Chapter VIII

Cross-sections

Maria del Carmen GARRIDO and José Maria CABRERA

1. INTRODUCTION

Investigators continue to affirm that structurally a painting is a stratification of materials applied in layers. These layers result either from the original execution of the painting or from later modifications, restorations, or retouchings.

The *in situ* observation of these structures begins with an examination of cracks, losses, or the painting's edges with a binocular microscope. Such examination supplies important general information that permits selection of the exact point at which a more detailed microscopic study can be carried out. All *in situ* observations permit only an oblique view of unpolished surfaces. In order to examine the paint layer perpendicular to the surface, it is indispensable to detach a small particle of paint and to prepare it adequately for microscopic study.

2. HOW TO TAKE A SAMPLE

A microscopic sample should be taken to resolve a specific problem that has been identified in the course of an examination with X-radiographs, infrared, etc. The problem should be related to questions about the techniques used in the original execution or, with respect to the painting's conservation, to problems stemming from later modifications. The exact location of the sample should be recorded in a photograph. One can carry out a variety of different studies with microscopic cross-sections. These studies can include investigating the different structures and components of a painting, determining the distribution of layers and their function, determining the mixture of colors, identifying media by staining tests, identifying pigments by different instrumental techniques, and so forth.

The sample is always taken while looking at the point selected with a binocular microscope at low magnification. Usually a small fragment is detached by inserting the sharp point of a scalpel[1] into one of the cracks or breaks in the paint surface. Although the method is less than perfect, it is the one that most researchers use ; the hypodermic needle and the instrument specifically designed by Gettens in 1932[2] have few followers for this use.

It is important to do the following :

— Put the painting in a horizontal position in order to make handling easier. If that is not possible, then place a small paper or receptacle so as to avoid losing the detached samples.

— Collect all the fragments. Although there may be some that are incomplete, these are nonetheless useful for the study of grounds or of some layers, and they are already isolated from the rest.

Among all the minuscule fragments that have been separated from the painting, we select the most appropriate one for mounting by using the binocular microscope. Normally we select the one that contains all the layers, from the preparation to the varnish.

— Do not use an adhesive on the tip of the scalpel (such as Canadian balsam, varnish, or saliva), because the different elements of the sample might be contaminated.

3. The embedding of the sample

In order to carry out a microscopic examination of the cross-section of one of these fragments, it is necessary to prepare a smooth, polished surface on one of them. To handle the microsamples, one must embed them in a substance whose consistency provides a support of a volume between 1 and 2 cm^3.

3.1. *Wax and paraffin*

At first the substances used for mounting were wax and paraffin, materials that were common in the early techniques of microscopy. Thus in 1914 Laurie[3] mounted the small fragments in paraffin, cutting them with a pointed knife along a plane that was perpendicular to the surface of the painting.

In 1936, Gettens[4] worked out a variant of the method of wax embedding that permitted him to obtain a preparation in a few minutes. He used two blocks of 3 × 4 inches of ceresina wax, and he deposited the microsample face down in one of the blocks. He then covered the sample with the second block, which had been slightly softened by heating (melting point 65-70°) in order to produce a bond. He immediately cut with a microtome along a

transverse plane. One some occasions it is possible to cut and mount a thin cross-section to study under the microscope with transmitted light. Normally, however, samples from old paintings are too friable for fine cutting, and it is much quicker to prepare an opaque polished section.

3.2. *Synthetic resins*

One of the most significant advances in the preparation of samples resulted from the use of synthetic resins, which had been employed since 1936 in the preparation of geological samples.

In 1940 Gettens[5] used methyl methacrylate monomer to impregnate friable material taken from paintings on cement and sandstone, because he did not obtain a satisfactory consolidation when using a mold with Bakelite and other plastics normally used for metal and mineral samples. To the methyl methacrylate monomer[6] 0.1 % Benzoyl peroxide was added as a catalyst. The sample was impregnated with this liquid in a test tube. A vacuum was created until air bubbles ceased to surface. Then the tube was quickly covered and placed in a lighted oven at 50 or 60° C for 24 to 48 hours so that it polymerized. By this method the consolidation of porous, fragile structures was accomplished, so that these structures could be cut and polished.

In 1950 Lefève and Sneyers[7] developed the methyl methacrylate technique for application to samples from easel paintings. They were aware that the older paraffin techniques gave unsatisfactory results : the paraffin techniques did not permit examination at more than 50×, and they were extremely hard to polish. Lefève and Sneyers made available a method that solves the problem of polishing : the sample is covered with destabilized methyl methacrylate monomer liquid[8] with Benzoyl peroxide, and to this powdered methacrylate polymer in pearls was added until the liquid acquired a pasty consistency ; it polymerized immediately in an oven at 50° C. By these means the swelling of some layers of paint that is produced by the slight solvent action of the hot acrylic monomer is avoided. The use of commercial products used by dentists was recommended[9].

For these purposes polyester resins are also used. In 1954 Plesters[10] described the method used in the National Gallery in London, which consists of covering the samples with resin[11]. Small cubes of polyethylene, similar to those used to make ice in a refrigerator, are used as a mold. In 1955 Straub and Rees-Jones[12] described the method in a study of different structures of paint layers. Plesters pointed out that, in her opinion, it was not necessary to make transparent sections, such as are used for studying rocks, but to make only opaque sections for examination with reflected light, which simplified preparation greatly[13]. This technique is widely known and has been used by many researchers in other countries[14].

Fig. 1. Domenicos Theotocopoulos. 'El Greco'. Pentecost. *Madrid, Prado, cat. no. 828 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Blue of the Virgin's mantle
1- Calcium sulphate : ⟩ 120 μ
2- Ochre, lead white, minium, organic black and azurite : ≃ 50 μ
3- Calcium sulphate, ochre, lead white, minium, organic black and azurite : ≃ 20μ
4- Lead white and azurite : ≃ 100 μ
5- Varnish : ≃ 30 μ
6- Blue overpaint : ≃ 10 to 25 μ.

Fig. 2. Paolo Veronese, Venus and Adonis. *Madrid, Prado, cat. no. 482 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Blue of the heaven
1- Calcium sulphate : ⟩ 220 μ
2- Oil impregnation : ≃ 15 μ
3- Lead white : ≃ 15 μ
4- Lead white and azurite : ≃ 20 to 40 μ
5- Lead white and lapis lazuli : ≃ 35 μ
6- Varnish : ≃ 10 μ
7- Blue overpaint : ≃ 15 μ
8- Varnish : ≃ 15 μ.

Fig. 3. Rogier van der Weyden, Pietà. *Madrid, Prado, cat. no. 2540 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Blue of the heaven
1- Calcium carbonate : ⟩ 30 μ
2- Lead white : ≃ 10 μ
3- Black drawing : ≃2 μ
4- Lead white and azurite : ≃ 5 μ
5- Lead white and lapis lazuli : ≃ 15 μ
6- Varnish : ≃ 10 to 25 μ
7- Lead white and azurite, later superposition : ≃ 40 μ
8- Varnish : ≃ 15 μ.

Fig. 4. Pedro Berruguete, Death of St Peter the Martyr. *Madrid, Prado, cat. no. 613 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Red of the personage's mantle.
1- Calcium sulphate : ⟩ 100 μ
2- Oil impregnation : ≃ 10 μ
3- Black drawing : ≃ 20 μ
4- Lead white : ≃ 20 μ
5- Red lake : ≃ 210 μ
6- Varnish : ≃ 50 μ.

Fig. 5. Raphael of Urbino. The Visitation. *Madrid, Prado, cat. no. 300 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Purple of the Virgin's mantle.
1- Calcium sulphate : ⟩ 60 μ
2- Lead white : ≃ 10 to 20 μ
3- Red lake and azurite and lead white : ≃ 124 μ
4- Varnish : ≃ 16 μ.

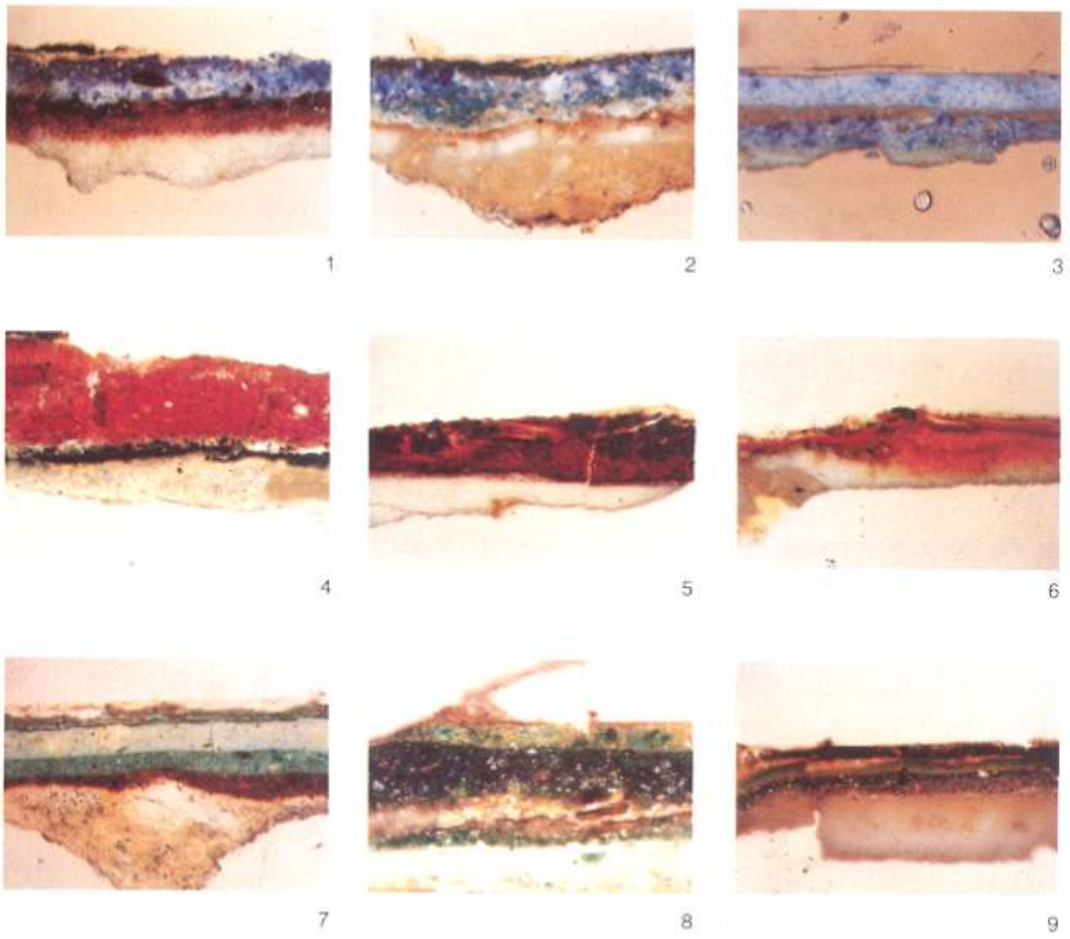


Fig. 6. Rogier van der Weyden. Pietà. *Madrid, Prado, cat. no. 2540 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Red of the donor's mantle.
1- Calcium carbonate : ⟩ 40 µ
2- Lead white : = 40 µ
3- Lead white and vermilion : ≈ 30 µ
4- Lead white and vermilion : = 30 µ
5- Red lake : = 20 µ
6- Overpaint and varnish : ≈ 20 µ.

Fig. 7. Domenicos Theotocopulos, 'El Greco'. The Crucifixion. *Madrid, Prado, cat. no. 823 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Green of the St. John's tunic.
1- Calcium sulphate : ⟩ 250 μ
2- Red ochre, minium, lead white and organic black : ≃ 20 to 60 μ
3- Cardenillo and lead white : ≃ 50 μ
4- Cardenillo, lead-tin yellow, lead white : ≃ 70 μ
5- Copper resinate : ≃ 10 μ
6- Copper resinate and lead-tin yellow : ≃ 20 μ
7- Varnish : ≃ 30 μ.

Fig. 8. Tiziano Vecellio, The Virgin and Child with St. George and St. Catherine. *Madrid, Prado, cat. no. 434 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Green of the curtain
1- Calcium sulphate : ⟩ 120 μ
2- to 6 - Lead white, different copper greens, some ochre and lead-tin yellow : ≃ 200 μ
7- Varnish : ≃ 10 μ
8- White overpaint : ≃ 146 μ.

Fig. 9. Hans Memling, The Purification. Madrid, *Prado, cat. no. 1557 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Green of te small temple superimposed to the architecture.
1- Calcium carbonate : ⟩ 140 μ
2- Lead white : ≃ 8 μ
3- Lead white and organic black : ≃ 32 μ
4- Copper resinate and lead white : ≃ 16 μ
5- Copper resinate and some vermilion : ≃ 30 μ
6- Overpaint : ≃ 32 μ
7- Varnish : ≃ 10 μ.

Figures 10-18 : see page 163.

Fig. 10. Sopetran. The Death of the Virgin. *Madrid, Prado, cat. no. 2578 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Brocade of the bedspread of the Virgin's bed.
1- Calcium carbonate : › 110 μ
2- Black drawing : ≃ 2 μ
3- Lead white : ≃ 5 μ
4- Vermilion and lead white : ≃ 15 μ
5- Lead white, red lake and organic black ; some azurite : ≃ 40 μ
6- Lead-tin yellow and lead white : ≃ 20 to 40 μ
7-8- Varnish : up to 40 μ.

Fig. 11. Pedro Berruguete. St Peter the Martyr praying. *Madrid, Prado, cat. no. 612 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Brocade of the rug.
1- Calcium sulphate : › 60 μ
2- Calcium sulphate, carbon black, oil impregnation : ≃ 100 μ
3- Organic black : ≃ 10 μ
4- Lead white : ≃ 10 to 15 μ
5-6- Copper resinate and lead white in varying proportion : ≃ 15 μ
7-8- Lead white and red lake and some vermilion : ≃ 20 μ
9- Varnish : ≃ 15 μ.

Fig. 12. Pedro Berruguete, Annunciation. *Burgos, Cartuja de Miraflores (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Blue of the Virgin's mantle.
1- Calcium sulphate : › 1000 μ
2-3- Calcium carbonate and oil impregnation : ≃ 80 μ
4- Organic black : ≃ 20 μ
5- Lead white and ochre : ≃ 25 μ
6-7-8- Azurite, calcium sulphate and lead white : ≃ 60 μ
9- Varnish : ≃ 10 μ.

Fig. 13. Domenicos Theotocopulos, 'El Greco'. The Crucifixion. *Madrid, Prado, cat. no. 823 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Red of the St John's mantle.
1- Calcium sulphate : › 250 μ
2- Red ochre, minium, lead white, organic black : ≃ 50 to 60 μ
3- Lead white and some red lake : ≃ 20 to 60 μ
4- Red lake : ≃ 10 to 50 μ
5- Lead white and red lake : ≃ 10 to 50 μ
6- Red lake : ≃ 10 to 50 μ
7- Varnish : ≃ 50 μ.

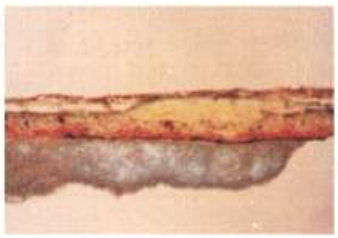
Fig. 14. Diego Velasquez de Silva, Vulcan's Forge. *Madrid, Prado, cat. no. 1171 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Green of Apollo's laurel crown.
1- Lead white and organic black : ⟩ 120 μ
2- Oil impregnation : ≃ 40 μ
3- Azurite, lead white and yellow organic lake : ≃ 80 μ
4- Varnish : ≃ 35 μ.

Fig. 15. Diego Velasquez de Silva, The Tapestry weavers. *Madrid, Prado, cat. no. 1173 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Flesh colour of the female figure at the right side.
1- Lead white, ochre and organic black : ⟩ 110 μ
2- Lead white, red lake, ochre and organic black : ≃ 25 μ
3- Lead white and organic black : ≃ 16 μ
4- Red organic lake : ≃ 5 μ
5- Change of composition, lead white, vermilion and azurite : ≃ 50 μ
6- Varnish : ≃ 45 μ.

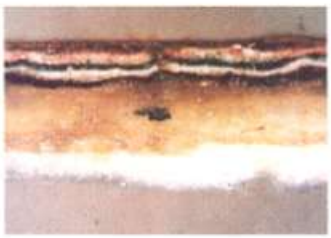
Fig. 16. Francisco de Zurbáran, Christ giving his blessing. *Madrid, Prado, cat. no. 6074 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Red sleeve of Christ's tunic.
1- Lead white, ochre, organic black : ⟩ 280 μ
2- Lead white and red lake : ≃ 60 μ
3- Varnish : ≃ 10 to 40 μ.

Fig. 17. Francisco de Goya, Judith and Holofernes. *Madrid, Prado, cat. no. 764 (Neg. Gabinete tecnico del Museo del Prado).*
Localization : Black of Judith's dress.
1- Calcium sulphate : ⟩ 170 μ
2- Carbon black : ≃ 170 μ
3- Lead white, vermilion : ≃ 30 to 50 μ
4- Change of composition, carbon black and lead white : ≃ 25 to 50 μ
5- Varnish : ≃ 10 to 25 μ.

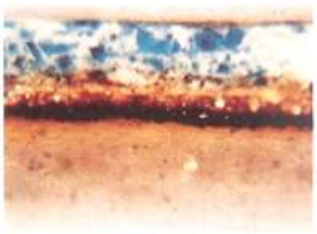
Fig. 18. Pablo Picasso, Guernica. *Madrid, Prado (Neg. Gabinete tecnico del Museo del Prado).*
Localization : White of the warrior's head.
1- Animal organic glue : ⟩ 20 μ
2- Barium sulphate : ≃ 80 μ
3- Lead white : ≃ 15 μ
4- Zinc white and organic black : ≃ 80 μ
5- Lead white and zinc white : ≃ 80 μ
6- Organic black : ≃ 35 μ
7- Zinc white : ≃ 80 μ
8- Varnish : ≃ 10 μ.



10

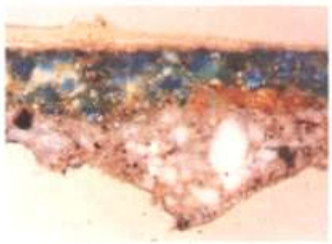


11



12

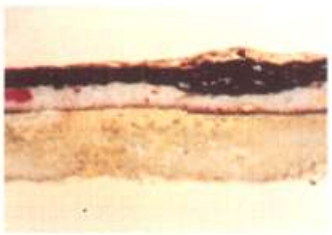
13



14

15

16



17

18

4. *Thin cross-sections*

The technique of thin cross-sections was used in 1958 by Sneyers and Thissen[15] in the examination of gesso in an Assyrian relief. They saturated the samples with methyl methacrylate monomer, cut the block perpendicular to the surface of the sample and polished it with emery paper until they obtained the desired surface in the small fragment under examination. This preparation was then quickly attached to a plexiglas slide 3 mm thick, making a kind of microscope slide. As an adhesive they used a half-polymerized monomer in a syrupy state, holding it down with a press and heating it in an oven to 60° C for 3 or 4 hours. The sample's thickness was reduced by sanding, and the final polishing was done by hand with emery paper of decreasing grit.

The thin cross-section was introduced into the study of paintings in 1959 by Coremans and Thissen[16]. Using the previously described method, they prepared a thin section from a sample of the *Adoration of the Mystic Lamb* by Van Eyck. They were able to evaluate the function of the different layers and to interpret the glazes, varnishes, etc., which illustrated the considerable possibilities of the method. In our opinion, the use of thin sections permits one to include the study of function within the study of form : in the different layers of paint, the formal changes that appear in different structures indicate quite specific functions.

5. Method used in the Prado Museum

Since 1970 Kockaert[17] also has embedded samples in methyl methacrylate. Kockaert used two cubes of plexiglas in a way similar to Gettens's method of two wax blocks, as described above. Kockaert cements the paint sample with cyanolit in one of the cubes. Once it is dry, it is covered with a coat of acrylic monomer in a syrupy state[18]. The other cube, which has also been covered with monomer, is placed on top of the first cube and lightly pressed with Hoffman tweezers and left in an oven overnight at 55° C.

In Madrid we have followed the methyl methacrylate technique since 1963, converting practically all our samples to thin sections on a support of plexiglas[19]. In our working method we mount the samples in small holes made in a bar of plexiglas measuring 1 × 2 × 20 cm. We surround them with methyl methacrylate monomer and polymer of the type used by dentists[20]. The method is as follows :

a) In a bar of plexiglas measuring 1 × 2 cm in section, small holes of 1 cm in diameter are made. The holes are placed 2 cm apart, and thus in a bar of 20 cm length, we can mount 10 samples, one in each hole ;

b) The bottom of the hole is covered first with liquid monomer to which polymer dust is added until it is saturated. This mixture should not fill more than half the capacity of the hole. Before the mixture hardens, the microsample is placed carefully so that the surface plane of the paint is face down. Then the hole is filled or overfilled with powdered and liquid polymer. Within a few minutes the mixture hardens, and the sample is embedded within the bar of plexiglas. Now the bar is ready to be cut ;

c) The bar of plexiglas is cut as close as possible to the sample, using an iron blade made of metals. The bar is smoothed with coarse sandpaper or emery paper followed by finer paper until the sample is reached. The final polishing of the surface is done with metallographic sandpapers of 0, 2/0, 3/0, and finally 4/0[21].

The first examination is carried out on this opaque preparation. Photomicrographs are also made in case subsequent handling during the preparation of thin sections should cause any accidental damage to the sample.

d) To obtain the thin section, the preparation described above is cemented to a plexiglas microscope slide of 2 mm thick ; the adhesive is syrupy methyl methacrylate monomer[22]. Strong pressure is applied with a screw press, and the slide is left in an oven at 50-65° C for at least 6 hours.

Then the plexiglas cube is cut with a saw as close as possible to the microscope slide. It is smoothed with sandpaper and it is polished as described above, taking the sample down to a thickness of between 0,02 and 0,04 mm, at which point the different layers of the paint structure are visible with transmitted light[23].

The characteristics of each school in its different stages, with respect to the materials used, the grinding of the pigments and the way paintings are elaborated and strata surimposed, may be determined through the microscopic study of thin layer stratigraphic sections, performed on microsamples obtained by the earlier mentioned procedure. Furthermore, within each school, the material pecularities typical for each painter and the evolution of his technique may be identified. The comparison of the data obtained for each school is of great importance to ascertain the influences, similarities and differences among them.

In the study of the thin layers it is observed which preparation is laid on the wood or canvas support[24]. In flemish and italian paintings, it is often calcium carbonate, while in spanish paintings, especially of the 15th and 16th centuries, it is usually calcium sulphate. The preliminary gesso grinding in the spanish schools is generally thicker than the one prepared with carbonate in the other foreign schools. This stratum may be applied in one layer, although in carefully elaborated paintings it has been possible to observe up to three layers[25].

The preparation tends to get darker in the 17th century, becoming very dark reddish-brown or even black, according to the stylistic preferences of each moment. In Spain, painters like Goya recuperated the white preparations from earlier epochs, performing them however with lead white. This material had been utilized by Velazquez for the same purpose, although mixed with other pigments that contribute to a greyish or pinkish coloration. In panelpainting the underdrawing is effected on top of the preparation and occasionally it is fixed by means of a thin layer of oily substance, sometimes with a proteic mixture, which impregnates the preparation in some cases. Then, a white layer (lead white) serves as priming for the color. From the 16th century on, this stratum will become colored, either in a uniform fashion all over the surface, rather common technique in Flanders, Italy and Spain[26], or locally, as performed by some italian painters, such as Raphael, in some of his paintings[27].

In the 17th century it is frequent that both layers of preparation and priming are combined into only one layer which tries to assume the characteristics of both. This may be seen in the paintings by Velazquez performed after his arrival to Madrid and after his two trips to Italy.

The pigments used in the different schools are similar. However it is difficult to find lapis-lazuli and mercury vermilion in spanish painting, especially in the 15th and early centuries, at least in the way it is used in flemish and italian painting : a tick layer, in some cases two, of lead white with vermilion or azurite depending upon the tonality, and a second layer of the same pigment mixed with lapis-lazuli or vermilion as coloring substances. In many cases glazes of lapis-lazuli and organic red lacquer are superimposed for the completion of these paintings.

The spanish painting of this epoch is, however, less structurally elaborated and the lack of these pigments may be determined by their high price[28]. In complex structures of blues and reds, organic red lacquer and azurite are usually the materials which substitute the aforementioned elements. Pigments like malachite appear more frequently in other countries ; in Spain it is seldom found.

The differentiating factors among painters are fundamentally the mode of effecting the mixtures, the grinding of the pigments, the superimposition of tonalities for the achievement of color, the brushstroke etc. All these elements are developed differently depending upon the personality and style of each painter, and that is the key to the results obtained by each of them which make them often unique within the worldwide artistic panorama. The changes in composition as well the layers of paint which correspond to those modifications may be determined by the microscopic examination of the thin layers. This may be observed, for example, in cross-section (see figures) corresponding to works by Berruguete, Goya, Velazquez and Picasso where it

is defined which strata correspond to the first composition and which to the second[29]. Possible modifications the works went through in other epochs and superficial overpaintings due to the different restorations they have gone through[30] may be observed as well.

The interpretation of the thin layer must never be carried out in an isolated manner but in relation with other technical documents such as radiography, infrared reflectography and technical photographies obtained with different artificial lighting procedures.

6. NOTES

1. We use a scalpel of the type normally used in eye operations because of the fine but strong point.
2. R.J. GETTENS, *A Microsectioner for Paint Film*, in *Technical Studies in the Field of Fine Arts*, I, 1932-1933, fasc. 1, July 1932, p. 20-28.
3. A.P. LAURIE, *The Pigments and Mediums of the Old Masters*, London, Macmillan, 1914, p. 18-24.
4. R.J. GETTENS, *The cross-sectioning of paint film*, in *Technical Studies in the Field of Fine Arts*, V, 1936-37, fasc. 1, July 1936, p. 18-22.
5. ID., *The Use of Methyl Methacrylate in the Preparation of Polished Specimens of Friable Material*, in *Technical Studies in the Field of Fine Arts*, IX, 1940-1941, fasc. 2, October 1940, p. 113-116.
6. To stabilize the monomer, the manufacturers add a polymerizer inhibitor ; they also give instructions for the elimination of the inhibitor before use.
7. R. LEFÈVE and R. SNEYERS, *La Microchimie des peintures anciennes. Une nouvelle méthode de préparation des coupes*, in *Mededelingen van de Vlaamse Chemische Vereniging*, XII, 1950, p. 99-101.
8. Three percent Benzoil peroxide is added to eliminate the polymerizer inhibitor, decanting and filtering the oxidation products.
9. Kallodent 1) liquid and 2) powder clear 222, made by I.C.I.
10. J. PLESTERS, *The Preparation and Study of Paint Cross-sections*, in *The Museums Journal*, 54, 4, July 1954, p. 97-101.
11. Polyester resins brand name « Resin SB. 26C » or similar products such as « Ceemar Resin » and « Beetle Resin 4166 ».
12. R.E. VON STRAUB and S. REES-JONES, *Mikroskopische Querschnitte von Gemälden*, in *Maltechnik*, 56, 1955, p. 119-125.
13. J. PLESTERS, *Cross-sections and Chemical Analysis of Paint Samples*, in *Studies in Conservation*, II, 3, 1956, p. 110-132.
14. In Spain it was used by M.C. DIEZ ATARES, *Investigación de las estructuras finas en las Obras de Arte*, in *Revista de la Academia de Ciencias Exactas, Físico Químicas y Naturales de Zaragoza*, serie 2°, XII, 1, 1957, p. 87-107. It is also used in the laboratory of the Louvre Museum, among others.
15. R. SNEYERS and J. THISSEN, *La technique des lames minces appliquée à l'examen d'un relief assyrien en gypse*, in *Bulletin de l'Institut royal du patrimoine artistique*, I, 1958, p. 94-95.
16. P. COREMANS and J. THISSEN, *L'Introduction des lames minces dans l'examen des peintures*, in *Bulletin de l'Institut royal du patrimoine artistique*, II, 1959, p. 41-45.
17. L. KOCKAERT, *Nieuwe vervaardiging van microscopische doorsneden in verfmonsters*, in *Bulletin de l'Institut royal du patrimoine artistique*, XIV, 1973/74, p. 118-120.

18. To prepare the adhesive, the author recommends dissolving 1/3 powdered methacrylate in 2/3 monomer. After a day the solution becomes syrupy and can be used.

19. Among the first published studies, the following should be pointed out : A. DIAZ MARTOS, and J.M. CABRERA GARRIDO, *La Virgen de la Mosca de la Colegiata de Toro*, in *Informes y trabajos del Instituto de Conservación y Restauración de Obras de Arte, Arqueologia y Etnologia*, n° 6. The archives of the Instituto de Conservación y Restauración, and of the Gabinete de Documentación tecnica del Museo del Prado contain more than three thousand thin sections.

20. The following products give a material that is very transparent without bubbles and without a solvent effect on samples of old paint : - Paladur, made by Kulzer & Co, GmbH, D 6380 Bad Homburg ; - Technovit. There are self-polymerizing methacrylate resins in powdered and liquid form. For polymerization at room temperature, they contain a tertiary amine (N-bustilamina) which produces solution of the initiator of Acilo peroxide (Benzoil peroxide).

21. For example, Buheler.

22. To prepare methyl methacrylate as an adhesive with a monomer base, the following procedure is used : 200 cc. of methyl methacrylate monomer is placed in an adequate container. Soda (NaOH) at 5 % is added several times (approximately 150 cc of NaOH total) until the hydroquinone that the product contains as an inhibitor is eliminated. Then one proceeds to wash the resulting liquid two or three times with distilled water. Neutrality is tested with pH paper. Afterwards sulfate of anhydrous sodium (SO_4NO_2) is added to eliminate the water, and the material is left in this state for several hours. Once the monomer is ready, it is placed in a test tube with a small quantity of Benzoil peroxide to convert it to a syrupy state and then placed in the oven at about 50° for 3 or 4 hours.

23. Preparations of wood and cloth in the support of paintings, as well as samples of mural painting, are impregnated with monomer in a vacuum, as mentioned in *op. cit.* 5 in order to consolidate the structures. Then the procedure for thin sections is followed.

24. The procedure of mounting microsamples is also valid for the study of the nature of the fibers, which constitute the support of canvaspaintings. Similarly, radial, transversal and tangential mountings of the wood that constitutes the support of the painting on panel may be performed, in order to determine its nature.

25. M.C. GARRIDO, *Contribuciòn al estudio de la obra* de *Pedro Berruguete, utilizando los métodos fisico-quimicos de examen cientifico : 'La Anunciación de la Cartuja de Miraflores (Burgos)*, in *Archivo Español de Arte*, Vol. LI, n° 203, 1978, p. 307-322.

26. See for example J.R.J. VAN ASPEREN DE BOER, R. VAN SCHOUTE, M.C. GARRIDO, J.M. CABRERA, *Algunas cuestiones técnicas del Descendimiento de la Cruz de Roger van der Weyden*, in *Boletin del Museo del Prado*, Vol. n° 18, 1983, p. 48-49.
M.C. GARRIDO, *Consideraciones técnicas sobre las pinturas de Rafael del Museo del Prado. Catalogue of the Exhibition : Rafael en España. Museo del Prado.* Marzo-Agosto 1985, p. 127-134.

27. L. FAILLANT-DUMAS, J.P. RIOUX, *Raphaël étudié au Laboratoire. Catalogue of the Exhibition : Raphaël dans les collections françaises*, Paris, 1983-84, p. 426.

28. It may be said for example that the Deposition by van der Weyden was a costlier painting than the Altar-piece of Ghent by van Eyck, considering the thickness of the layer of lapis-lazuli, *op. cit.*, no. 26, p. 49, It is curious to observe how, for example, in Spain vermilion is reserved in some cases for the donors of the painting.

29. If in the case of paintings by Velazquez and Picasso the superimpositions correspond to a change in the position of the figures, in the case of Goya, the structuration is the outcome of a complete remodeling of the subject of the black paintings since they were originally conceived as landscapes to be subsequently completely modified. J.M. CABRERA, M.C. GARRIDO, *Estudio técnico del Guernica*, in *Boletin del Museo del Prado*, II, n° 6, 1981, p. 147-156.
M.C. GARRIDO, *Algunas consideraciones técnicas sobre las Pinturas Negras de Goya*, in *Boletin del Museo del Prado*, V, n° 13, 1984, p. 4-40.

30. J.M. CABRERA, *La Piedad de Roger Van der Weyden. Análisis de Laboratorio*, in *Boletin del Museo del Prado*, I, n° 1, 1980, p. 39-49.

RÉSUMÉ

Les auteurs indiquent la manière de prendre un prélèvement de peinture et de l'incorporer dans une matière qui, après séchage, peut être polie conformément à un plan perpendiculaire à la surface de la peinture. Diverses techniques ont été utilisées à cet effet depuis que Laurie, en 1914, mit les premiers échantillons dans un lit de paraffine. La cire fut utilisée, et dans la suite, surtout les résines synthétiques adoptées depuis 1940.

L'étude des coupes au moyen du microscope permet de déterminer les caractéristiques des différentes écoles de peinture et des différents peintres, notamment en ce qui concerne la superposition des couches et les pigments utilisés. Ainsi ont varié, selon les écoles, les matériaux adoptés pour la couche de préparation l'adoption ou non de couches intermédiaires blanches ou colorées. Si les pigments en usage furent les mêmes dans les différentes écoles, l'Espagne se distingue néanmoins par une élaboration simplifiée des couches par rapport à l'école flamande, et par l'usage parcimonieux de pigments précieux tels la malachite et le lapis-lazuli.