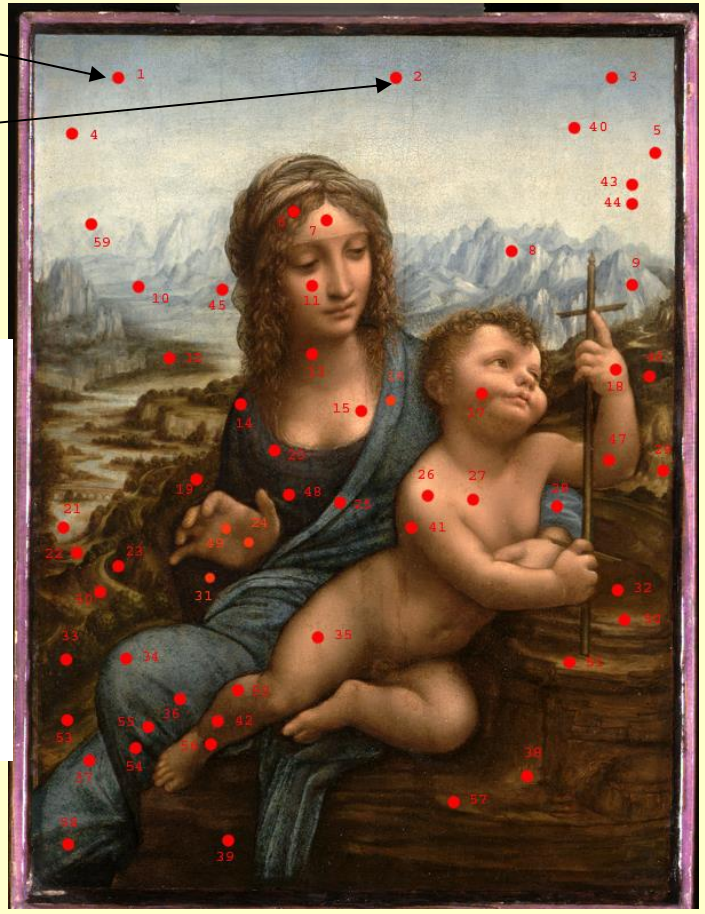
- Pigments
- Preparatory layer
- Binding medium
- Conservation state of the painted surface and of the support
- Varnish
- Pentimenti
- Previous restoration works

FORS, PIXE-PIGE e XRF have demonstrated the presence of two different blue pigments: lapis lazuli and Thénard blue. This latter was unknown before the XIXth century.

Lapis lazuli

Thénard blue

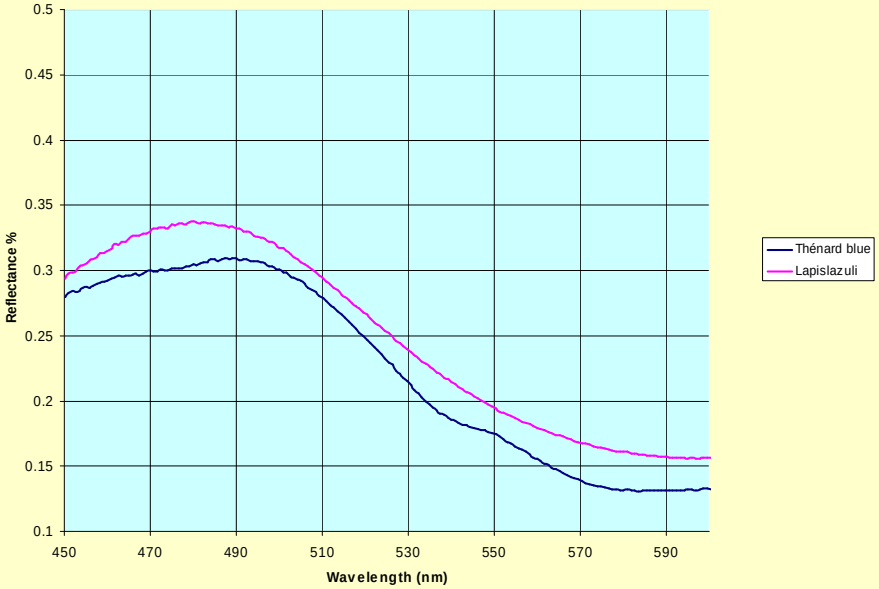


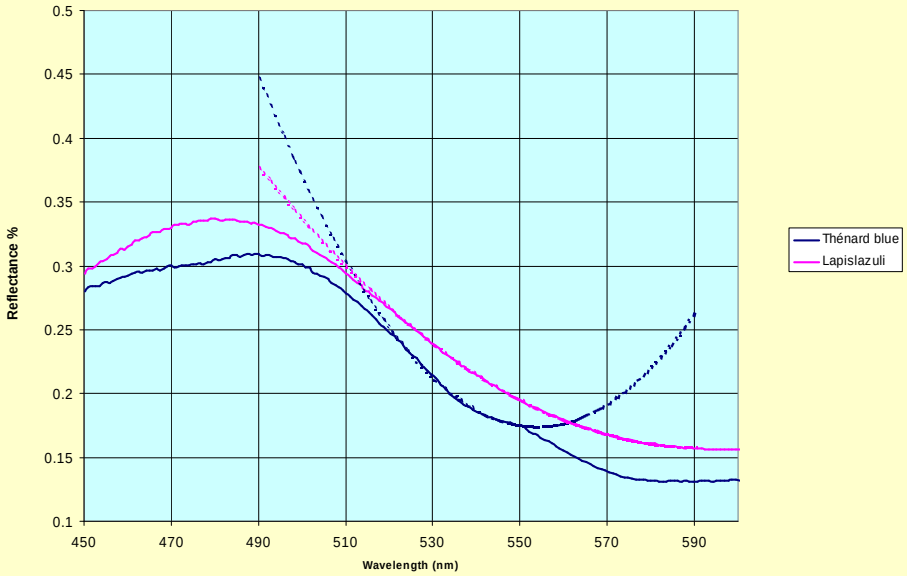


Hyperspectral scanner for image spectroscopy

The areas painted with different materials can be brought out by means of statistical methods, for instance PCA, or, in some cases, by taking into account the different band shape.

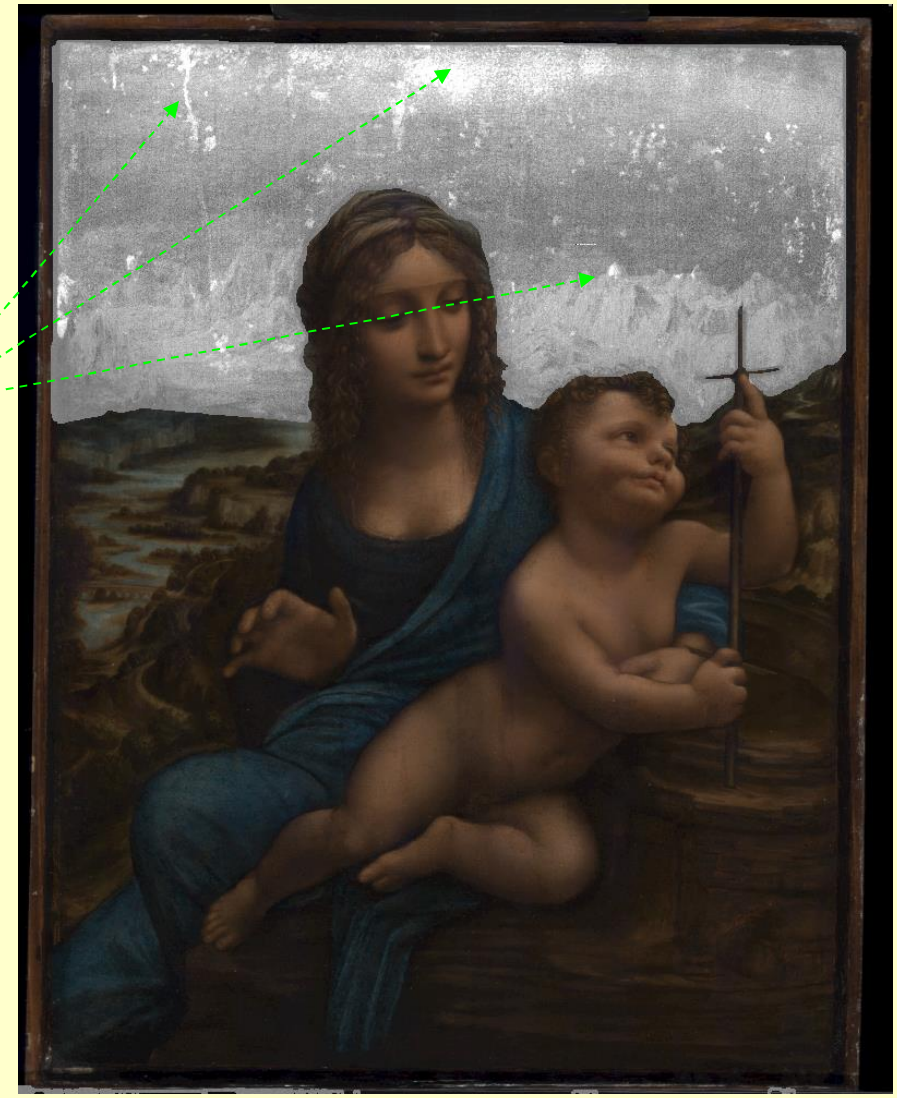
Parabolic fitting of a portion of the reflectance spectrum of the two pigments





Gray-level image based on the different band shape of the two blue pigments, lapis lazuli and Thénard blue

White areas correspond to the presence of Thénard blue



CONCLUSIONS

- At the present integrating several non-invasive techniques allows a good information without any damage to the object of art.
- Even in the worst situations it is possible to strongly reduce the amount of micro-invasive measurements.
- Coordination among different laboratories is necessary.

ACKNOWLEDGEMENTS

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