The application of pre-diagnostic UV-VIS-IR combined imaging analysis as a tool for the in situ investigation of wall paintings.

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INTRODUCTION

The analytical techniques available nowadays for the study and diagnostics of Cultural Heritage are many and various (e.g., pXRF, Raman, FTIR, FORS, etc.). While some of these can be used *in situ*, others are preferably applied in the laboratory; in addition, some are micro-destructive, whereas others are not. The choice of the most proper analytical approach fit to characterize the studied materials represents therefore a fundamental step for the Conservation Scientist, and preferably involves a preliminary knowledge of the artwork.

An additional expertise is required for the choice of the most suitable sites of analysis – especially when dealing with invasive techniques. This is particularly true for Cultural Heritage, often undergoing deterioration processes and/or restoration interventions. For what concerns wall paintings, frequently overlaid coats of different ages and nature, consequent to retouching or restoration, may appear on the surface, at times hiding the original pigment coatings.

In this report, the preliminary results concerning the pre-diagnostic analyses of images obtained by inspecting the artworks with different wavelengths are discussed. Such an information is aimed at possibly identifying restoration interventions as well as characterizing some of the constituent pigments. In particular, the acquisition of such images was carried out by combining visible (VIS 400-700nm), ultraviolet (UV 360-380nm) and infrared (IR 900-1050nm) radiation.

PRINCIPLES AND METHOD

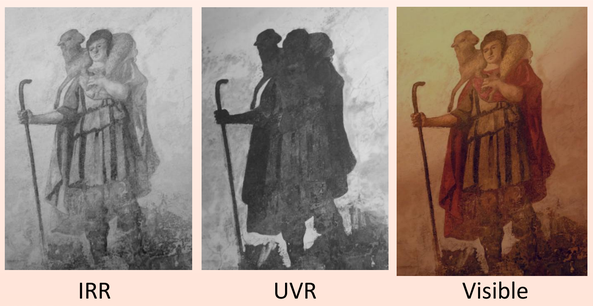
Diagnostic through imaging is a powerful, non-invasive technique based on the properties of specific materials (e.g., pigments, as well as organic/inorganic compounds used for painting or restoration purposes) to reflect or absorb in a different way the incident electromagnetic radiations, as a function of their different wavelength (λ).

In the case studies reported here, in addition to visible light (VIS; λ = 400-700nm), ultraviolet (UV; λ = 360-380 nm) and infrared radiation (IR; λ = 900-1050nm) have also been used. Images of the studied wall paintings are therefore presented in visible light, reflected ultraviolet light (UVR) and reflected infrared light (IRR).

In most cases, organic compounds such as fats, oils, polymers and synthetic pigments are excellent absorbers in UVR (and therefore appear as darker areas, in the related images) but mostly transparent to IRR (brighter areas, in the related images). Besides, the behaviour of most of the well-known historical pigments when exposed to electromagnetic radiations of a certain wavelength are reported in the available literature.
The presented images were treated as follows:

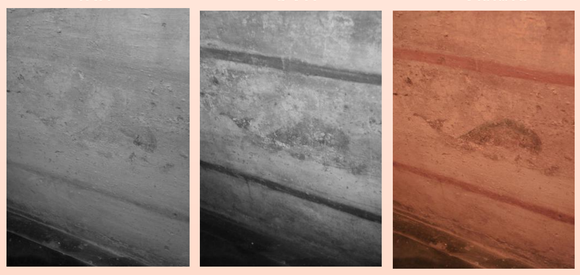
- Visible = no pre-treatment;
- IRR = extraction of the red channel (UV sensitive) with increased contrast and brightness;
- UVR = extraction of the red channel (IR sensitive) with increased contrast and brightness.

SANTI APOSTOLI (ROME)



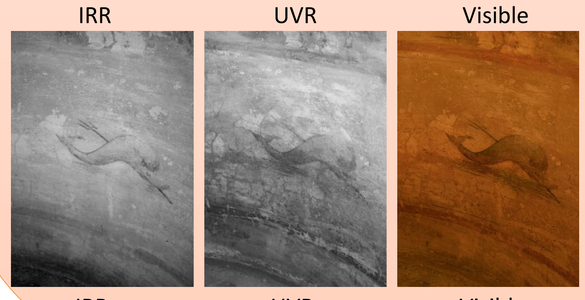
IRR UVR Visible

Crypt (1): UVR evidences the intervened application of a protective film due to a restoration intervention – probably an organic compound with a strong UV absorption (365nm). The same compound does not appear in other portions of the crypt, apparently yet unrestored. The presence of this protective glaze frustrates any further consideration, as far as UVR is concerned. In IRR, a shadow appears near the eyes, possibly due to a later touch-up.



IRR UVR Visible

Crypt (2): in this area, no restoration yet occurred. In UVR, both horizontal bands look dark, whereas in IRR only the lower one is evident. This points to the possible presence of hematite (Fe2O3; UVR absorbent and transparent to IRR) plus a black, possibly carbonaceous pigment (both UVR and IRR absorbent), responsible for the darker hue of the lower band.



IRR UVR Visible

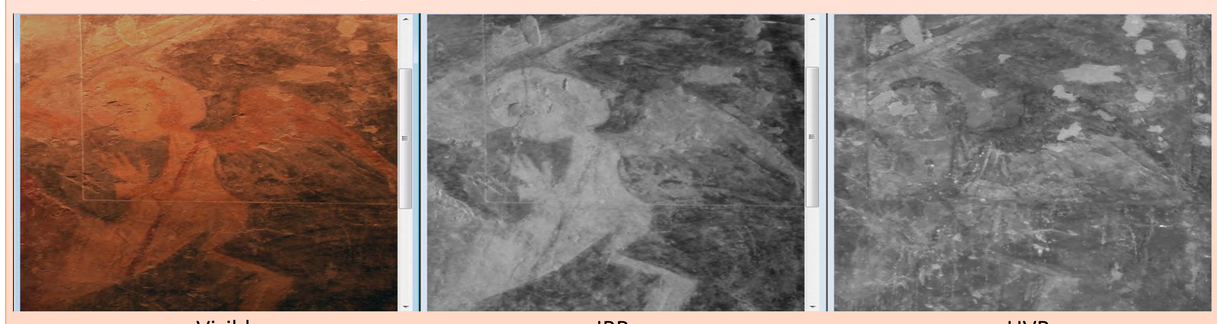
Crypt (3): in a different part of the crypt, the horizontal bands react to IRR and UVR exactly as above. The IRR image shows darker contours (almost black) for both the dolphin and the trident, possibly obtained by using a carbonaceous black pigment. On the other hand, both IRR and UVR suggest that in the lower part of the dolphin, hematite could have been used.

Acknowledgement Federica Di Napoli and padre Aniello for the authorization

SANTA MARIA ANTIQUA - FORO ROMANO (ROME)

Visible IRR UVR

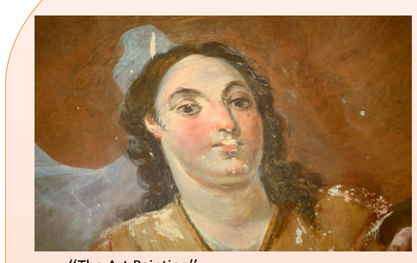
S.M. Antiqua, fresco during restoration: in all images, an area undergoing restoration is visible in the upper right corner – whose details are better appreciated in the UVR image (see below). In addition, UVR also shows some possible paint dripping on the right side, not evident by IRR.



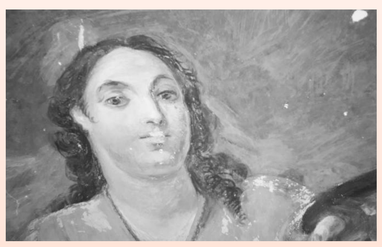
Visible IRR UVR

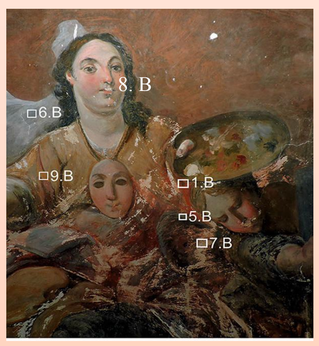
S.M. Antiqua, fresco, magnification of the restored area: the area undergoing restoration shows, when observed in UVR, some details that are not appreciable in visible light (e.g., in the face as well as in the thumb, possibly subjected to subsequent touch-ups). This might be due to the presence of specific, highly UV absorbent pigments (i.e., hematite) in the flesh-coloured areas. The same UVR image shows that the "cleaning" effect due to restoration is highlighted by the use of this specific radiation.

SALA VACCARINI (CATANIA)

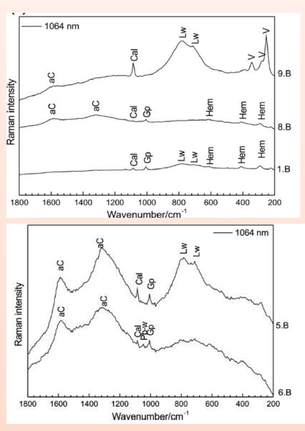


"The Art Painting"





The comparison between visible and IRR images suggests the use of Fe-bearing pigments (hematite) for the flesh color, characterized by high IRR reflectance. This hypothesis is confirmed by raman analysis (see 8B).
The dark and gray areas (hair and face contour) were obtained with prevalent use of carbonaceous pigment as observable by the raman spectra (see for example 6B).
Finally, the IRR image doesn't highligth preparatory draw and touch ups.



Raman spectra collected in the medallion representing "The Art Painting" by using 1064 - nm line on a: skin color (point 8.B),
reddish layers (points 1.B and 9.B) and grayish layers (points 5.B and 6.B)
aC= amorphous carbon, Cal= calcite, Gp= gypsum, Hem=hematite, Lw =limewash, V= vermillion, Pb-w= lead white

CONCLUSION

The reported examples of Roman wall paintings and Baroque frescoes highlight that the combination of VIS, UV-reflected and IR-reflected imaging represents a powerful pre-diagnostic tool for the screening of artworks. This method allows in fact a quick, non-destructive and contactless recognition of portions of paintings hardly detectable in other ways, related to degradation, subsequent touch-ups or improper restoration interventions. Moreover, the analytical results contribute to the identification of different pigments and allow circumscribing those areas in which organic or inorganic protective products were eventually used.

In conclusion, this approach allows a feasible planning of the subsequent diagnostic, conservation and restoration studies.

References

- Barone, D. Bersani, A. Coccato, D. Lauwers, P. Mazzoleni, S. Raneri, P. Vandenabeele, D. Manzini, G. Agostino, N. F. Neri Nondestructive Raman investigation on wall paintings at Sala Vaccarini in Catania (Sicily). Appl. Phys. A (2016) 122:838 DOI 10.1007/s00339-016-0370-7.
- N. Buzgar, A. Buzatu, A. Apopei, V. Cotiuga˘, Vib. Spectrosc. 72, 142 (2014)
- A. Deneckere, W. Schudel, M. Van Bos, H. Wouters, A. Bergmans, P. Vandenabeele, L. Moens, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 75, 511 (2010)
- P. Vandenabeele, J. Raman Spectrosc. 35, 607 (2004)