Magnetic memory of oil paintings

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The color in oil paints is obtained sometimes from magnetic minerals. This fact implies that oil paintings could present an intrinsic magnetization. Magnetic imaging of an oil painting consists in the measurement of magnetic flux related to the magnetization of the painting. In this report results of magnetic measurements show that oil paints from different manufacturers (Maimeri, Pebeo, and Grumbacher) are magnetic. The magnetic imagings of four similar oil paintings done with the same visual color, obtained using different mixtures of oil paints for each painting, were different. This shows that the magnetic imaging can be used as a fingerprint for the oil paintings. Magnetic imaging was obtained for oil paintings done by Oswald, Bianco, and Timoteo, all of them are Brazilian painters. The imaging obtained in measurements at different times was always the same, showing that the magnetic images are stable. This leads to the conclusion that magnetic imaging would be a common authentication technique of paintings. *© 2007 American Institute of Physics*.
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I. INTRODUCTION

The American Institute for Conservation of Historic and Artistic Works states that conservation is an activity devoted for the future preservation of humanity's legacy. These activities include examination, documentation, treatment, and preventive care. Sometimes conservation and preservation are not distinguished. Conservation activities are necessary for the authentication of paintings because they preserve their original structure. Similar to conservation, authentication also has the objective of future preservation because it avoids the faking of fine art pieces.

It is usual to hear about paintings stolen from museums or private collections, and eventually these paintings are found or returned. How can one be sure that the returned painting is the original one, and not a forgery? The methods used nowadays to verify the authenticity of art works involve experts on the artist's brush stroke and physical and chemical techniques such as photography, x-ray, optical spectroscopy, synchrotron radiation, and many others.[1–3] But even those physical and chemical techniques require the opinion and experience of art specialists.

A unique technique for the authentication of oil paintings, based on the acquisition of the magnetic image of the work piece, was proposed by Costa Ribeiro *et al.*[4] This technique is based on the fact that the color in oil paints usually comes from magnetic minerals, which are the source of an intrinsic magnetization of the paint. Magnetic measurements are made with a superconducting quantum interference device (SQUID), a device that among other experimental techniques has already been used to measure the minute magnetic field generated by the human heart and the human brain.[5,6] The SQUID is able to detect very weak magnetic fields, such as the ones generated by the magnetic pigments in the paintings. Following the original proposal of magnetic imaging advances in this technique are presented here on oil paintings.

II. EXPERIMENTAL DETAILS

The measurement technique was described elsewhere.[4] It consists of scanning the canvas of the painting using a SQUID magnetometer. The technique is known as scanning SQUID (SSQUID). To avoid any signals from past magnetization, a standard protocol was adopted before the measurement: the painting was magnetized in an approximately homogeneous magnetic field of about 100 G, perpendicular to the canvas plane. The sample was then placed horizontally on a controlled mobile table and the measurements were performed with the SSQUID technique. Measurements with the SQUID magnetometer were made without any external magnetic field, just in the local geomagnetic field. A standard distance of 10 mm between the Dewar containing the SQUID and the sample was used. Magnetization measurements were performed using a second order gradiometer with 15 mm diameter coils and 40 mm base line coupled to the SQUID at 4.2 K. The SQUID signal was detected as a voltage and stored in computer files. The LABVIEW software allows the automatization of the measurement and it controls

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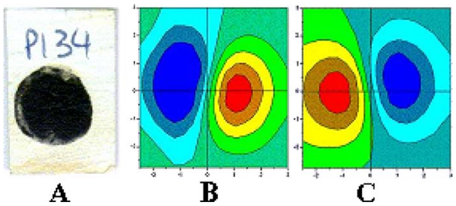

FIG. 1. (Color online) (A) Spot made with the oil paint Grumbacher P134 Mars Black. (B) The magnetic signal of the front view of the spot (as in A). (C) The magnetic signal of the rear view of the spot. Images B and C are in false colors. Bluish colors represent higher positive magnetic flux and reddish colors represent higher negative magnetic flux.

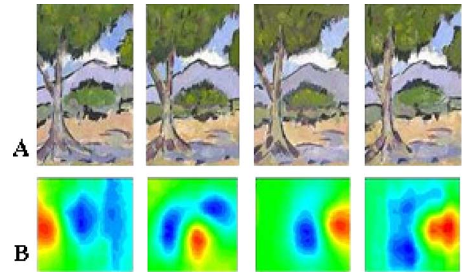

FIG. 3. (Color online) (A) Four apparently similar oil paints produced with different mixtures of colors, causing the same visual effect of color. (B) Magnetic imaging obtained for each oil paint. Below each paint the corresponding magnetic image is shown.

the *X*-*Y* scanning motion of the table where the canvas rests during the measurement.

The magnetism of different oil paints, from different manufacturers and of various brands, was determined as follows: a circular spot of paint was placed on a paper card and left to dry, for magnetic imaging of the spot. When the spot showed a magnetization, the magnetic imaging corresponded, in general, with that of a magnetic dipole.

In order to illustrate the technique used here, Ref. 4 showed how the magnetic signature of three identical black flower pictures painted with different kinds of black paints was determined. Here the magnetic imagines of four similar oil paintings were obtained using the technique. These paintings were produced by one of the authors. All represent the same view of a tree, and the colors used are the same but they were obtained with the mixture of different oil paints, producing the same visual sensation. The magnetic image of every painting was obtained and compared to see if the mixture of paints affects the magnetic imaging. Also, the magnetic images obtained from oil paintings of Bianco (1918-), Oswald (1882-1971), and Timóteo da Costa (1879-1932) are shown as examples of the use of this technique.

III. RESULTS

Previous measurements using the SQUID technique[4] have shown that several oil paints, of different colors, and various brands had magnetic signals with different intensities. Figure 1 shows the magnetic image obtained with the paint spot formed with the Grumbacher Mars Black P134. In this case, the magnetic imaging corresponds to an image generated by a magnetic dipole almost parallel to the plane of the paper card.[7] This figure shows an anisotropy in the intensity of the magnetic flux for each magnetic pole, indicating that, in fact, the magnetic dipole is tilted with respect to the paper card plane. Figure 2 shows the magnetic image of the spot formed with Maimeri Mars Red P248. Here the magnetic imaging corresponds to an image generated by a magnetic dipole almost perpendicular to the plane of the paper card, because also in this case the flux of the magnetic pole observed is not totally symmetrical, indicating that the magnetic flux is slightly tilted with respect to the vertical. All the spots analyzed showed the same behavior: the magnetic image corresponds to tilted magnetic dipoles. This must be related to the nature of the magnetic microparticles mixed in the oil paint, allowing different kinds of packing for every oil color and causing a range of magnetic interactions between these microparticles, and even producing single magnetic domains with a tilted magnetization vector. Almost all the samples analyzed having the Pebeo and Maimeri trademarks were magnetic, showing magnetic dipoles oriented almost parallel to the paper card plane. In the case of the Grumbacher trademark samples, a large percentage of them were not magnetic; those were magnetic showed magnetic dipoles almost parallel or almost perpendicular to the paper card plane, depending on the color. Spots done with Grumbacher oil paints P134, P026, and P071 showed magnetic dipoles almost parallel to the paper card and those done with oil paints P001, P013, P025, and P110 showed magnetic dipoles almost perpendicular to the paper card.

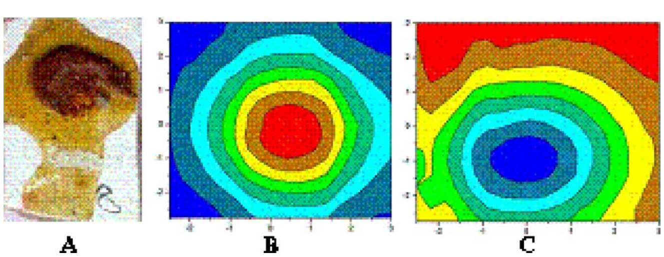

FIG. 2. (Color online) (A) Spot made with the oil paint Maimeri P248 Mars Red. (B) The magnetic signal of the front view of the spot (as in A). (C) The magnetic signal of the rear view of the spot. Images B and C are in false colors. Bluish colors represent higher positive magnetic flux and reddish colors represent higher negative magnetic flux

Figure 3 shows a set of four oil paintings and their corresponding magnetic images. It can be observed that forgeries or copies of an oil paint can be distinguished from the original one by using their magnetic image because all of them are different, showing signals that correspond to different magnetic dipole configurations in the plane of the canvas. Figure 4 shows a magnetic map obtained on the oil painting "Paisagem" done by the well-known Brazilian artist Oswald

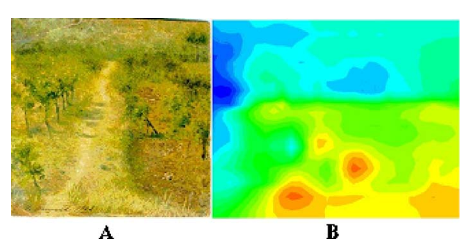

FIG. 4. (Color online) (A) "Paisagem" (from about 1902), an oil painting from Carlos Oswald. (B) The corresponding magnetic image.

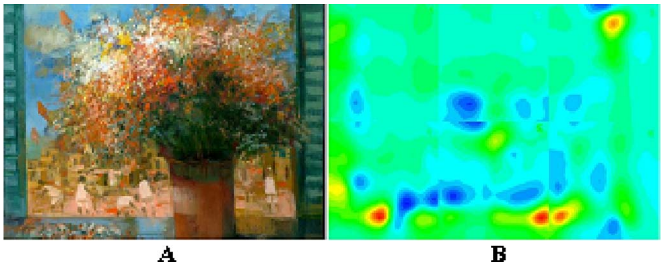

FIG. 5. (Color online) (A) "Composição," an oil paint from Enrico Bianco. (B) The corresponding magnetic image.

(1882-1971). It is interesting to note that this structure is stable in time because different measurements produced the same magnetic map (data not shown). Figure 5 shows the magnetic map obtained from the oil painting "Composição" done by Enrico Bianco, an Italian artist residing in Brazil; he worked with the well-known Brazilian artist Portinari. In this case results show a group of magnetic dipoles distributed on the canvas; their positions were reproduced over different measurements and at different dates (data not shown). Figure 6 shows the magnetic image obtained from an oil painting done by Timóteo da Costa, also a well-known Brazilian artist. As in the other examples, the magnetic image of the painting shows well defined regions with magnetic poles facing the canvas front.

IV. DISCUSSION

The results presented here show that many oil paints from different manufacturers are magnetic, implying that fine art oil paintings are intrinsically magnetic; experiments described here show that this is the case. This important property can be used to characterize physically, in an objective way, an oil painting created by an artist. This technique of authentication could help museums and insurance companies as a preventive measure, where the magnetic imaging of a previously analyzed art piece can be recorded and filed as a reference in case it gets stolen and perhaps later returned. Figure 3 shows that fake paintings, visually identical to the original, would not have the same magnetic image as the original painting. That happens because a fake painting is not made using the same exact colors as the original one. Even if the same colors were used, the distribution of pigments and their density on the canvas surface would not necessarily be the same, thus producing different magnetic images. Hence, the magnetic image is a signature of the painting because it is unique like a fingerprint. For instance, an orange shade can be found in different brands of paint, and it could also be obtained by mixing red and yellow. The as-made orange and the orange made from a mixture of red+yellow could have the same effect on the eyes, but not on the SSQUID. Moreover, a forger would never know all the color combinations and paint brands used by the artist; he would never be able to reproduce them exactly the same way. A very interesting advantage of this method is that the SQUID operators do not need to know about the artist's brush stroke or about the history of the painting. An important characteristic of this technique is that it is noninvasive. The examples of magnetic images obtained from oil paintings from different dates show that the magnetic images are stable, and that they are reproducible every time the measurements are repeated. The observed stability of the magnetic image substantiates the claim that the magnetic image can be used as the fingerprint of a painting.

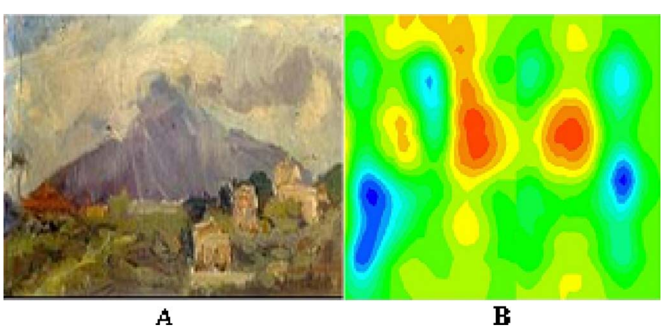

FIG. 6. (Color online) (A) An oil paint from João Timóteo da Costa. (B) The corresponding magnetic image.

V. CONCLUSION

The study presented here on the magnetism of oil paintings shows that they have a magnetic memory and that the magnetic image of an oil painting can be used as its fingerprint. A unique feature of this fingerprint is that it originated when the painting was produced and that it will retain its character throughout the lifetime of the piece of art. This fingerprint can be used for cataloging and as an identification tag by insurance companies and museums. The equipment necessary for obtaining the magnetic map is commonly found in the scientific market, and personnel with expertise in this field can be found at various laboratories and universities worldwide. This work shows that now a new characteristic can be associated with an oil painting, its magnetic memory.

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