EARTH SCIENCE AND MODERN-CONTEMPORARY ART: FINGERPRINTS FOR THE SAFEGUARD OF ARTWORKS IN VIEW OF FINE ARTS TRANSPORTATION

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INTRODUCTION

In cultural heritage domain, it has known that artworks, in addition to be studied by historical-artistic and stylistic points of view, could be examined taking advantage from scientific disciplines.

Among different search fields, various disciplines of Earth Science also offer a valid contribution in the sector of the cultural heritage in support to archaeological studies, material analysis performed on rocks, gemstones, etc. Moreover, if we consider, that inorganic pigments are usually obtained by grinding natural stones (*i.e.*, natural Ultramarine blue by lapis lazuli) and earth (Green earth, ochre, etc.) or produced by artificial processes of some mineralogical phases (*i.e*. White titanium dioxide), it is easy to understand that also the Earth Science could contribute to study paintings deepening, *i.e*. for the identification of pigments through mineralogical phases.

In addition, these information could be useful both to project optimal maintenance and restoration actions on Cultural Heritage and to support research about artworks' dating and study of authentication.

In fact, considering that the discrimination and characterization of paintings, usually based on classical humanistic approach (*e.g*., historical-artistic criteria and stylistic-aesthetic information), do not always allow to accurately differentiate the originality of artworks, the identification of materials and artistic techniques may give additional information in support to this kind of studies.

Authentication and dating studies of painting are, in fact, two of the most difficult researches, especially for modern and contemporary artworks. Historical-artistic-stylistic studies, designed for false artworks' identification, are increasingly followed by chemical and spectrographic analyses that allow the material characterization of support and painting, underlining the important role of "dating pigments". These concepts are very often applied for the recognition of false or remakes of ancient artworks, but they are not very reliable when artworks were made near the periods of production and/or commercial introduction of some of these pigments, which are currently used in restoration. In fact, the most common used "dating pigments" are the artificial pigments, produced with the advent, in the 18th century, of new technologies; for these reasons, in modern and contemporary art, the analysis of pigments focused only to the simple identification of pigments (*i.e*, White titanium dioxide) cannot be always enough, preferring a deeper analysis of pigments, which may allow to recognize the mineralogical phases within the pigment and the trace of the production methods, in order to compare data with detailed chronological table and results obtained in other artworks considered as datum-point (*e.g.*, White titanium dioxide pigment; Fitzhugh, 1997).

Moreover, considering that nowadays the replacement of original paintings with perfect copies is among new sly art-thefts and that a painting or a mobile artwork increases its value also in correlation to the number of art-exhibition, the handling of artworks for art-exhibitions around the world can increase the problems linked to this aspect. Even if this problem is very common, the assurance agencies usually require only some general information (owner, economic value, title, artist, etc.) as well as the drafting of *condition report*, a document used for fine art transportation, do not request details on materials.

In the last years, lots of scientists have tried to propose new solutions for the safeguard of artworks taking advantage by important scientific equipments (*i.e*., Elettra-Synchrotron light source) and exploiting new anti-counterfeiting/proof marks (Bollanti *et al.*, 2012). Considering that marking the surface or applying tags, barcode, RFID systems, etc., are not always allowed for all artworks, especially for paintings, it is interesting to propose other possible solutions.

Considering that artworks are unique and consequently also the surface and the chemical composition of materials of these masterpieces are unique, the search of microscopic features, that are punctual placed and difficultly reproducible, is very important to establish the authenticity and uniqueness of artwork, becoming a further possible solution in order to prevent forgery and unpleasant replacement.

RESULTS

The study carried out in this Ph.D. thesis focused its attention to the identification of the microscopic characteristics - *ArtFingerprints* - (not only pigments but also pictorial peculiarities of artistic technique, trace of restoration acts, structural and material characteristics, etc.), that, in addition to support historical-artistic studies (*e.g.*, dating, artistic techniques, etc.), could be useful also for the safeguard of painting in view of fine arts transportation. The creation of a database containing all the *ArtFingerprints* and taking note of their spatial coordinates on the paintings during the analysis, allows to obtain a "painting's identity card" that could follow the artworks during its transportation. In this way, the exact correspondence between point analysis and *ArtFingerprints* could define if the artworks analyzed today are the same as the one that it was originally studied in the past (*i.e.*, before fine art transportation) and so if there could be a painting's replacement. Further benefit of this methodological procedure is that, knowing the exact position of point in previous analysis, it is possible to examine, with major precision, the same point analysis by different non-invasive and complementary scientific techniques. This allows to better understand analytical data and to carry out analysis after time, particularly useful to control conservative condition and originality of artworks.

The identification of *ArtFingerprints* at microscopic level was tested, through multi-analytical approach, both on pictorial specimens taken from painting (in a not-repainted area and where conservative condition allowed the sampling) made by national and international artist (J.S. Sargent, P. Picasso, A. Modigliani) and on entire painting which artist attribution and dating studies are currently in progress (G. Boldini, F. De Pisis). Considering the uniqueness of analyzed paintings and samples, the analytical procedure began using non-invasive techniques (for paintings) and finished carrying out non-destructive analysis in order to preserve samples for further analysis.

Taking advantage from methodologies usually used in Earth Science disciplines, this research focused its attention to *ArtFingerprints* based on pictorial surface, its morphology and on in-depth pigment analysis.

For the investigation of *ArtFingerprints* concerning the morphology and pictorial layer, microscope investigation demonstrated to be very useful for the detection of μ-sized features characterizing brushstrokes, conservative condition (*craquelures d'âgé* and *craquelures prématurée*), etc. (Fig. 1).

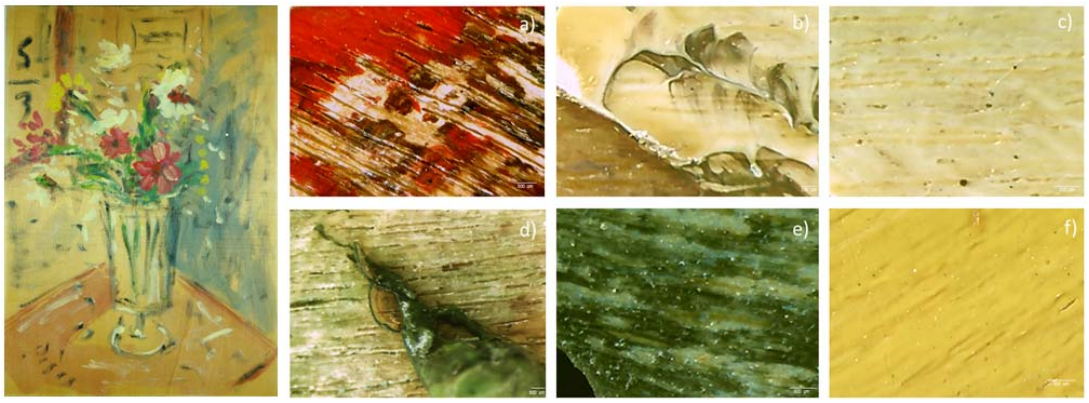

Fig. 1 - *Flowers in glass vase* (oil on wood, 1945 - F. De Pisis?). Observation under stereomicroscope at different magnification: a) micro-photographs of color painting and wooden panel (magnification = 40×); b) d) brushstroked enriched in matter; c) e) micro-photographs of color painting (magnification = 45×); f) microphotographs of color painting and μ-craquelures (magnification = 60×).

Image processing, carried out taking advantage of a software that is usually used in Earth Science, allowed a good elaboration of data obtained by multispectral imaging (Fig. 2), in particular useful for the choice of point analysis. Analysis of pictorial film, that began with in-depth study of chemical composition, employing several techniques (EDXRF, PIXE, SEM/EDS), was supported by other analytical techniques to obtain more precise information about the identification of pigment and mineralogical phases (μ-Raman, XRD). Even if it was not always possible to apply the above mentioned multi-analytical suite to whole artworks, the study carried out on few μ-samples allowed to detecting *ArtFingerprints*, without damaging (or modifying) specimens, in order to preserve them for further analysis (*e.g.*, μ-XRD, XRD-XRF on the same samples).

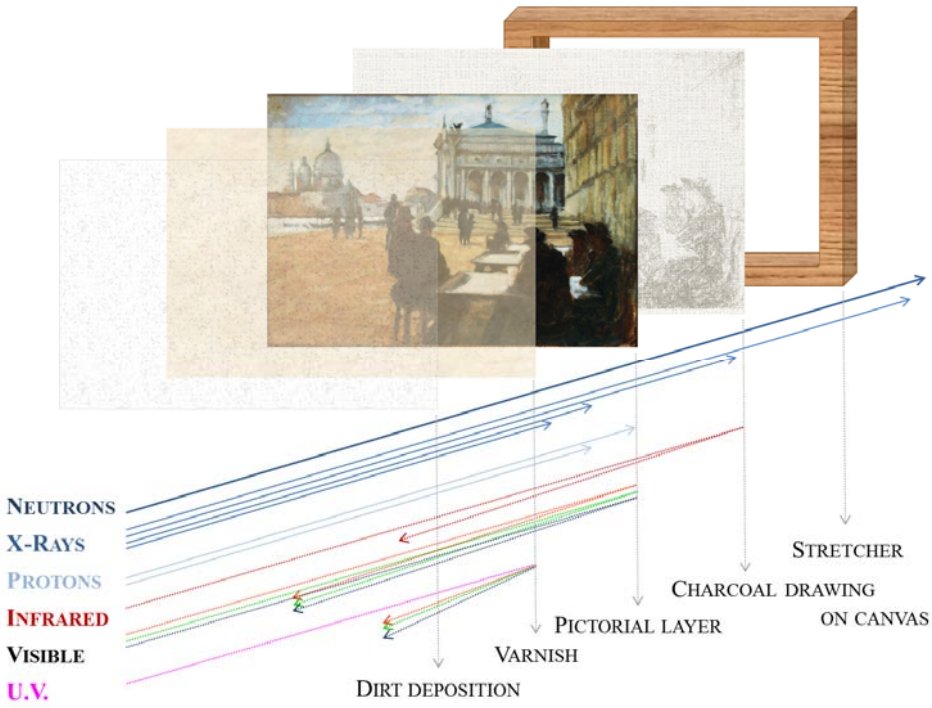

Fig. 2 - *Caffè Orientale sulla Riva degli Schiavoni* (J.S. Sargent, oil on canvas): schematic representation of the different penetration depth and layers probed by various analytical techniques that employ diverse radiation and particle source (reworked from Leonardi, 2005).

The scientific contribution of these techniques demonstrated to be particularly useful for the study of painting structure-texture and, especially, for the chemical-mineralogical identification of inorganic pigments. In-depth pigment analysis based on to the identification of the mineralogical phases, contained in pigment compounds, allowed to detect some characteristic features that, sometimes, are not detected with routine pigment analysis. For instance, a deep pigment analysis on Green Earth pigment, that is a natural mixtures of minerals (in the majority green minerals), may allow to characterize the heterogeneous mineralogical compositions, especially for artificial compounds which composition is mainly linked to secret patents and commercial companies (Eastaugh *et al*., 2008). In this way, the identification of the pigment's mineralogical composition can be considered as an *ArtFingerprints*. In samples taken from *Flowers in glass vase* (F. De Pisis), in-depth pigment analysis allowed to suggest the use of Green Earth pigment composed identifying several minerals such as celadonite.

Moreover, the study carried out on white samples brought interesting results, especially for the White titanium dioxide pigment. This pigment, used in artistic pigment compound since earlier 20th century, is usually considered dating pigment for ancient and modern artworks. Its effectiveness, as dating pigment, encounters

difficulties for dating studies of modern and contemporary artworks, in which White titanium dioxide pigment can be one of the material employed for the paintings. For these reasons, the identification of the mineralogical composition of the analyzed white titanium dioxide pigment can be useful both as *ArtFingerprints* and in support of dating studies.

Pigment analysis carried out on white titanium dioxide-bearing samples revealed the presence of rutile and anatase in the analyzed artworks (Fig. 3, 4).

Fig. 3 - *Caffè Orientale sulla Riva degli Schiavoni* (oil on canvas, 1880/1882? - J.S. Sargent), sampling point: a) microphotograph of sample; b) SEM image of sample (Bruni *et al.*, 2012).

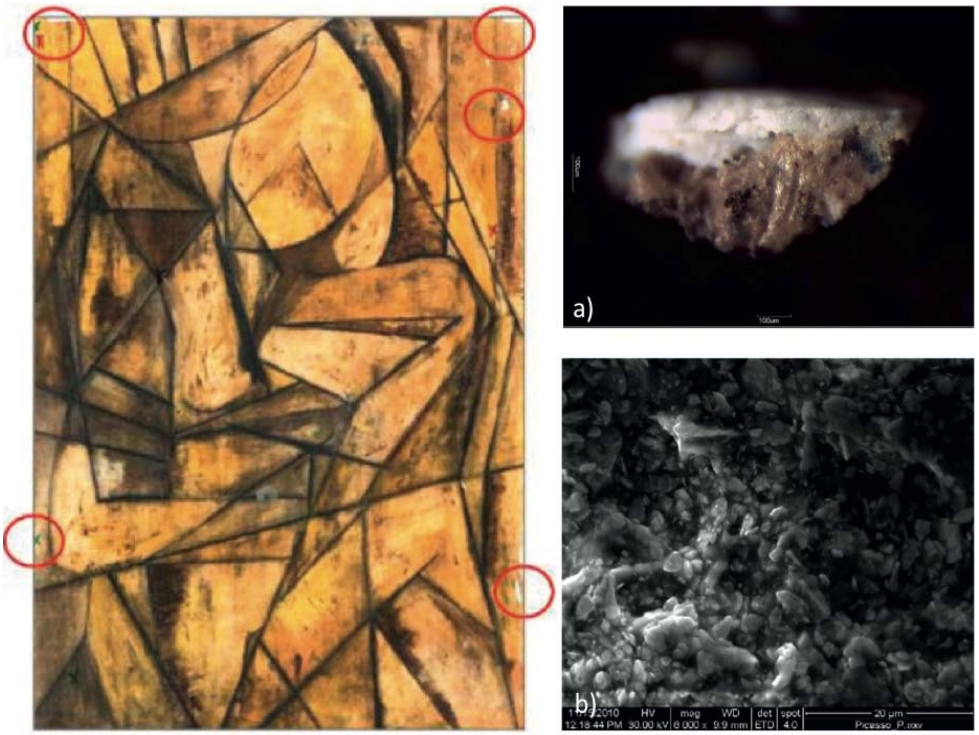

Fig. 4 - *Cubist Figure* (oil on canvas, 1909 - P. Picasso), sampling point: a) microphotograph of sample; b) SEM image of sample (Bruni *et al*., 2012).

Considering the history of use of Titanium White Pigment, it is possible to suggest different *post-quem* achievement date according to the purity and morphology of pigment based on anatase or rutile. For istance, the production of $TiO_2/BaSO_4$ (rutile form), of $TiO_2/CaSO_4$ (rutile form) or of high quality pigment (pure rutile pigment with particle size around 0.3 μm) suggest respectively three following *post-quem* date: 1939, 1941, 1957 (Eastaugh *et al*., 2008; McCrone, 1994; Leonardi, 2005; Lewis, 1987; Fitzhugh, 1997).

In conclusion, this research belongs to the cognitive path in which Earth Science know-how can be transferred to cultural heritage domain. The *ArtFingerprints* set, identified for each studied artwork through methodologies used in Earth Science's disciplines, could be useful for assurance policy, creating a more detailed and interactive condition report, to assist art-historical studies and art investigations on attribution decision and for future restoration and maintenance actions.

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