

# Evaluation of the veracity of one work by the artist Di Cavalcanti through non-destructive techniques: XRF, imaging and brush stroke analysis



E.A.M. Kajiya<sup>a,\*</sup>, P.H.O.V. Campos<sup>a</sup>, M.A. Rizzutto<sup>a</sup>, C.R. Appoloni<sup>b</sup>, F. Lopes<sup>b</sup>

<sup>a</sup> Instituto de Física da Universidade de São Paulo; Rua do Matão, Travessa R, 187, São Paulo, SP, Brasil

<sup>b</sup> Universidade Estadual de Londrina, Departamento de Física, Grupo de Física Nuclear Aplicada, CEP 86055-900, Caixa Postal 6001, Londrina, Paraná, Brasil

## HIGHLIGHTS

- Identification of the forgery of an easel painting of Di Cavalcanti.
- Diagnosis for ascertaining the authenticity of the work entitled “Violeiro” (1950).
- X-Ray fluorescence spectroscopy and image analysis.
- Image analyses allow some identification as hidden underlying lines.
- Materials and techniques not characteristic of the artist.

## ARTICLE INFO

### Article history:

Received 26 October 2012

Accepted 5 March 2013

Available online 4 April 2013

### Keywords:

X-ray fluorescence

Easel painting

Image analysis

Brush stroke analysis

## ABSTRACT

This paper presents systematic studies and analysis that contributed to the identification of the forgery of a work by the artist Emiliano Augusto Cavalcanti de Albuquerque e Melo, known as Di Cavalcanti. The use of several areas of expertise such as brush stroke analysis (“pinacologia”), applied physics, and art history resulted in an accurate diagnosis for ascertaining the authenticity of the work entitled “Violeiro” (1950). For this work we used non-destructive methods such as techniques of infrared, ultraviolet, visible and tangential light imaging combined with chemical analysis of the pigments by portable X-Ray Fluorescence (XRF) and graphic gesture analysis. Each applied method of analysis produced specific information that made possible the identification of materials and techniques employed and we concluded that this work is not consistent with patterns characteristic of the artist Di Cavalcanti.

© 2013 Elsevier Ltd. All rights reserved.

## 1. Introduction

Introductions of forgeries of the artwork in the market are indeed a practical problem, ethical and financial. It might reflect on erroneous interpretations about the artist and his work. The artist Emiliano Augusto Cavalcanti de Albuquerque Melo (1897–1976), known as Di Cavalcanti, is a Brazilian painter, caricaturist and illustrator whose artworks are frequently forged. His esthetic and artistic technique is marked by definition of volumes, the richness of the colors, the luminosity, and the use of themes related to his daily life (Almeida, 2007; Goldenberg, 1985). The light is outstanding, the bright and dark preponderant over the color, blacks outlining the shapes, and colors with reds, yellows and greens used to enhance the brightness.

The intersection of several sciences such as “pinacologia”<sup>1</sup>, graphoscopy<sup>2</sup>, applied physics and art history produces a detailed study of the brush stroke, graphic gesture and the elemental composition of the artwork allowing an accurate diagnosis of the ascertaining authorship. This paper presents systematic studies and analyses that helped to identify the forgery of the painting “Violeiro”, which was attributed to Di Cavalcanti.

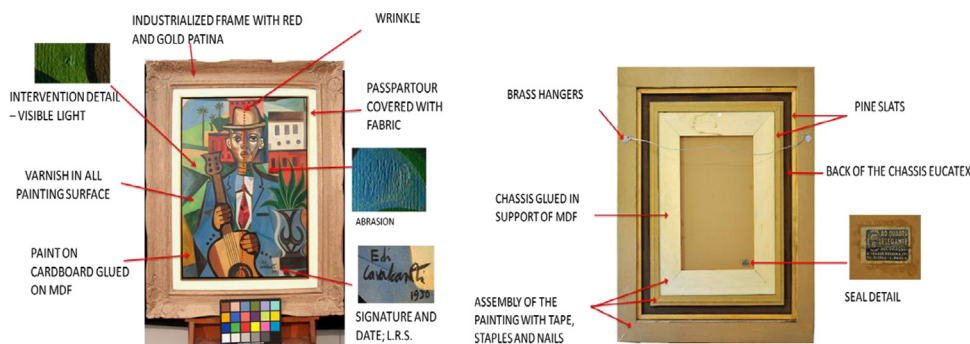
In the certificate of authenticity, which accompanies the artwork, has the following technical information: Artist: Di Cavalcanti, Emiliano; Dimensions: 81 × 60 cm<sup>2</sup>; Title: Violeiro; Technique: o/s/p (oil on paper), year: 1950, a.c.i.d. (signature in the right bottom corner).

<sup>1</sup> “Pinacologia” is the investigation of the characteristic features of paintings. It is the study of physical characteristics, dimensions, shapes, textures and graphic and artistic expression that can be noticed from the imprint of the brushwork that is generated by its prints and depth (Gumi, 2007).

<sup>2</sup> Examination for handwriting recognition by collating details of the letters.

\* Corresponding author. Tel.: +55 11 994568408.

E-mail address: [elizabethkajiya@gmail.com](mailto:elizabethkajiya@gmail.com) (E.A.M. Kajiya).



**Fig. 1.** High resolution photography with visible light. The signaled points reveal some anomalies found in the artwork attributed to Di Cavalcanti. Left: image of the front part. Right: image of the back part.



**Fig. 2.** Photography with grazing light at the indicated points that reveals some characteristics of the artwork attributed to Di Cavalcanti.

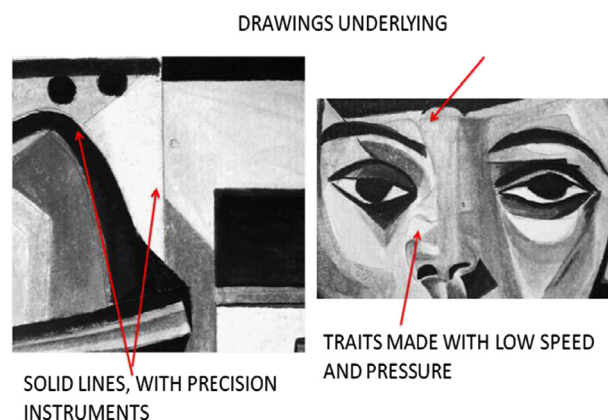
## 2. Methods and results

In this work, documentary and bibliographic studies on the artist as well as instrumental analyses with non-destructive analytical methods such as imaging infrared reflectography (IR), fluorescence with ultraviolet radiation (UV), visible and tangential light and optic digital microscope ( $400\times$ ), portable X-ray fluorescence and brush stroke examinations were carried out. For obtaining confrontation patterns, artworks with techniques of paintings on paper and canvas, from distinct periods (1920–1950), belonging to the collections of the Institute for Brazilian Studies of the University of São Paulo (IEB-USP) and the Pinacoteca of São Paulo were also analyzed. The analyses were applied systematically to cataloged artworks of Di Cavalcanti such as “Loira Sentada” (1926), gouache on paper, “Paqueta” (1926), gouache on cardboard, “Retrato de Moça” (1921), oil on cardboard, “Figuras de Animais” (1954), oil on canvas and to the respective suspect painting “Violeiro”.

The painting attributed to Di Cavalcanti was imaged with a high resolution digital camera in visible light allowing evaluation of the state of conservation and detection of several anomalies in the object as shown in Fig. 1.

Imaging with tangential light enhanced the presence, in the support, of textures due to the kind of paper and a folding clearly visible as show shown in Fig. 2.

The infrared reflectography technique (IR) employed a high resolution digital camera which operates from the upper UV region to the low IR region (380–1000 nm), with IR filters coupled to the lens. The fundamental characteristic of this system is the ability to clearly visualize, in terms of spatial resolution, the details of the underlying drawings (Gargano et al., 2007). The results



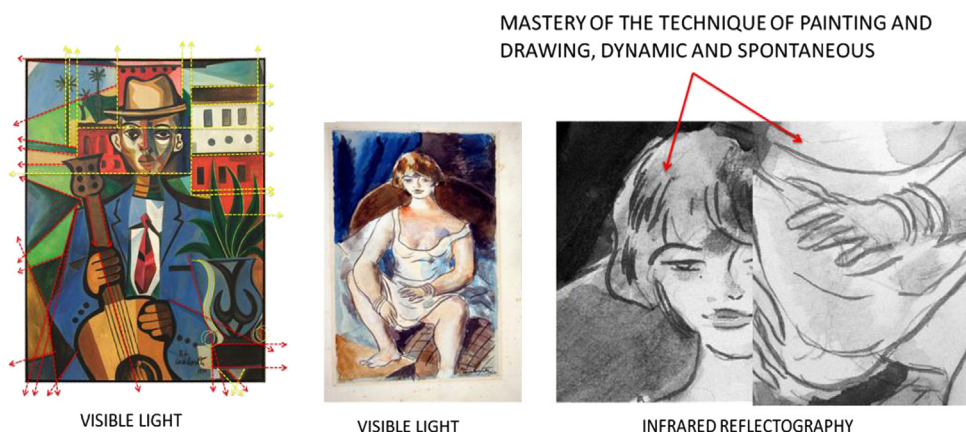
**Fig. 3.** Photography with infrared reflectography (IR) technique and also the marked points that reveal some graphic-artistic gesture that characterize this artwork attributed to Di Cavalcanti.

obtained with this technique showed underlying drawings (Fig. 3) that were drawn with low velocity and pressure (Pellat, 1927) that means slow and not vigorous execution different of the characteristics Di Cavalcanti artwork. Some features of the graphic-artistic gesture were also observed, particularly indicating the use of drawing instruments to make some marks.

Fig. 4a also highlights these analyses, which show continuous, parallel and symmetrical lines with duplicates and mirrored shapes that are completely different of the “Loira Sentada”, a standard work of Di Cavalcanti, a gouache on paper made in 1926 belonging to the collection of the Institute for Brazilian Studies of the University of São Paulo (IEB-USP). This artwork has features of dynamic and spontaneous traces, speed and the domain of techniques of graphic-artistic gesture and painting as shown in Fig. 4b.

The UV photographic technique is based on ultraviolet-fluorescence and phosphorescence of the ink layer in the visible range. To avoid overlapping with the visible light reflectography, the only lighting sources are UV lamps. The fluorescence signal manifests itself as colorful lights, of low frequency, and intensities with different shades of violet, pink green and others, that are characteristic of the materials. Some pigments with binders such as linseed oil are fluorescence-inhibitors, others stimulate fluorescence and others do not generate any fluorescence in the paint, such as some red pigments (Stuart, 2007; Pelagotti et al., 2005). The strong UV fluorescence observed in the red pigment of the “Violeiro”, shown in Fig. 5, is not consistent with the fluorescence properties of known red pigments cataloged by Stuart (2007).

Several pigments of an artwork attributed to Di Cavalcanti were analyzed by Energy Dispersive X-Ray Fluorescence spectroscopy (EDXRF). The 27 spots submitted to analysis are indicated in Fig. 6



**Fig. 4.** Details of analyzed objects showing some graphic-artistic gesture (a) left: photograph with visible light of the artwork “Violeiro” and (b) photograph with visible and infrared reflectography (IR) light of “Loira Sentada”.

#### VISIBLE FLUORESCENCE WITH ULTRAVIOLET LIGHT



**Fig. 5.** Photography with ultraviolet light emphasizing the fluorescence of the red pigment.



**Fig. 6.** Photography of the artwork attributed to Di Cavalcanti with the select areas measured with EDXRF.

and were distributed in different colors pigments. EDXRF consists in exciting the chemical elements of a sample to emit their characteristic X-rays, allowing the identification and quantification of the elements presents in each pigment. Portables X-ray fluorescence equipment are convenient to be used in museums and the employed apparatus consists of a mechanical support, specially designed to accommodate a mini X-ray tube with a silver anode coupled to a 50 mm Ag filter (used for the excitation of the sample) and an X-ray Si-PIN detector (171 eV FWHM @ 5.9 keV), making an angle of 90° with each other. The system has three degrees of freedom: linear, rotational and angular. The measurements used 28 kV voltage applied to the tube, 4  $\mu$ A of tube current with an excitation/detection time of 500 s (live time).

Table 1 summarize the elements that were found in each pigment analysis. The XRF analysis showed the presence of Fe, Zn, Ti and Ca in all analyzed spots. Copper element is usually associated to green or

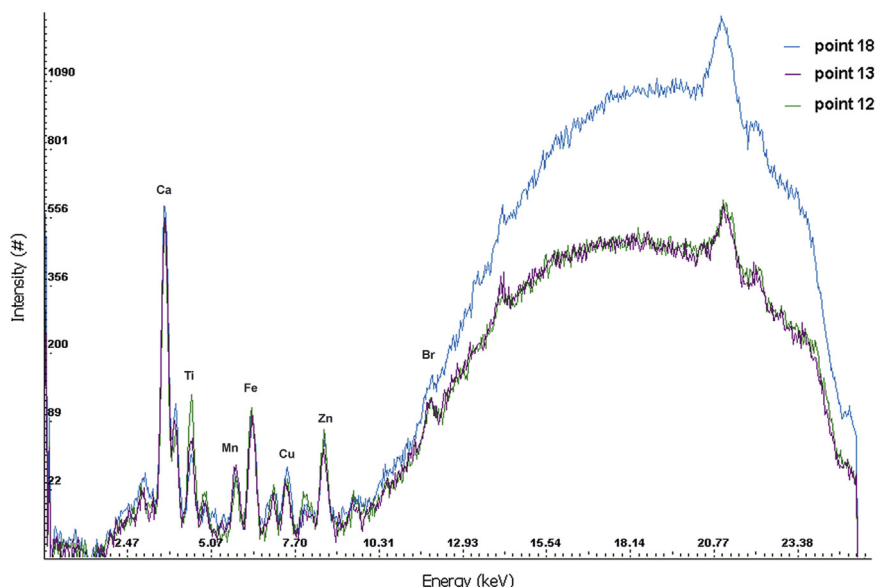
blue pigments (Stuart, 2007) and is present in all areas analyzed except in the brown color. At point 24, the top left yellow stripe, showed the presence of Ba but not Cr, the key element to identify barium yellow pigment, BaCrO<sub>4</sub> (Stuart, 2007). At this point, Ba can only be associated to barium sulfate white, BaSO<sub>4</sub>, and the yellow pigment is probably an organic pigment. The comparison between the XRF spectra of the red spots (12, 13 and 18) shown in Fig. 7, showed similar features until approximately 12 keV, and a broad structure due to the inelastic scattering of the tube X-rays. This Compton scatter structure, present in other spectra of the analyzed spots in this painting, is probably due to an organic matrix used in the pigments of this painting in disaccord to its certificate that says that the “Violeiro” should be oil on paper. Also, the comparison of the X-ray spectra obtained of the red pigments of Di Cavalcanti artworks in gouache (“Paqueta”), oil (“Retrato de moça”) and in the “Violeiro”, as shown in Fig. 8, present complete different



**Table 1**  
Studied colors on the painting and the respective elements determined.

Color	Point	Ca-K	Fe-K	Ti-K	Ba-L	Cu-K	Sr-K	Zn-K	Mn-K	Ni-K	Br-K
Ocher	1	X	X	<sup>a</sup>	X	X	X	X			
	5	X	X	X				X			
Blue	3	X	X	X		X		X			X
	7	X		X							
Brown	19	X	X	X		X		X	X		
	22	X	X	X		X		X			
	4	X	X	X				X			
Red	6	X	X	X				X			
	12	X	X	X		X		X	X		X
Green	13	X	X	X		X		X	X		X
	18	X	X	X		X		X	X		
	11	X	X	X		X		X	X		X
	16	X	X	X		X		X	X		X
White	17	X	X	X		X		X	X		X
	20	X	X	X		X		X			
	21	X	X	X		X		X			
	25	X	X	X		X		X			X
	15	X	X	X		X		X			X
Yellow	23	X	X	X		X		X	X		
	28	X	X	X		X		X			
	29	X	X	X		X		X	X		
	24	X	X	<sup>a</sup>	X	X		X			
Pink	26	X	X	X		X		X	X		
	27	X	X	X		X		X	X		
Bordeaux	14	X	X	X		X	X	X	X		X
Black	2	X	X	X		X		X		X	X

<sup>a</sup> Small.



**Fig. 7.** Spectra comparison of the red pigments (points 12, 13 and 18) obtained with EDXRF measurements at “Violeiro” painting.

characteristics suggesting that the “Violeiro” is in disagreement with the oil and gouache artwork studied here. Additionally, Fe and Br measured here in modern organic red pigments (not published) were also identified in the red spots in this artwork. Di Cavalcanti cataloged artworks show Pb and Hg in the red pigments, not measured in the present work.

### 3. Conclusions

The advantages of using photographic techniques with different wavelengths and with different methods resulted in relevant

information about the artworks. Photographs with visible light can register, allowing a careful observation, the conservation status of the artwork; graphic gestures of writing and strokes; composition; stylistic details; color palette; interventions; textures and varnish. The photograph with visible light was useful as a comparative instrument with other techniques.

The results obtained with the infrared (IR) reflectography technique showed underlying drawings that were drawn with slow and not vigorous execution different of the characteristics Di Cavalcanti artwork. The features of the graphic-artistic gesture observed in “Violeiro” are different of the others artworks analyzed and suggest the use of drawing instruments to make this painting.

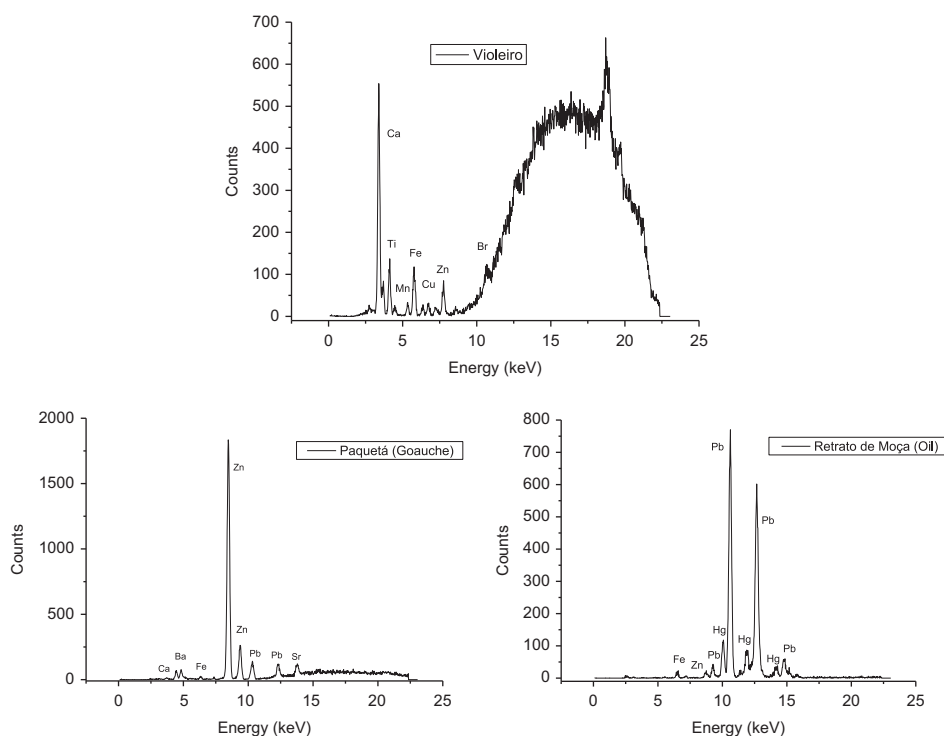


Fig. 8. Spectra comparison of the red pigments of different Di Cavalcanti artwork in gouache (“Paqueta”) and oil (“Retrato de moça”) paintings.

The examination of the image obtained with the ultraviolet-fluorescence in the visible range clearly indicated a contradiction with the technique used in this artwork, mentioned in the certificate as oil on paper. The strong UV fluorescence observed in the red pigment of the “Violeiro”, is not consistent with the fluorescence properties of known red pigments.

XRF spectra of the red pigments of the artwork attributed to Di Cavalcanti were compared with those obtained in standard works. It is possible to see the difference in the high energy part of each spectrum that is related to the Compton scattering due to the matrix organic matter. The structure of the red pigment spectrum measured in the “Violeiro” is not compatible with the red oil pigment spectrum measured in the artwork “Retrato de moça”. The measured red pigments in the cataloged works also have the element Pb and Hg, not seen in “Violeiro”. The elements Fe and Br were identified and measured in the red pigment of this artwork and in modern organic pigments. Additionally, as we observed in the UV image (Fig. 5) of the “Violeiro” the red pigments have a high fluorescence and this is in contradiction with the Fe present in oil pigment thus indicating that this artwork, did not use the oil technique.

As a result, it became possible to identify the materials, underlying drawings and graphic-artistic gestures in the work in question, featuring a specific “fingerprint” which does not fit the profile of Di Cavalcanti. So, it was found to be a false artwork.

## Acknowledgment

The authors would like to thank FAPESP and CNPq for financial support and also to the Institute for Brazilian Studies (IEB-USP)

and Pinacoteca for the use of some artwork from its collection. The authors also thank V.D. Muniz for his suggestions and comments in the graphoscopy area.

## References

- Almeida, M.B., 2007. *As Mulatas de Di Cavalcanti: Representação Racial e de Gênero na Construção da Identidade Brasileira (1920 E 1930)*. (The Afro-Brazilians of Di Cavalcanti: Racial and Feminism Representation in the Molding of the Brazilian Identity). M.S. Thesis Presented to the History Department of the Universidade Federal do Paraná, Curitiba.
- Gargano, M., Ludwig, N., Poldi, G., 2007. A new methodology for comparing ir reflectographic systems. *Infrared Phys. Technol.* 49, 249–253.
- Goldenberg, S.S., 1985. *As Brasilidades de Di Cavalcanti (Brazilian Customs of Di Cavalcanti)*. Amaral, Aracy (Org.) Drawings of Di Cavalcanti in the Collection of the Museu de Arte Contemporânea of the Universidade de São Paulo. il. p.b. Color, MAC, São Paulo, 221 p.
- Gumi, J., 2007. *La Pinacologia: Investigacion De Les Pinzellades Personals Dels Artistes Pictorics*. Farell, (Ed.), Barcelona.
- Pelagotti, A., et al., 2005. A Study of UV Fluorescence Emission of Painting Materials. *Istituto Nazionale di Ottica*, (<http://www.ino.it/home/lella/pdf/>), (accessed 28.10.11).
- Pellat, Edmond-S., 1927. *Les Lois de L'écriture*, Paris, Vulbert ([http://www.grafologiauniversitaria.com/intro\\_forensic\\_handwriting.htm](http://www.grafologiauniversitaria.com/intro_forensic_handwriting.htm)), Carrera, F.V., Balsells, M. L.P. (Eds.), *An Introduction to Forensic Handwriting analysis*, (<http://www.grafoscopia.com.br/artigos-grafoscopia/>), (accessed 26.07.11).
- Stuart, B., 2007. *Analytical Techniques in Materials Conservation*. John Wiley & Sons Ltd., England.