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CLEANING AREAS: THE LOCATION OF TESTS IN THE CLEANING OF PAINTINGS

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Abstract

Cleaning tests are usually carried out in order to study the solubility of the non-original layers. They also supply part of the information necessary in order to understand the configuration of the deposits, to select the layers which will be removed and to design the most adequate cleaning systems. Study of these tests has been chiefly based on protocols which allow decisions to be made concerning which chemical agents should be used in a given cleaning operation. The aim of this research has been to develop a system to improve the design and, particularly, the location of cleaning tests. In order to do so, cleaning area has been defined, a concept which allows the surface of painting to be divided into areas which do not show a regional variability. This division enables the location of cleaning tests to be organized in a structured and efficient manner.

Keywords: *Cleaning; Cleaning test; Solubility; Painting; Stratigraphy.*

Introduction

The two instruments needed in order to design an adequate cleaning strategy are a profound knowledge of the physical history and condition of the painting (obtained through examination of the work and analysis of samples) and the possibility of carrying out cleaning tests. Cleaning tests are usually carried out in order to study the solubility of the non-original layers. They also supply part of the information necessary in order to understand the configuration of the deposits, to select the layers which will be removed and to design the most adequate cleaning systems. Cleaning tests thus inform approaches to subsequent treatment.

Cleaning tests have been studied with great detail in relation to elaborating protocols for the selection of chemical agents. Solubility tests with solvents are the most usual as they allow the solubility parameters of the layers, which are to be removed, to be established. In view of these tests, the solvent or mixture which presents the most adequate parameters for dissolving a given material, with as little interaction as possible with the original pictorial structure, can be chosen. R. Wolbers [1] has expressed very clearly how this methodology is usually carried out: ‘a series of “steps” or mixtures of slightly varying polarity’ formulated ‘to define a heuristic or methodological approach to finding a mixture of solvents appropriate for a given coating or situation’. Different protocols have been developed for carrying out solubility tests, although,

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perhaps, the best known is R.L. Feller's: a series of 11 mixtures of three solvents (cyclohexane, toluene and acetone), prepared in order of increasing polarity [2]. Other researchers, such as P. Cremonesi [3] or R. Wolbers [1] have made important contributions by way of substantially improving this kind of tests.

Perhaps the most usual technique in the application of cleaning agents is a rolling technique with a small cotton swab, varying the period of rolling according to the activity of the cleaning agent. This technique allows the quantity of solvent to be well-controlled, together with the size of the treated area and the degree of the mechanical action applied [4].

This paper addresses issues related to the size, shape and in particular the location of tests. The edges of the picture were considered to be the ideal areas for carrying out cleaning tests. However, the information which can be gleaned from these areas is very scarce as the data are not always representative of the state of the whole work. It is frequent to find that the structure of the edges is very different to the rest of the picture.

In order to improve the design and, particularly, the location of cleaning tests, a new concept is proposed (*cleaning area*), which allows the surface to be divided into areas which do not show a regional variability. That is, each cleaning area will correspond to an area of the surface where there could be different reactions to a cleaning process (the differences would be checked by means of the tests). This division enables the location of cleaning tests to be organized in a structured and efficient manner.

Defining goals for cleaning tests

Before the definitive removal of the various non-original layers, cleaning tests must be carried out so that an adequate cleaning system can be designed. It is possible to define cleaning as the removal of a target stratum (TS) without affecting in any way the underlying layers or linked strata (LS). The TS is a non-original stratum, such as a dirt layer or overpaint. The LS can be original or non-original. The term target stratum focuses on the fact that the cleaning is carried out selecting and removing a given layer. Linked strata refer to the fact that other strata are physically and chemically linked to the TS, and therefore have a decisive influence on the cleaning. Therefore, regarding each phase, the structure created by the TS+LS must be studied and a cleaning test designed for that particular configuration. The layers below the LS should also be taken into account, especially if they are very porous or cracked and there is an obvious danger of the cleaning agent penetrating in depth. Although in designing the cleaning system the conservator has to focus on the TS+LS relationship, he must not forget the entire stratigraphic structure as a whole.

Cleaning tests can be divided into three types, according to the kind of information required by the conservator: *solubility*, *interfacial* and *stratigraphic* tests. This division does not mean that these aspects are completely independent from each other. In fact, tests usually combine characteristics from the three. The aim of the *solubility tests* is to disclose information regarding the ‘cleaning system-target stratum (TS)’ interaction: the idea is to check whether the stratum the conservator intends to eliminate (TS) can be removed with a given cleaning system. It is a question of observing an effect of minimum cleaning, that is, if a positive or negative result is obtained (Fig. 1a). The removal of a layer would be understood to be a positive effect. From an operative point of view, it is the simplest kind of cleaning test to carry out.

The *interfacial test* is used for obtaining information concerning the ‘cleaning system-target stratum (TS)-linked stratum (LS)’ interaction (Fig. 1b). The information is more complete than in the solubility tests: it is not a case of just evaluating the solubility of a layer, but of considering other aspects which will be fundamental during the cleaning process. For example, the following can be observed: if the cleaning system which eliminates the TS affects in any way the underlying layer with which it has physical contact (LS), if cleaning can be carried out in a homogeneous manner (Fig. 1c), if different degrees of cleaning can be established (that is, if the TS can be partially removed) or how long it would take to remove a layer.

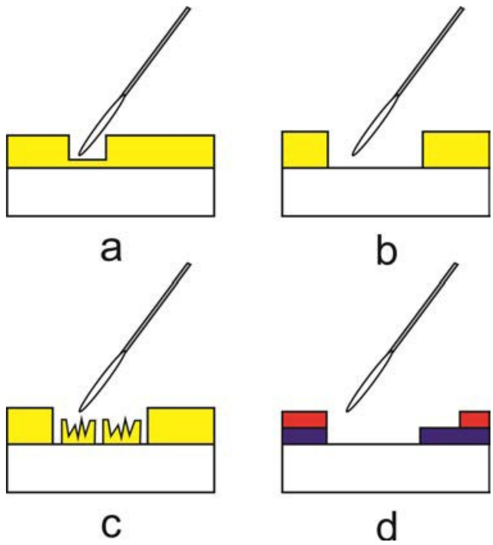

Fig. 1. Kinds of cleaning tests: (a) solubility test, (b and c) interfacial tests and (d) stratigraphic test.

The *stratigraphic test* is used as a means of studying the configuration of the non-original layers, completing the information obtained by the analysis of micro-samples (cross-section staining tests, gas chromatography-mass spectrometry and scanning electron microscopy-energy dispersive X-ray spectroscopy, for example) and the examination of the work in infrared reflectography, UV-induced visible fluorescence imaging and X-radiographs, among other techniques [5]. It is the usual test when the non-original layers are totally opaque (fillers, overpaints, new polychromies, etc.) and neither the underlying layers nor their condition can be ascertain. It is a common technique used in the study of sculptures covered by several polychrome layers as it allows a detailed deposit model of the materials on the surface to be built before any process of cleaning takes place (Fig. 1d) [6].

Size and shape of the cleaning tests

A very important issue concerns the shape and size of the tests. This matter has been discussed by very few authors although photographic evidence is frequently published. Initially, a test can be defined as the smallest area which can be removed in such a way that significant information is obtained. From this starting point, it can be said that the test's shape and size will depend on the type of information the conservator wishes to obtain.

Until a few years ago, the usual procedure was to record the cleaning process by means of photographs of the cleaning tests which varied in size and were of a very clearly defined rectangular or square shape. In this way, spectacular photographs were obtained as the well-defined limits separating the cleaned areas from those areas which had not been cleaned emphasised the difference. At the same time, this type of presentation of the tests had a tidier, more ordered appearance. This procedure has been progressively abandoned due to the fact that sometimes the cleaning is forced in the cleaning test as a whole or on the edges (in order to better “draw” the window shape), which can provoke permanent over-cleaned areas after the overall cleaning of the painting. In general, it is advisable that the shape of the tests be, more or less, rounded or irregular, although, in any case, without clearly defined edges.

From the experience gathered over more than 20 years and from different works, two reference sizes can be established for the cleaning tests: solubility tests can have a diameter of about 3-5mm and be round or oval-shaped (Fig. 2) and the interfacial tests can have the size of, approximately, 10 x 15 mm up to a maximum of 20 x 20mm and be of an irregular shape (Fig. 3). Solubility tests must be small as they are usually carried out in a greater number. In the case of interfacial tests, these must be bigger in order to observe more variables. Needless to say, these are only guidelines as the size of cleaning tests may vary according to the size of the layer where the tests are carried out and the information desired.

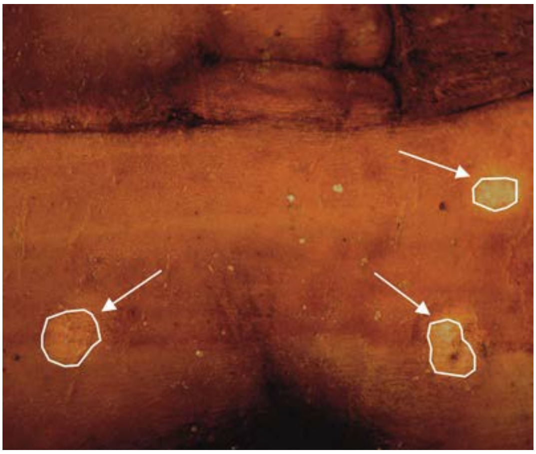

Fig. 2. Solubility tests for the removal of a varnish coating.
Detail of the Mary Magdalene (sixteenth century, private collection, Valencia).

Fig. 3. Interfacial test for the removal of a varnish layer. Detail of the *Immaculate Conception* by Jerónimo Jacinto de Espinosa (1660, Universitat de València).

Although stratigraphic tests can be flexible in shape, they are usually long and thin [7] or small stratigraphic scales [6]. They are usually slightly larger than solubility tests, as a greater amount of information is required and it is much more difficult to visualize. As with the other tests, it is always advisable to observe with the aid of magnifying equipment, which will allow the size to be kept to a minimum. Dimensions of 3 x 7mm or 3 x 10mm have been suggested [6], which are indeed a valid reference; although we must insist that it is always necessary to adapt size and shape to each particular case.

It must be pointed out that many small tests are preferable to a few large ones. This is due to the fact that each test only offers data concerning itself and, therefore, the amount of information obtained is very small and restricted to the specific spot where it is carried out. The greater the number of tests and the number of cleaning areas tested, the greater the amount of information obtained. Figure 4 shows the cleaning tests carried out on various overpaints (stratigraphic units SU 7, 16 and 19), during the cleaning of a painting from the end of the fifteenth century.

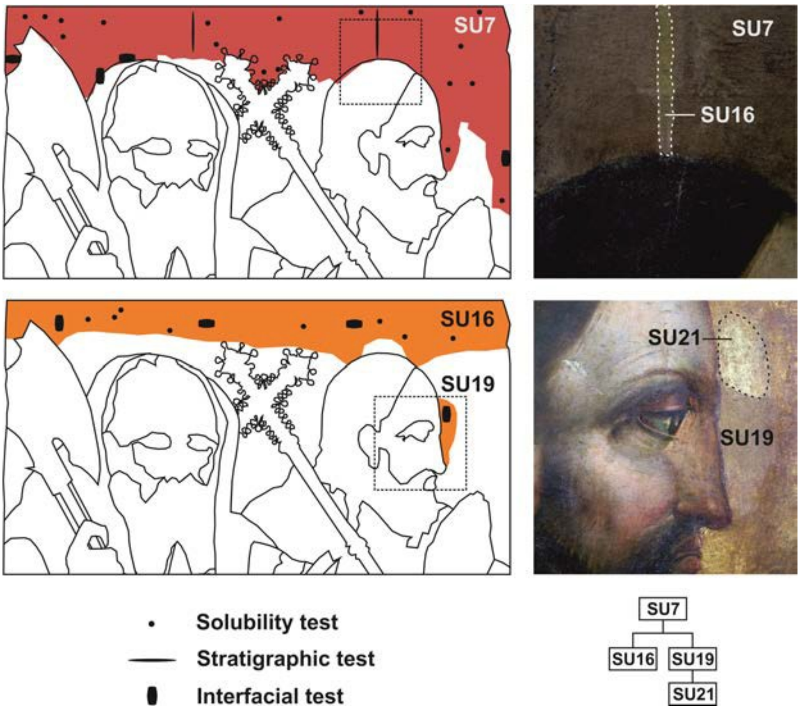

Fig. 4. Cleaning tests carried out on some overpaints (stratigraphic units SU 7, 16 and 19), during the cleaning of *St. Matthias and St. Philip* by Paolo da San Leocadio (fifteenth century, private collection, Madrid).

Differentiated areas

In order to design a structured approach to cleaning tests we must bear in mind that the cleaning process will be carried out on a stratigraphic structure which is usually quite complex. The paint layers usually have different pigments and even different mediums and varying proportions of pigment-medium in different areas. Other variables can also be found, such as texture or porosity, determined by the artist's intention or by the action of external agents (degradation of the medium, previous more aggressive cleaning, etc.). On this original structure there is another one which can be just as complex, if not more: the structure made up of non-original layers (varnishes, fillers, overpaints...). The composition of these layers can be extremely varied, as they can have very different origins.

The study of all these physical-chemical variations, both in the original layers as well as in the deposits, is of great importance in the design of cleaning processes. It is possible to divide the surface into 'differentiated areas': the division of a layer into areas which show physical-chemical variations which could influence the cleaning process. Some of the characteristics which could influence cleaning in a more obvious way are the differences in composition, texture, porosity, thickness and cohesion.

The concept of differentiated areas refers not only to the variations in the original pictorial structure, but also to any variation in the non-original layers. A varnish coating can show differentiated areas such as, for example, areas where its thickness is much less due to an irregular application: in a cleaning process, the areas of different thickness will react differently. Figure 5 shows, in a simplified way, three examples of the division into differentiated areas in an original paint layer and in a layer of varnish.

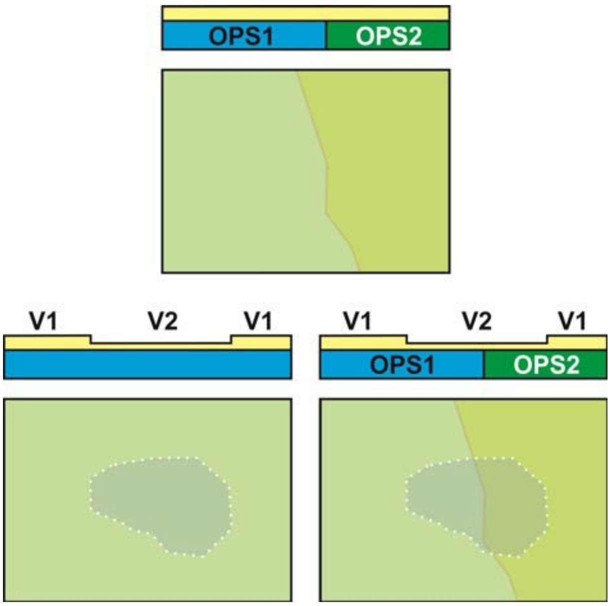

Fig. 5. Division into differentiated areas on the original pictorial structure (OPS) and on a varnish layer (V).

Let us consider a simple case: a homogeneous layer of dirt on a pictorial structure. The adhesion of dirt may be different in each area depending on the physical and chemical characteristics of the paint layers. Some of the factors related to the original pictorial structure which influence the adhesion of dirt are the type of binding medium and pigments, texture, hardness, plasticity and electric and thermal conductivity [8]. The differences in the adhesion of a layer are applicable to dirt and to any other deposit. Factors such as the degree of oxidation of a film, polar interactions, pH or the presence of soluble ionic material will affect the adhesion of the deposits [9].

Variations in the colour of the paint layer imply differences in composition, at least regarding pigments. This simple variation is usually, in itself, extremely important. The deposits may show greater molecular interactions with layers made up of certain pigments [10]. In Figure 6, a painting has been divided into differentiated areas, according to the different pigments in the original paint layer. Firstly, the layer was divided into several main areas (Fig. 6a) and, secondly, one of these areas was further divided into smaller areas (Fig. 6b).

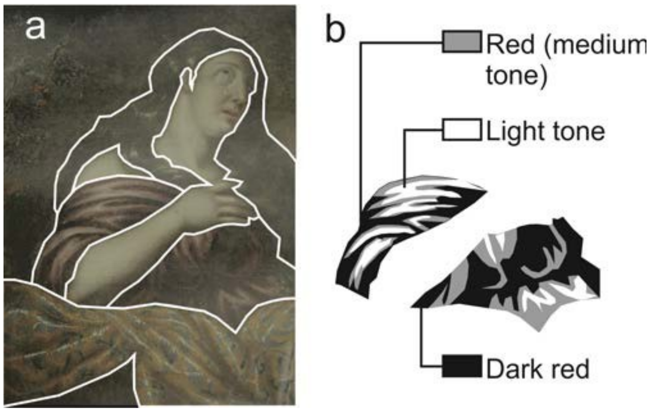

Fig. 6. **D**ivision into (a) main differentiated areas and (b) further division into smaller areas, according to the pigments present in each area.
Mary Magdalene (eighteenth century, private collection, Valencia).

An important aspect in relation to the fact that the original paint layer has differentiated areas is that the action of the cleaning agent used to remove a deposit may have very different effects on each of these differentiated areas. Research on cleaning [11, 12] has shown that the action of solvents can have different effects depending on the pigments present in the pictorial structure.

Another issue to bear in mind is texture, which is determined by the support, the paint layer and the intermediate layers between these. A perfectly smooth and homogeneous surface, with no porous areas, no cracks or any other irregularity, makes the cleaning process easier. However, this is not usually the case. The intricate topography of a rough texture not only increases surface area but also facilitates the adhesion of deposits and hinders their removal [13]. Different textures can greatly influence how cleaning is carried out, an obvious problem with regard to contemporary art.

In short, a target stratum (TS) can show d***ifferentiated areas***, which would imply that their reaction to a cleaning agent could vary. In addition, the TS may show variations in its adherence to the linked stratum (LS) depending on the d***ifferentiated areas*** of the latter, and, consequently, differences regarding a cleaning process. In some areas the TS may be easily removed whereas in other areas it may be more adhered to the LS. This means that the physical-chemical variations in a given layer may provoke variations in the action of cleaning agents applied on the uppermost layer. This also implies that the effects of the cleaning agents on the LS (whether original or not) could vary from one area to another. In many cases, the variations in the relations between the TS and the LS would hardly be significant, but in other cases they could determine important differences in a cleaning process.

Cleaning areas

The location of the tests is determined, in the first place, by the location of the TS. However, as we have seen above, the layers may have differentiated areas which must be taken into account when designing the cleaning process. This means that the surface must be divided into 'cleaning areas' in each phase. Each cleaning area will correspond to just one TS or to a differentiated area of the TS and/or of the LS. That is, each cleaning area will correspond to an area of the surface where there could be different reactions to a cleaning process (the differences would be checked by means of the tests). Figure 7, from a very simple example (varnish on an original paint layer), shows how to divide the surface into cleaning areas: (a) a

TS: one cleaning area; (b) two TS: two cleaning areas; (c) two differentiated areas on the TS: two cleaning areas; (d) two differentiated areas on the LS: two cleaning areas; (e) two differentiated areas on the LS and another two on the TS: four cleaning areas.

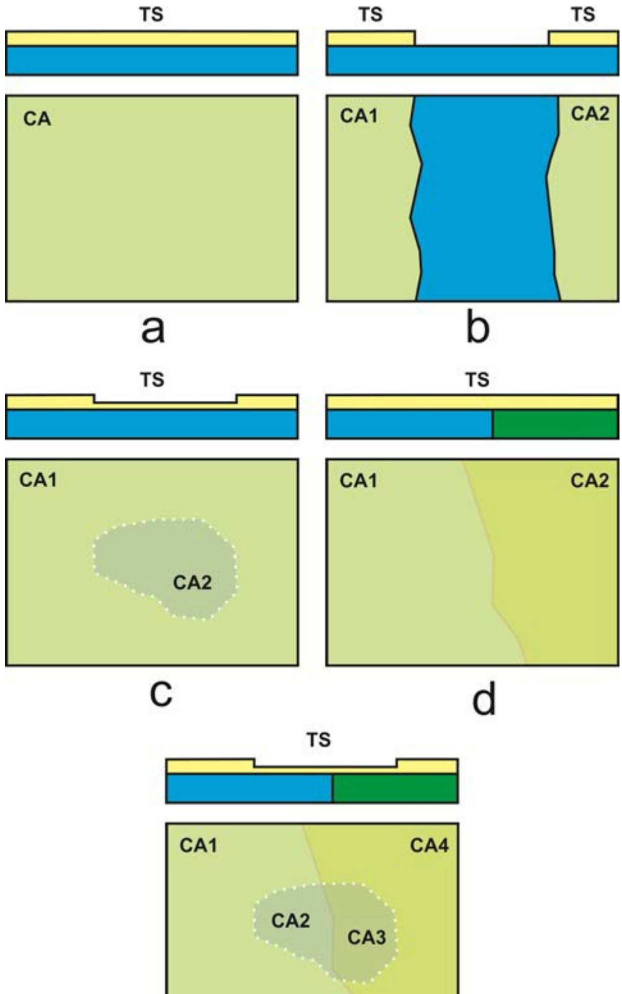

Fig. 7. Division of the surface into cleaning areas (CA): (a) a target stratum (TS), (b) two TS, (c) two differentiated areas on the TS, (d) two differentiated areas on the linked stratum (LS) and (e) two differentiated areas on the LS and another two on the TS.

The idea of cleaning areas is a non-stratigraphic concept which allows the surface to be divided into areas which do not show a regional variability. That is, if various cleaning tests are carried out with the same chemical agent, the results should always be the same on any spot of the cleaning area. Of course, it is not always possible to establish a complete and exact division of the surface into cleaning areas, as it may be very difficult to mark the exact limits of some of the areas while others may be very small. Despite these obvious difficulties, this method can be carried out, adapting it to the characteristics of each painting.

In the case of opaque TS (overpaints, fillers, etc.), the conservator needs to know which layers are underneath. For this purpose, the most usual techniques are examination by X-rays and also the carrying out of stratigraphic tests. These will allow information to be obtained concerning an underlying layer and to check whether it is homogeneous, heterogeneous (with differentiated areas) or if there are several layers. From this information the TS+LS relationship can be established and the division into cleaning areas can, consequently, be carried out.

This division enables the location of cleaning tests to be organized in a structured and efficient manner. In the case of solubility tests, these should be carried out in each of the areas (Fig. 8a). In the case of interfacial tests, these should be bigger, but they can be carried out on the borders between two cleaning areas in order to increase the information obtained in each test (Fig. 8b and 9).

Fig. 8. Suggested location of (a) solubility and (b) interfacial tests from the division into cleaning areas in Fig. 6.

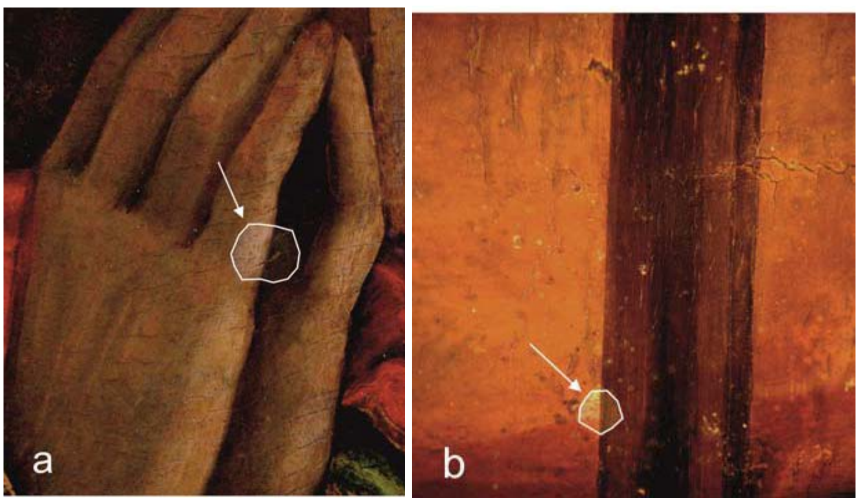

Fig. 9. Interfacial tests for the removal of varnish layers: (a) detail of *St. Matthias and St. Philip*, (b) detail of the Mary Magdalene *(sixteenth century, private collection, Valencia).*

With these tests, different systems of reduction of layers can be tested, whenever it is technically possible [14]. Before reaching the definitive cleaning process, the conservator must verify, by means of interfacial tests, what degrees of cleaning can be reached in each cleaning area, especially where coats of varnish are in direct contact with the original paint layer. With no desire to enter into any controversy concerning semi- or selective cleaning, there are certain cases in which it may be very convenient to leave part of the varnish [15]. Stratigraphic tests can also be carried out on the limiting borders between different cleaning areas. Similarly to the case of interfacial tests, this enables more data to be obtained by means of just one test.

At the end of each phase, cleaning must be organized according to the new cleaning areas into which the surface will be divided. Therefore, new tests will be carried out in order to design the adequate system in that phase.

Recording cleaning tests

Different recording sheets have been designed for recording cleaning tests. For example, Ruhemann's form for recording tests, used for establishing the 'safety margin' [16] or the one published by Masschelein-Kleiner in 1981 [17], the use of which has been widespread, with some variations, in Spain. In general, recording sheets include, as basic information, the identification number of the cleaning test, the cleaning system used, the location (with a map to show the exact spot where the test was carried out) and the data obtained. Moreover, other data can also be included, such as the technique used to apply the solvent, the contact time needed to obtain a positive result, etc. [18].

However, although these sheets are perfectly valid, it is necessary to link them to the stratigraphic unit (SU) recording sheets. This connection between the two sheets is very important because it allows a cleaning test to be linked to the layer on which it was carried out. A SU recording sheet records the description of the physical characteristics of a layer (colour, texture, composition, etc.), its location on plan and its relationships with the other units (where the SU is situated within the stratigraphic sequence) [19, 20]. This allows all available information concerning a single layer to be gathered together on just one recording sheet, which is why it is logical to link it to the documentation of the cleaning tests carried out on that same layer.

Moreover, the sheets usually used in cleaning are very useful for recording solubility and interfacial tests but not so much for stratigraphic tests, which need another kind of sheet for recording the different layers observed and their characteristics [6]. The use of SU recording sheets also allow this kind of stratigraphic information to be gathered as sections and stratigraphic relationships between the different layers are included [20]. The ideal solution is the creation of databases which include stratigraphic information (SU recording sheets) and the cleaning test information, although this is an issue on which much work still needs to be done [21].

Conclusions

The final objective of the cleaning tests is to obtain information: data concerning the solubility of materials but also stratigraphic knowledge. Thus, the carrying out of tests and the analytical reading of the structures must be linked together in one system of research, which will be developed in all of the cleaning phases. This paper does not aim to put forward a rigid system in the design of cleaning tests, although the importance of a systematic methodology for carrying out cleaning tests must be emphasized.

Indeed, this is a fundamental issue not only in research and documentation but also in the teaching of painting conservation. Most of the information on cleaning available to students refers to chemistry, but there are very few publications which deal with other practical matters (of no lesser importance) such as the size and shape of cleaning tests, the recording of tests, or how to organise the location of tests as progress is made throughout the different phases. These matters are key in order to have available a methodology which will enable an understanding of how the cleaning process can be carried out and how to attain adequate objectives.

Although the aim of this paper is to provide some guidelines for practising conservators and students, it must be pointed out that it is a preliminary approach to a number of very complex issues which need a great deal of research in order to provide cleaning with a complete and structured methodology.

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