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# PICASSO UNDER INVESTIGATION

## Condition Assessment of the *Acrobat Family* by Pablo Picasso


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Uppsats för avläggande av filosofie kandidatexamen med huvudområdet kulturvård med inriktning mot konservering
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# Picasso Under Investigation
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## ABSTRACT

This study focuses on a painting on cardboard by Pablo Picasso (1881-1973), *The Acrobat Family,* created in 1905 and currently part of the collection of the Gothenburg Museum of Art. Because of the scarcity of documentation about the object's condition, the necessity of an extensive investigation has arisen on the occasion of a loan request from abroad. The primary purpose of the research is to gain enough information in order to be later used to discuss and evaluate the artifact's suitability to be included in an external exhibition. The study is the first step for the arrangement of an eventual conservation plan and for the development of a housing, transport, and exhibition strategy specifically designed to meet the painting's needs.

As first part of this research, an initial study was carried out due to the contradictions and the lack of evidence regarding the identification of materials and techniques. The investigation was conducted through a literary review of Picasso's contemporary production sharing similar features and through instrumental analysis. An ocular examination of the painting, supported by photographic documentation, has been carried out under magnification in order to inspect its current condition and verify the presence of potential structural problems. Multispectral imaging has been employed as well in order to deepen the study of the materials used by Picasso. Although only non-invasive and non-destructive methods have been chosen for this case study, fibre analysis and pH measurement of the support has been made possible due to the unintentional detachment of some micro-fragments of cardboard. Even though more sophisticated analysis will be necessary in order to understand the exact material composition of the painting, the results provided some documented indications and suggestions about the materials involved and their state of preservation/degradation. After the analyses, the main risk for the object's stability is considered to be the fragile condition of the support, which is acidic and shows signs of discoloration, surface embrittlement and delamination. The use of pastels has not been detected, but further analyses are required to exclude this possibility. In fact, this technique is highly sensitive to vibration and its presence would represent a serious hinder for a loan abroad. Light fastness of blue pigments has also been underlined as an issue to be taken into account for the preservation of the object.

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# Table of Contents

# 1 Introduction

## 1.1 Background and Presentation

This study will focus on a painting on cardboard by Pablo Picasso, the *Acrobat Family*, created in 1905 and currently in the collection of the Gothenburg Museum of Art (Göteborgs konstmuseum, GKM). Originally purchased in 1905 by the American art collector Leo Stein during his stay in Paris, the painting was produced by Picasso during the so-called Rose Period, which spans from late 1904 to the end of 1906. Besides the pictorial quality and the intrinsic artistic value, another peculiarity lies in its support. The use of cardboard as support for oils, gouache or pastels were employed occasionally by Picasso in his early career but only rarely after 1906. In 1922 the painting came into possession of the GKM. During my internship at the museum's paper conservation department in the autumn of 2016, a loan request from a prestigious gallery abroad raised the interest towards the opportunity to allow the painting to be exhibited in another institution. To evaluate this possibility, it has been decided to set up an investigation plan in order to inspect the current condition of the artwork. The study presented in this paper will serve as the first step of this plan. Due to the scarcity of information about the technique and the materials involved, a preliminary study is also required in order to gain a deeper understanding of the structure and composition of the artifact.

## 1.2 Previous Studies in the Field

Picasso's artistic production has been largely studied both from an art historical perspective and from a scientific point of view. Catalogues and texts about the early works of the artist have been written through the years such as *Picasso 1900-1906: catalogue raisonné de l'œvre peint* by Daix and Boudaille (1966), *Picasso. Life and Work of the Early Years: 1881-1907* by Palau i Fabre (1981), *Picasso: Blue and Rose Periods: the Complete Paintings of Picasso* by Lecaldano and Sutton (1987) and *Picasso: The Early Years 1892-1906* by McCully and Staller (1997). Essential sources of information specifically about the *Acrobat Family* are represented by two articles by Dorthe Aagesen (2006) and Lena Boëthius (2006) included in the catalogue *Akrobater och harlekiner, familj och kvinnor* (Aagesen 2006). Nevertheless, scientific studies concerning the painter's choice of materials and techniques during the early years of his career, specifically regarding works on paper/cardboard and related techniques (gouache, watercolor, pastel, etc.), are less numerous than those available for later periods or regarding other supports or materials. To date, the most complete published investigation about several of Picasso's works on paper has been carried out by the scientific research department of the Metropolitan Museum of Art and reported as technical notes in the catalogue *Picasso in the Metropolitan Museum of Art* (Tingerow & Stein 2010).

## 1.3 Definition of Problem and Issues

The study aims to answer to the following questions:

- What are the materials and techniques used by Picasso in the *Acrobat Family*?
- What is the current physical condition of the artwork?
- What are the risks for the artifact´s safety that needs to be taken into account when discussing the possibility of a loan?

## 1.4 Purpose and Aim

The purpose of the research is to collect information about materials and techniques of the *Acrobat Family* and to analyze the condition of the object. The aim is to contribute to the evaluation of the painting's suitability for an inyternational loan.

## 1.5 Methods and Materials

An initial study was carried out due to the contradictions and the lack of evidence regarding the artifact's technique. The identification of the involved materials is a necessary requirement for a further evaluation of the object's condition. The investigation was conducted firstly through a literature review of Picasso's contemporary production sharing similar features with the *Acrobat Family* in order to achieve an indication about the technique that might have been used by the artist.

Secondly, the object was examined through instrumental analysis, which included an ocular observation of the object under direct and raking light, with a stereo microscope and, finally, through multispectral imaging (MSI). Fibre analysis of the support was possible due to the inevitable detaching from the edges of some micro-fragments of cardboard during the removing of the painting from its frame.

The collected data from the analytical investigations served to confirm or dismiss the hypothesis gathered from the literature study and provide indications about the painting's state of preservation.

## 1.6 Limitations and Ethical Considerations

The literature review was carried out by limiting the study to Picasso's production on cardboard preceding and contemporary to the *Acrobat Family*, between 1900 and 1906. Due to the renowned interest of Picasso towards mixing and experimenting with materials, the description of techniques from Table I in Appendix 1 need to be considered only as a general indication about the artist's working practice on a specific piece. However, the lack of published scientific investigation on the materials used by Picasso in his works on paper does not preclude considering the information obtained from catalogues to be a reliable starting point to gain an idea about the identification of the *Acrobat Family*'s technique.

Ethical aspects regarding the choice of materials and methods of investigation of a cultural property were taken into account based on the professional guidelines and code of ethics produced by the European Confederation of Conservator-Restorers' Organisation, E.C.C.O. (1993, § 5 and 9), the American Institute of Conservation of Historic and Artistic Works, AIC (1994, § II, IV, V, VI, VII, VIII) and the International Council of Museum, ICOM (2013, § 3). Those principles can be summarize as follows:

- Examination and scientific investigation shall be conducted with respect of the aesthetic and historic significance of the cultural property and its physical integrity.
- All actions of the conservation professional must strive to select methods and materials appropriate to the aims of each specific investigation or treatment.
- The conservator-restorer shall evaluate the advantages and the potential negative effects of a chosen method or material in order to limit the risk of compromising the integrity of the object or the possibility of future examination, analysis and treatments.

As a consequence of the above-mentioned guidelines, some restrictions were imposed due to the artifact's uniqueness and cultural value and the impossibility to transport the painting outside the museum. Therefore, all investigations and analyses were conducted on site and performed with portable equipment or instrumentation already available at the museum's conservation department.

The diagnostic techniques were chosen with priority given to non-invasive and non-destructive methods. Even though bench-top equipment and sampling methods would provide at once more reliable results, the disadvantages in terms of performance were compensated by the total respect for the integrity of the object. The eventual use of complementary methods in further investigations will integrate the collection of data, thus providing sufficient and reliable information about the artifact.

Due to the page limitation on this thesis, the art historical presentation in Chapter 2 is presented very briefly. A deeper study about the painting's iconography and the related preparatory drawings can be read in the article “Den heliga familjen och apan” by Lena Boëthius, published as a contribution to the catalogue *Akrobater och harlekiner, familj och kvinnor* (Aagesen 2006).

## 1.7 Terms and Definitions

The term ‘cardboard’ is used in this study to generally describe a paper-pulp based support of various thickness. It has not been possible to deepen the research in order to distinguish the different types of paperboard used by Picasso mainly due to two factors: the contradictions between the sources and the lack of time which would have been required to gain a correct description of the support. Therefore, the list in Table I in Appendix 1 reports paintings whose support has been variously described as ‘cardboard’, ‘millboard’, ‘paperboard’ and ‘pasteboard’ without any further distinctions.

The terms "non-invasive" and "non-destructive", despite the fact that they are sometimes used as synonyms in the literature, are used in this paper having in mind their peculiar meanings. "Non-invasive" refers to a method of analysis that does not affect the physical state of the object due to the fact that it does not involve sampling. On the contrary, the term "non-destructive" refers to methods that may do require sampling, but not imply the destruction of samples permitting thus the repetition of the analysis (Pinna, Galeotti & Mazzeo 2009).

The use of the term "catalogue raisonné" refers to a descriptive catalogue arranged according to a specific subject, often regarding works of art, in this case the artistic production of Pablo Picasso, equipped with explanations and scholarly comments.

# 2 Literature Study

## 2.1 Historical Context: the Early Years from Barcelona to Paris

> *I used to say that when Picasso had looked at a drawing or a print, I was surprised that anything was left on the paper, so absorbing was his gaze*. (Stein, 1947, p. 170)

Born in Malaga in the 1881, Pablo Picasso manifested as early as during his childhood, an extraordinary artistic talent, a tenacious will and a voracious curiosity towards experimentation which let him become one of the most significant artists within the art history of the 20th century. Son of an art teacher, he attended art classes in Malaga, La Coruña and Madrid. Picasso and his family moved to Barcelona in 1895. He came thus in contact with the Catalan version of Modernism, the artistic avant-garde of the time, which was heavily influenced by the aesthetic of the Art Nouveau and Symbolism (Palau i Fabre 1980; McCully 1997).

Between 1902 and 1904 Picasso worked alternatively between Barcelona, Madrid and Paris. Those early years were distinguished by the efforts to establish himself as an artist coping with financial difficulties and personal struggles. Maybe mirroring the sense of precariousness and suffering, the production of that period is characterized by the depiction of subjects such as indigents, wretches and social outcasts. Those compositions find their peculiarity in the use of a palette dominated by blue nuances and livid tones. This is what the art critic Gustave Coquiot named in 1914 as the Blue Period (Boardingham 2006).

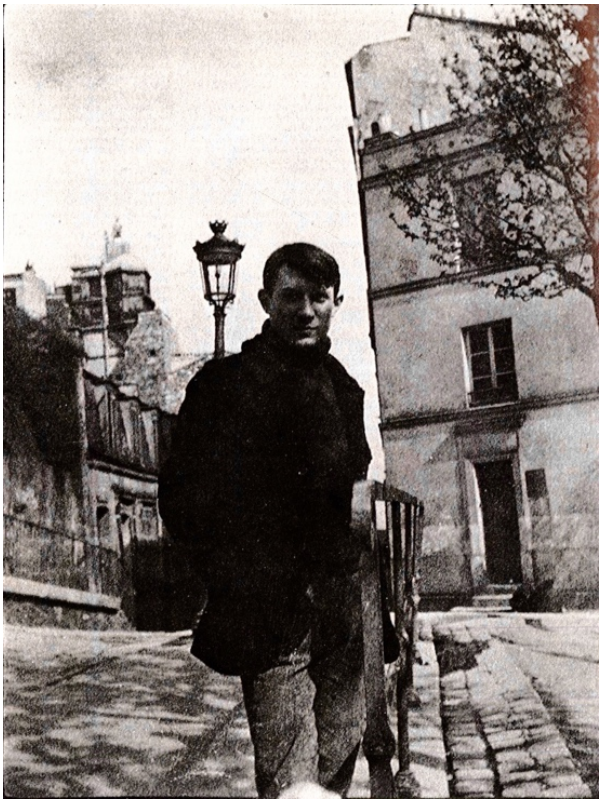


*Fig. 1 Picasso on Place Ravignan in Montmartre, 1904.*

*Fig. 2 Entrance to the Bateau-Lavoir from Place Ravignan.*

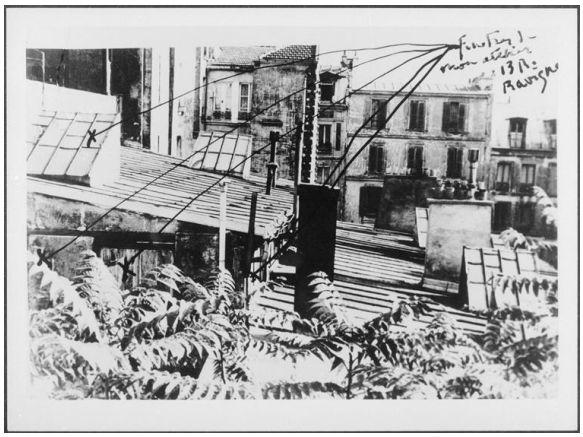


*Fig. 3 Roofs at the Bateau-Lavoir: the lines show Picasso's atelier.*

In 1904 he finally settled in Paris moving to the *Bateau-Lavoir*, the legendary atelier at 13 Rue de Ravignan in Montmarte (Figures 1-3), where he lived and worked until 1912. Once there, the palette and the subjects of Picasso's works began to change. Tones and shades passed from being melancholic, cold and dull to a warm and pale brilliancy. It was the beginning of the Rose or Pink Period, which also corresponded to the start of his relationship with Fernande Olivier, the muse of his first cubist period between 1907 and 1909 (McCully 1997). The artist and his circle of friends, those who Fernande used to call 'la band à Picasso' (McCully 1981), enjoyed attending theaters, cabarets and, among all, circus exhibitions. Clowns, travelling comedians and performers soon became the protagonists of drawings and paintings. Still in uncertain economic condition, the alienate world of comedians and acrobats represented for Picasso an allegory of his own condition of a broke, bohemian artist (Aagesen 2006; McCully 1997).

## 2.2 *The Acrobat* Family: Provenance, Description and Theme

> *When, a few days later, I dropped in at Sagot's to talk about Picasso, he had a picture by him, which I bought. It was the picture of a mountebank with wife and child and an ape. The ape looked at the child so lovingly that Sagot was sure this scene was derived from life; but I knew more about apes than Sagot did, and was sure that no such baboon-like creature belonged in such a scene. Picasso told me later that the ape was his invention, and it was a proof that he was more talented as a painter than as a naturalist.* (Stein, 1947, p. 169)


*Fig. 4 Pablo Picasso, Acrobat Family, 1905. Göteborg Konstmuseum.*

*Fig. 5 The Acrobat Family on the wall of Leo and Gertrude Stein's apartment in Paris.*

With these words Leo Stein remembered his first contact with the *Acrobat Family* (Figure 4), which he immediately decided to purchase, at the Clovis Sagot Gallery in Paris in 1905. A few days later he and his sister Gertrude visited Picasso's atelier in Montmartre. It was the start of a profitable acquaintance.

The Steins would soon become patrons of the Spanish artist, buying and commissioning some of the most outstanding pieces of his early career (Figure 5).

As reported by Lena Boëthius (2006), the painting was later sold to Walther Harvolsen, a Norwegian artist and art dealer. By the 1917 it became part of the collection of the Swedish businessman and patron Conrad Pineus in Gothenburg. In 1922 Pineus sold the artwork to the Gothenburg Museum of Art for the price of 14,000 Swedish crowns.

The *Acrobat Family* (inventory number GKM 699) is a painting on cardboard of 104 x 75 cm without the frame, whose technique is often presented as a mix of gouache, pastel, watercolor and Indian ink. The painting is still mounted in its original frame.

As a general description of the work, it can be said that it shares aesthetic features with other pieces from that period, which, regardless of the technique employed, seems to indicate the effort of the painter to obtain a specific opaque appearance of the pictorial surface. Guillame Apollinaire, poet and close friend of Picasso, seems to properly identify this quality when, writing about the harlequins series in an article on La Plume in 1905, describes "La couler a des matités de fresques, les ligne sont fermes"[1] (Daix & Boudaille 1966). Despite the use of cold colors as the opaque turquoise, the blues and the bright white for the background and the acrobat's costume, the yellow-brownish tone of the cardboard is visible in large areas of the surface, consciously left unpainted by the artist, contributing to produce a sense of chromatic unity with the splendid pink and earthy tones of other areas of the painting. A general warm hue permeates the composition.

The picture represents an intimate family scene of circus artists. The subject is depicted in a place that can be recognized as a backstage, during an intermission or maybe right before or after the performance. The location is suggested by the presence of the blue-turquoise curtain-like background behind the group. A gracious mother is sitting holding her baby on her knees, while the little boy is struggling to escape the embrace, looking towards the observer. On the left, the slender figure of the father is seated on a drum, beside the woman, looking tenderly towards their son. On the right, at the foot of the mother, a crouched baboon is also attracted by the figure of the child, which clearly appears to be the focus of the entire composition. As reported in the previous paragraph, acrobats, clowns and commedia dell'arte imagery had a profound influence in the artist's production related to the Rose Period. The *Acrobat Family* stands out as one of the most peculiar and exquisite examples of that creative moment and probably the last piece of the series dedicated to the world of circus (Rivero 2006). Picasso returns to explore that imagery later, during the 1920's, during his collaboration as a set and costume designer for several productions of Sergei Diaghilev's company Ballets Russes (Carmean 1980).

## 2.3 Picasso's Production on Cardboard between 1900 and 1906

A literature review of the production of painting on cardboard has been carried out through the consultation and confrontation of the following catalogues raisonnè regarding the early production of the artist:

- *Picasso 1900-1906: catalogue raisonné de l'œvre peint* by Daix and Boudaille (1966).
- *Picasso. Life and Work of the Early Years: 1881-1907* by Palau i Fabre (1981).
- *Picasso: Blue and Rose Periods: the Complete Paintings of Picasso* by Sutton and Lecaldano (1987).

Table 1 lists the artworks correspondent to a determined technique and the year of production. More detailed information about those paintings are reported in Table I, Appendix 1. The techniques are reported as described in the above mentioned literary sources. When possible, this information has

[1] "The colour has the flatness of frescoes, the lines are firm", trad. By M. McCully (1981, p. 52)

been double checked through the consultation of museums' online databases or other catalogues. Table 2 documents the different descriptions of the *Acrobat Family*'s technique as reported in several catalogues from 1951 to 2014.

**Table 1**. Pablo Picasso's production on cardboard between 1900 and 1906.

| | Oil | Pastel | Pastel, Charcoal | Gouache | Gouache, Watercolor, Pastel, India Ink | Gouache, Chalk, Oil | Gouache, India Ink | Gouache, Watercolor | Pen and Ink, Colored Pencil | Watercolor, Sanguine | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1900** | 1 | 4 | - | - | - | - | - | - | - | - | **5** |
| **1901** | 37 | 4 | 1 | - | - | - | - | - | - | - | **42** |
| **1902** | - | 1 | - | - | - | - | - | - | 1 | - | **2** |
| **1903** | - | - | - | - | - | - | - | - | - | - | **0** |
| **1904** | 1 | - | - | 2 | - | - | 1 | - | - | - | **4** |
| **1905** | 4 | - | - | 18 | 1 | 1 | 2 | 1 | - | - | **27** |
| **1906** | 1 | - | - | 7 | - | - | - | - | - | 1 | **9** |

**Table 2**. Description of the *Acrobat Family*'s technique as reported in several catalogues from 1951 to 2014: 1- Westholm & Ryndel (1951, p. 226), 2- Daix and Bourdaille (1966, p. 258), 3- Göteborgs konstmuseum 1979 (1979, p. 78), 4- Palau i Fabre (1980, p. 545), 5- Sutton & Lecaldano (1987, p. 100), 6- Rivero (1992, p. 160), 7- Göteborgs konstmuseum 1992 (1992, p. 97), 8- McCully (1997, p.245), 9- Aagesen (2006, p. 30), 10- Arvidsson (2014, p. 284).

| | Gouache, Watercolor, Pastel, India Ink | Gouache, Watercolor, India Ink | Tempera |
|---|---|---|---|
| 1 Westholm & Ryndel | | | X |
| 2 Daix & Bourdaille | X | | |
| 3 GKM 1979 | | X | |
| 4 Palau i Fabre | X | | |
| 5 Sutton & Lecaldano | X | | |
| 6 Rivero | X | | |
| 7 GKM 1992 | | X | |
| 8 McCully | X | | |
| 9 Aagesen | X | | |
| 10 Arvidsson | | X | |

## 2.4 Hypothesis about the *Acrobat Family*'s Composition

Results presented in Table 1 show a rather clear correlation between the use of cardboard as a painting support in a specific period and the employment of a particular technique. The artist's production on cardboard seems mostly concentrated during the periods 1900-1901, characterized by the use of oil paint, and 1905-1906, when the most common medium used by Picasso appears to be gouache. A

more frequent use of pastel on cardboard is almost circumscribed to the beginning of his career. Mixed media techniques are most recurring in the second part of the considered period. The *Acrobat Family* is amongst those few paintings characterized by the employment of multiple techniques.

Regarding the description of the mixed media technique employed in the *Acrobat Family*, the most common combination presented in catalogues is 'gouache, watercolor, pastel and India ink on cardboard', as it can be noted from Table 2. Pastel is not present in three catalogue editions from the GKM describing the painting as a 'gouache, watercolour and ink on cardboard'. An early GKM catalogue from 1951 represents a unique voice presenting the technique as 'tempera on cardboard'. Due to the rare use of tempera by Picasso during his early years and the fact that the indication is not followed by any other source, this technique will not be included in the list of credible materials employed for the painting.

Rachel Mustalish, paper conservator at the Metropolitan Art Museum of New York, published in 2010 an interesting contribution to the study of Picasso's modus operandi during the beginning of the 19th century. Presented as a technical note in the catalogue of the exhibition *Pablo Picasso at the Metropolitan Museum of Art*, Mustalish and the research department of the museum, conducted a study on *Saltimbanque in Profile,* a painting on paperboard which shares similar characteristics with the *Acrobat Family* and which was painted by Picasso the same year, in 1905 (Tingerow & Stein 2010). Described in numerous catalogues as gouache on cardboard, under a more accurate investigation, the *Saltimbanque in Profile*'s technique resulted as something else. The aspect of the paint, which presented a type of craquelure which is not typical of gouache, and the detected presence of fatty acids, revealed that the technique was actually the so called 'essence´. Essence or 'peinture a l'essence' consists in oil paint that has been heavily diluted with turpentine, causing the leaching of much of the oil (Ash 1985). The appearance of essence is dry and matte and because of that it is often mistaken for gouache. Picasso did used essence on paper in early small portraits from the 1900´s (Tingerow & Stein 2010). The analytical investigations detected also sandarac, a coniferous resin which was often used as an intermediate or final varnish over paintings (Ward 2008). Mustalish argues that sandarac could have been applied by the artist on the paper board surface as a ground layer or already been present in the support from the fabrication process. Sandarac was in fact commonly employed as a protective coating for boards to impart water resistance and increase stability.

As a result of the literature study, the support being certainly cardboard, it seems reasonable to circumscribe the potential materials and technique used by Pablo Picasso for his *Acrobat Family* to: gouache, watercolor, oil paint/essence, pastel and India ink.

## 2.5 Presentation of Plausible Materials and Techniques

This section briefly explains the materials and techniques tat were possibly used by the artist resulting from the literature research. Major conservation issues characterizing these specific materials, especially when used on paper-based supports, are mentioned in order to highlight and present problems which have to be taken into account for the final evaluation of the painting's condition. A concise description of the common appearance of the different techniques is also presented in order to be used as an overall guide for their identification during the visual examination of the painting. Additionally, a photographic record of the general look of those techniques under magnification is available in the Table II, Appendix 3.

### 2.5.1 Cardboard

Cardboard is a generic term for paper-based board of various strengths and thicknesses. Since the 19th century, the commercial production of various types of board, although not specifically intended for artistic use, has increased the range of potential supports for painting. 20th century artists have used them as material for sketches, preparatory drawings and paintings due their affordable cost and availability (Ward 2008). Boards of paper may be produced either by laminating two or more layers of paper (pasteboard) or by forming, combining and pressing several layers of paper fibers in special board machines, as for examples in the fabrication of 'millboard' (Ward 2008). Often made from

wood pulp, the raw components of cardboards are generally of poor quality, with a high lignin content. As a natural component of wood pulp employed in western paper production, lignin is a very reactive polymer which easily oxidizes into colored compounds and acidic products. The presence of lignin and, eventually, of various chemicals involved in their manufacture, contributes to compromising the physical stability of cardboards (Mills 1994). Such paper-derived materials have proved to be self-destructive and, if used as mounting board, to harm the artwork they house. When employed as a support, they are potentially harmful for the paint layer. A common problem derived from the combined action of acidity and lack of flexibility is breakage and delamination, particularly at the corners and along the borders, separation and the tendency to be soft and spongy when exposed to a moist environment (Burns 1990).

### 2.5.2 Watercolour and Gouache

Watercolor paints are composed essentially of transparent pigments ground to an extremely fine texture in an aqueous solution of gum. The ingredients of watercolors are: finely grounded pigments; gum arabic, which works as binding medium and adhesive; glycerin, which imparts moistness, prevents extreme caking or drying of paints and increases solubility; syrup, which acts as a plasticizers, contributes smoothness for grinding and painting; oxgall as wetting agent, improves uniform flow of paint on surfaces; dextrin, improves smoothness of texture and brushing quality in some pigments (Mayer 1940; Ward 2008; Doerner 1976). Being water-based techniques, both watercolor and gouache produce a matt colored surface once dried. Gouache, also called bodycolor, differs from watercolor paint because of its opaque appearance rendered by the addition of white paint or pigment, as for example, Chinese white, an opaque white originally based on lead and later on oxide of zinc, or white fillers, such as chalk, barium sulfate or even marble dust. The commercial product can vary considerably, but pigments are usually bound with gum arabic or gum tragacanth. Glycerin and dextrin are also added to increase the solubility of the colour in water. Gouache produces a flat and even color that confers to this technique the characteristic unified quality of light. Pigment and glycerin are used in larger proportions for the preparation of gouache than for transparent watercolours in order to gain a greater opacity and flexibility (Ward 2008; Doerner 1976; Mayer 1940). Such water-based paints may be fugitive due to their exposure to light, moisture and oxygen, which can provoke fading or change in color. The causes of this sensitivity are to be found in the thickness of the applied layers, the eventual inclusion of dyes and natural organic materials, the minimum amount of binding gum and its level of adhesiveness and, lastly, the characteristics of the support. The paint can flake if the paper surface does not ensure a sufficient adhesion, because of its poor absorbency, if it is too thin or too smooth. Thicker paint layers, as in the case of gouache, can crack and flake as a consequence of the movement of the support (Ash 1985).

### 2.5.3 Oil Paint

Oil paint consists basically of fine grounded pigments dispersed in oil and combined with various painting media, which modify the drying time, the handling qualities and the general appearance of the painting. Resins and alkyds are often added for these purposes. It can take several weeks, months or even years for oil paint to dry. The most frequently used fatty oils are the ones extracted from linseed, poppy seed and walnut. Because of their high refractive index, higher than egg tempera for example, the aspect of the pigments in oils is more translucent than in other techniques using other types of binding medium (Ward 2008; Doerner 1976). The paint layer appears "greasy" and glossy. The shininess of the paint can vary depending on the amount of thinning media, the pigment or the mix of pigments employed. In fact, the obtained viscous paint is usually thinned during the application on the support with a volatile liquid, such as an essential oil, which gradually evaporates from the painted surfaces. Oil of turpentine is by far the most employed thinner in oil painting. Prepared from the pitch of various pine trees, it is used as a diluent but also as solvent for resins. When applied in considerable quantities, much of the binding medium will be absorbed by the support and the colour will be dissolved to the point to lose its body. The rapid evaporation of turpentine can also cause cracks on non-porous grounds if overdosed the necessary amount of essential oil (Doerner 1976). Oil paint is considered incompatible with paper support because it causes oxidation of the paper resulting in

degradation, discoloration and embrittlement of the support. The oil migrates into the porous paper structure producing a halo of discoloration around the painted area which oxidizes the fibers. With age, thick layers of hard/polymerized oil paint can crack and flake due to the expansion and contraction movements of the paper reacting to temperature and humidity fluctuations (Ash 1985).

### 2.5.4 Pastel

The pastel technique uses chalky colored powder, modelled into sticks or crayon, to be used as a drawing material. It is manufactured by three principal raw components: pigments, filler (usually precipitated chalk) and a binding medium (usually gum arabic). Binding medium, only present in small amounts, serves to hold together the filler, which gives physical support, and the pigment, which carries the color. The powdery colored matter applies by friction and does not adhere to the support by any medium. Only electro-static forces make the pastel stick on the surface. Adhesion is enhanced often by the application of very dilute binder used as fixative afterwards (Ward 2008; Doerner 1976). The technique possesses a rather unique versatility in the application: pastels can be smudged, applied in straight lines or curved, overlaid or hatched in parallel lines, scraped and scratched. Pastel has usually a matt, velvety texture and it is characterized by a vivid brilliance in tones. A certain roughness of the ground is necessary to hold the powdery consistency of the material. Paper, cardboard or canvas are often the most frequently used supports for pastel paintings. The major disadvantage of the pastel technique is its fragility under mechanical wear or shock, because the color adheres but loosely to the support (Doerner 1976; Mayer 1940; Ash 1985).

### 2.5.5 India Ink

India Ink or Chinese ink is a mixture of soot or lampblack with animal glue or vegetable gums, such as acacia gum. In India black inks were based on carbon in the form of lampblack and of charcoal from various materials, combined with vegetable gums such as acacia gum. Modern production of India may add shellac or gelatin to make the ink more durable once dried (Ward 2008). It is considered a long-lasting and stable painting material.

# 3 Analytical Investigations

## 3.1 Visual Examination

Visual examination represents the first step in the study of an artwork. An accurate, methodical observation can provide the necessary information about the structure of the object and its condition, the materials involved and the technique used for its production.

### 3.1.1 Performed Investigation

The investigation was carried out in the paper conservation studio at GKM between the 28th and the 30th of March 2017 (Figure 6). The painting was firstly examinated ocularly under natural and artificial light. Photographic records of the investigation were taken by the author with a Canon PowerShot G9 X digital camera. Images with raking light were taken with a Nikon D3x camera by Hossein Sehatlou, photographer at the GKM. The object was observed under magnification with a Leica M80 Stereo Microscope provided with a Leica EC4 color camera.

*Fig. 6 Set up for the visual examination of the painting in the paper conservation studio at GKM.*

### 3.1.2 Results

#### *3.1.2.1 Support*

Under direct light the support shows no significant planar distortions (Figure 7 A). Once observed with raking light, on the right side of the painting, a long crease going from the top to the bottom is clearly visible (Figure 7 B, C and D). By a nearer examination and under magnification, the paint in that area shows no signs of damage, which lead to suppose that the crease might have been present on the cardboard before being used by Picasso as a support.


*Fig. 7 Documentation of the longitudinal crease on the right side of the painting. A: direct light shows no sign of planar distortion. B: Raking light from the right. C: raking light from the left. D: close up in raking light from the left. The arrows indicate the presence of the crease.*

The board's edges show clearly the layered structure of paper sheets pressed together. The aspect of the paper from the sides presents signs of delamination and appears rather brittle, discolored and of a spongy consistence (Figure 8). The situation seems even more critical when it comes to the corners, which have also lost part of the paint layer (Figure 9). During the removing from the frame and every time the object is moved, even slightly, a brown, dusty material comes off from the sides of the support, as well as micro-fragments. However, such high rate of fragility of the material is not detected either on the back or on the front of the object. This is probably due to the intrinsic structural construction of the board, the edges being the weakest part, and/or because of the use of some sort of coating applied on the cardboard either during the fabrication to increase its physical strength (see section 2.5.1), or by the artist as a preparation.

*Fig. 8 Detail of the right edge of the board. It is evident the delamination of the paper layers.*

*Fig. 9 Detail of the bottom right corner. The arrow indicates the detached paper particles.*

The cardboard's fibrous and uneven superficial texture can be easily observed in some areas left unpainted, as for examples the hat of the acrobat or the portions recreating the flesh tone of the family members (Figure 10). Nevertheless, this irregular, rather rough surface can be distinguished almost in the whole area of the painting, emerging through the different textures of the paint layers (Figure 11).

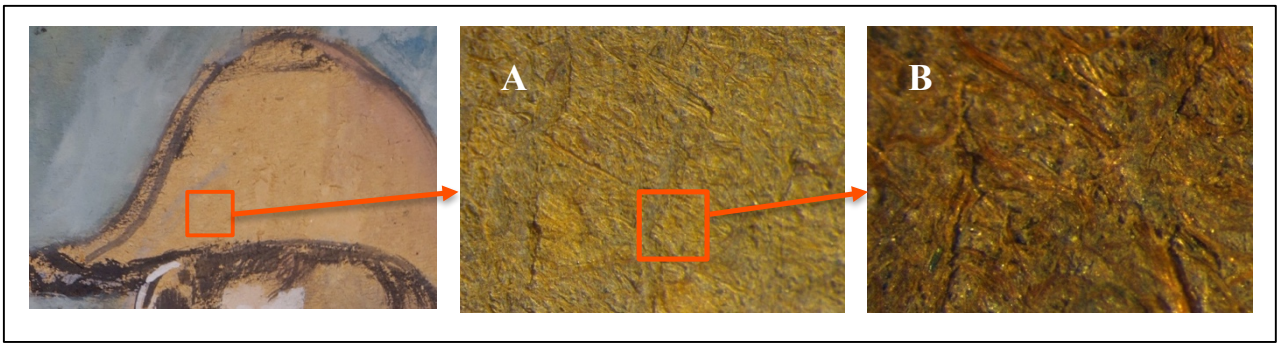



*Fig. 10 The hat of the acrobat. A: at 25x magnification. B: at 60x magnification.*

*Fig. 11 Detail of the turquoise background near the shoulder of the acrobat. The fibrous texture of the cardboard emerges through the paint layer. The picture documents the absence of a varnish layer.*

The observation under raking light shows the pattern of embossed parallel diagonal fine lines, a typical feature of this type of machine-fabricated cardboard, as well as the presence of lifting flakes and cleavages of various dimensions distributed on the whole surface of the board (Figures 12 and 13). Those superficial defects as well as the presence of foreign material, including hairs and feathers, are recorded under the observation with magnification (Figure 14).

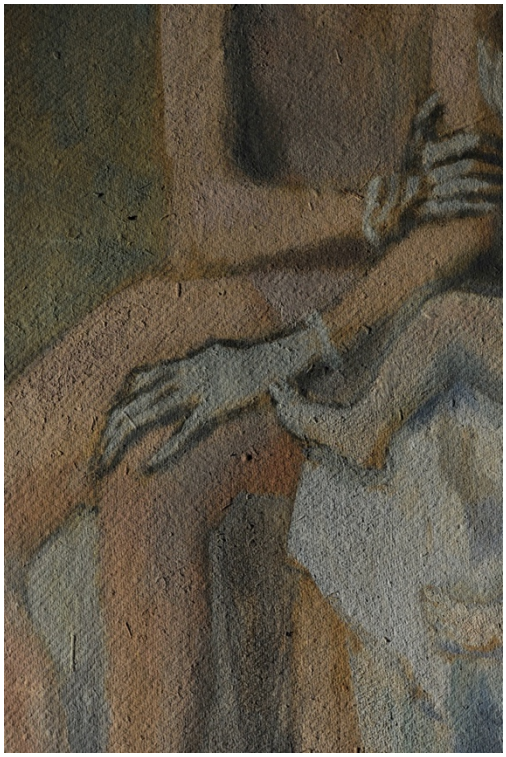


*Fig. 12 The painting under raking light from the right. Parallel diagonal lines are visibile on the whole surface.*

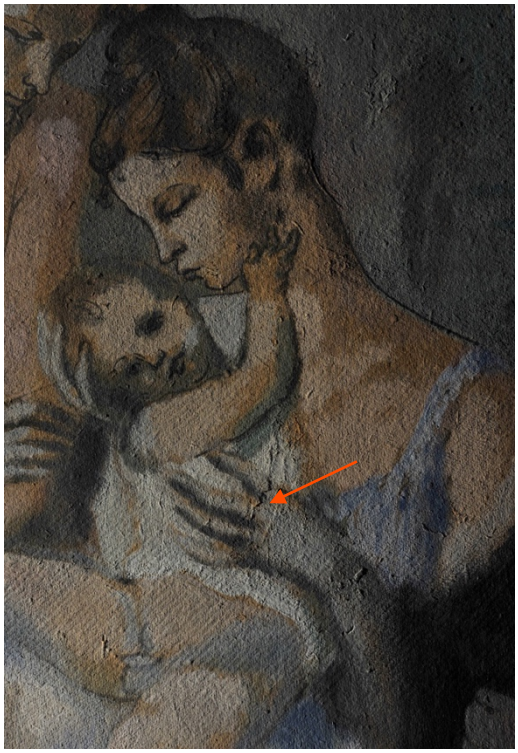


*Fig. 13 The painting under raking light from the right. A major crack is indicated with the arrow.*


*Fig. 14 Captures at 10x magnification of examples of impurities and defects. A: delamination of the cardboard. B: hair, maybe from a brush, captured in the paint. C: a feather. D: crack near the bottom right margin.*

### *3.1.2.2 Paint Layer*

The painting does not present signs of varnish or coating over the paint layer (see for example Figures 11 and 18). However, no trace of detached pigmented particles or fragments has been detected during the removing of the object from its frame. At first observation under diffuse light, the texture appears generally matt with some areas left unpainted, some areas presenting a sort of transparency while others just opaque (Figure 15). The paint is applied in different ways. Sometimes with large, energetic brush strokes, as in the case of the turquoise background or the acrobat's skirt. Other times Picasso worked in a more precise manner, as for example when tracing the family members' faces or in the details of the harlequin's collar, executed with fine dark lines. The variation of the application results in a variety of textures.


*Fig. 15 Examples of the different covering textures of the paint layers. A, B, C: opaque. D and E: transparent. F and G: unpainted.*

A close-up observation of the head of the mother permits to appreciate the working method of Picasso (Figure 16): he seems to have first sketched the head with the black ink, then successively applied layers of paint of variable transparency, and finally re-defined the facial features and hair with additional quick fine strokes of ink. Some areas appear to be smudged, maybe with fingertips. A close-up capture of the hand of the acrobat (Figure 17) shows as well the final application of highlight touches, particularly noticeable in the white ruffled cuff 's detail.

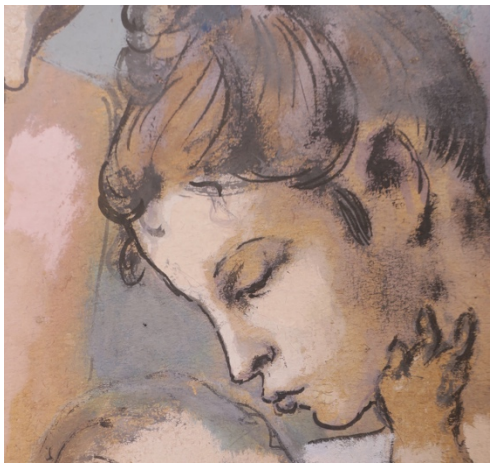


*Fig. 16 Close-up capture of the head of the mother. The superimposition of fine black lines and wider brush strokes is noticeable.*

*Fig.17 Close-up capture of the hand of the harlequin. The arrow indicate the final strokes of white paint shaping the ruffles of the cuff.*

As previously stated, the rough surface structure of the cardboard ground is visible on almost the entire extension of the painted surface. When observed slantwise under direct or raking light, some areas revealed a shiny aspect which is not visible from a frontal point of view (Figures 18 and 19). These glossy strokes correspond generally to the highlight spots of the painting and could be the result

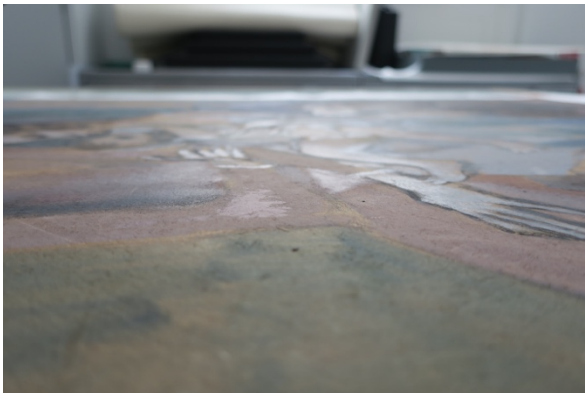


*Fig. 18 The shiny surface of some of the highlighted areas are visible from a slanted point of view. It could be the indication of the use of a greasy paint as for example oil paint or essence. The photo shows as well the absence of varnish coating.*

*Fig. 19 Observation with raking light reveals the presence of the brighter surface of some of the highlighted areas.*

of the use of techniques which indicate greasy media, as for example oil paint or essence. A more precise understanding of the different textures of the paint layers is possible by the examination with a stereo microscope. The opaque areas of the painting can be thus further distinguished between two major groups according to their appearance under the microscope: a first group showing a matte, dry and even surface and a second group presenting a thick, shiny and almost greasy consistency, with visible brush stroke marks (Figure 20). The thicker and shinier areas detected with the microscope, correspond to the glossy areas previously observed when looking at the surface slantwise or with raking light.


*Fig. 20 Different textures under microscope examination: A, B and C have a thick and shiny appearence, while D, E and F appear dry and matt. Pictures were taken at 25x magnification.*

The action of the light on colored matter is not the only, but indeed the most common cause of fading. The painting's edges have been protected by the original frame for about 1-1.5 cm from the exposure to light, while the rest of the painted surface endured years of exposition. The comparison of the tone of the shielded perimeter with the whole painted surface shows signs of slight discoloration or fading (Figure 21). Discoloration is referred to the change in color of the binding media, often yellowing or


*Fig. 21 Comparison of the changing in color tone between the edges and the rest of the painted surface. The arrows indicate discolorated areas.*

darkening effects, while fading is rather a phenomenon concerning pigments and dyes.

However, a major color change can be observed when comparing the painting in its present condition with photographic records from the past. A dated picture of the *Acrobat Family* from 1964 is kept in GKM archive and can be used as a reference.

*Fig. 22 On the left the reproduction of the Acrobat Family dated 1964, on the right the painting in its actual condition. The ovals indicate the area most interested by the colour change.*

Because it is a photographic reproduction of the original, once used as a catalogue picture, reliability of the color rendering can be affected by numerous variables, as for example camera settings, lighting, exposure, photographic support, etc. However, setting aside the dissimilarities in color brilliancy, it can be said that a quite evident change it has occurred on the right side of the composition, more specifically concerning the blue drapery (Figure 22). Here it seems that the body of some of the blue paint has somehow faded or fallen off.

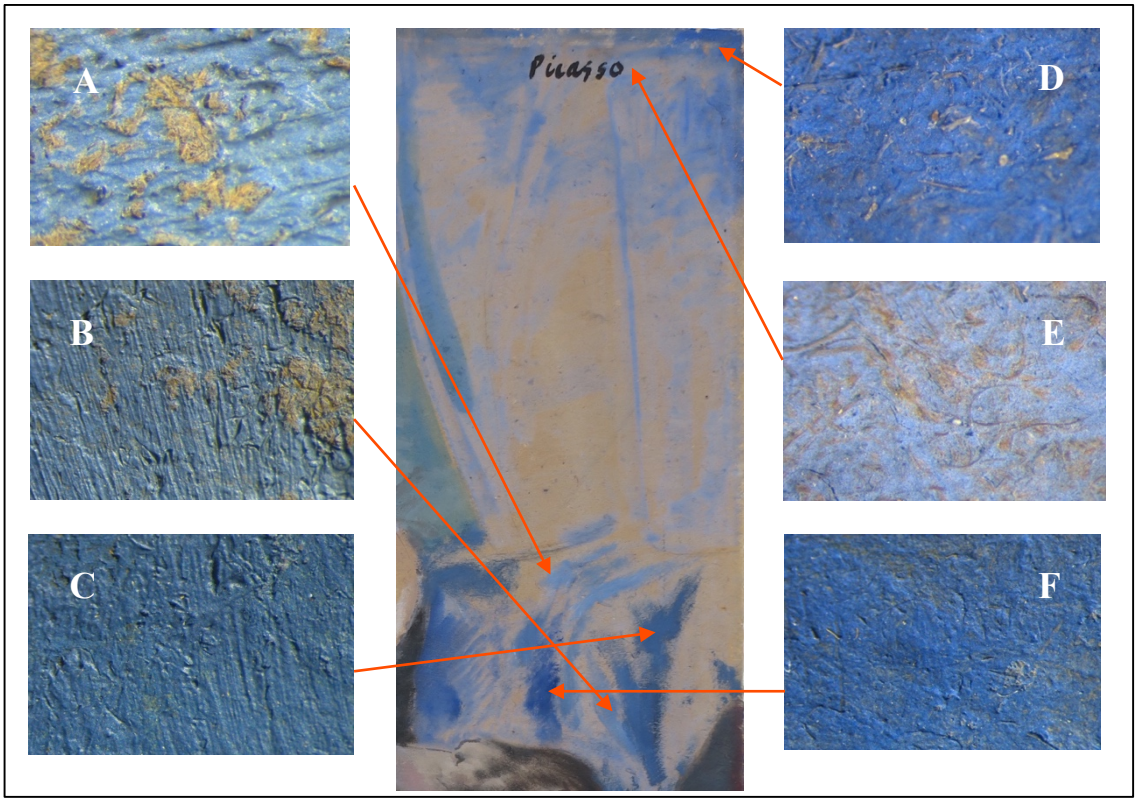



*Fig. 23 Details of the blue tones of the drapery under microscope at 25x (B, C and F) and 60x (A, D and E) magnification.*

The blue shades shaping the curtain show different characteristics regarding coverage power, texture, consistence and application when observed under the stereo microscope as presented in Figure 23.

## 3.2 Multispectral Imaging

Multispectral imaging (MSI) is a non-destructive and non-invasive method of analysis used to map and to tentatively identify pigments and retouching of artworks. The required equipment consists, in its simplest form, of a monochromatic camera and a set of few bandpass filters. The system acquires a series of spectral images of the object under examination. Since the light that is not reflected is absorbed or transmitted, depending on the chemical composition of the tested material, the reflectance spectral features gathered at different wavelengths can provide useful information for the identification of that specific material. The system operates in the ultraviolet (UV), visible (VIS) and near infrared (IR) mode (Liang 2012). Since the method can only provide qualitative information and results can be affected by various factors which cannot be eliminated, it has to be underlined that the use of MSI for material identification of artworks should always be considered as a supplementary technique or a preliminary step to more sophisticated and detailed examination. A limit of this technique lies for example, in the fact that the reliability of the results is affected by the purity and provenience of the pigments. In the presence of mixed or layered pigments, the interpretation of results implies more difficulties. Figure 24 shows a scheme of the electromagnetic spectrum and the range of information about a painted object that can be provided by the images acquired at the different spectral bands.

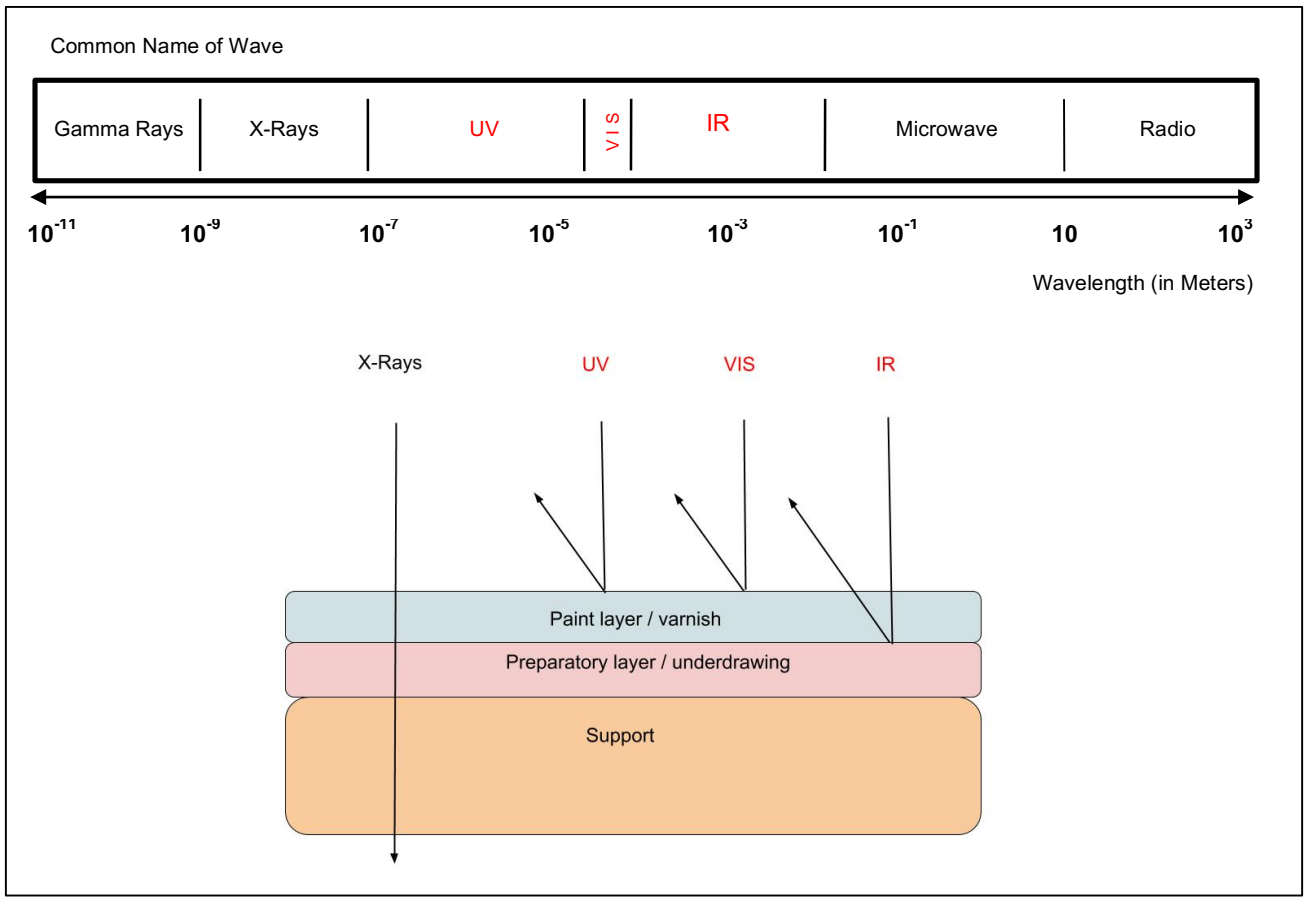



*Fig. 24 Above: scheme of the electromagnetic spectrum. Under: the recovered information when a painted object is investigated using different wavelengths. The waves covered by MSI are highlighted in red.*

Since the UV radiation interacts mostly with the superficial layer of an object, UV-reflectance and UV-fluorescence images provide indication about pigments, binders and varnishes. Ultraviolet reflectography (UVR) is based on the observation of the ultraviolet radiation reflected by the artwork. The object is illuminated by a UV-light source while the visible light is blocked by filters applied on the camera lenses. Even though materials can appear only bright or dark in UVR, the method can be very useful to distinguish white pigments. For example, both titanium white or zinc white appear very dark in UVR image, while lead white has a very bright appearance (Cosentino, 2015). The UV fluorescence (UVF) is based upon the phenomenon which occurs when the UV radiation excites an electron of an atom to a higher energy state inducing the emission of a photon. The energy of the emission is associated with the difference between the two states and it depends on many factors as for example the nature of the painting materials (pigments, binders, varnish, etc.), how they interact with each other, their age and present condition. When using UVF aiming to the preliminary identification of pigments in a polychrome object, it is recommended to proceed after the previous removal of the varnish, if present, because varnish generally strongly fluoresces, which can interfere with the detection of the actual fluorescence of the other materials. Infrared (IR) photography takes advantage of the ability of the infrared radiation to penetrate deeper through the paint layer thus allowing the investigation of the preparatory layer and the detection of possible underdrawing or compositional sketches, “pentimenti”, signatures, dates and inscriptions. False color infrared photography (FCIR) is used to differentiate pigments presenting the same color in visible light but different chemical composition. The identification is possible because of the specific reflectance characteristics of pigments in the near infrared band of the spectrum. The method consists in combining the multispectral digital acquisition corresponding to channels sensitive to green, blue and infrared spectral regions as the green, blue and red components of an RGB image. The resulting "pseudo color image" presents the contribution of the information gained from the infrared region, making visible the differentiation of the materials (Pinna et al. 2009; Pitzalis et al. 2008).

### 3.2.1 Performed Investigation

The photographic acquisition by MSI was performed in one session on the 4 th of April 2017, in a semi-dark room at the paper conservation studio of the GKM and under the supervision of Jacob Thomas, Gothenburg University, and Mariateresa Pullano, paper conservator at GKM. An Artist Camera from Art Innovation with a 5 megapixels Panchromatic CMOC sensor without IR filter and a Schneider Kreuznach Xenoplan 1.4/23 CCTV-lens (400-1000 nm) was used. The camera was calibrated on a 17% grey card. The instrument was equipped with a 7 positions internal filter wheel (Art Innovation 2015) which permitted the collection of images in ultraviolet light (between 320-400 nm), visible light, divided into three bands (400-500 nm: blue; 500-600 nm: green; 600-700: red) and infrared light, divided in two bands (750-800 nm: IR band 1; 900-1000 nm: IR band 2). During the MSI session, the painting was placed vertically on an easel. The camera was positioned on a slider which facilitated covering the whole surface of the object in 8 snapshots. The collected captures were then processed with ImageJ 2017 software providing images in visible light (VIS), UV-reflectance (UVR), UV-fluorescence (UVF), infrared (IR) and infrared false color (IRFC1 and IRFC2).

Because of the critical condition of the blue drapery on the right, which was discussed in 3.1.2.2, the attention of the diagnostic investigation was particularly focused on that region. This was done in the attempt to identify the composition of that area and enable a speculation about the causes of the degradation. Because of that and to be used as reference material, a set of swatches of blue pigments and zinc white were prepared and analysed with MSI in order to provide a comparison with the MSI captures of the painting. The captures of the references were done by the author after the session at GKM, using the same instrumental equipment and setup, but in a different location, this time in the photographic studio of the Department of Conservation at the University of Gothenburg. The pigments which have been tested are cobalt blue, prussian blue, ultramarine, indigo and zinc white. Different

types of techniques, based on the result of the literature review, were investigated. The materials used for the preparation of the swatches are listed below:

- Dry pastels: cobalt blue, prussian blue and ultramarine Rembrandt soft pastels for artist.
- Oil paint: linseed oil from Sandbergs and pure pigments from Schmincke (Indigo) and Kremer (cobalt blue, prussian blue, ultramarine, zinc white) were mixed.
- Gouache: cobalt blue PB28, prussian blue PB27, ultramarine PB29 and zinc white PW5 from Windsor and Newton Designers Gouache, indigo PB60 from Schmincke Horadam Gouache.
- Watercolors: cobalt blue PB28, prussian blue PB27 and ultramarine PB29 from Windsor and Newton Professional Watercolors in pans.

The paints were applied on a Bainbridge acid free cardboard 2,6 mm white. The smooth surface of the cardboard were mechanically removed to reveal the grainy texture underneath. This was done in order to achieve a surface showing similar characteristics to the support used by Picasso. The samples were also employed by the author as visual references during the investigation under the microscope to better understand the physical features of the different techniques applied to a fibrous texture. A photographic record of the swatches captured at 10x magnification is presented in Table II Appendix 3, while MSI captures are presented in Appendix 4.

### 3.2.2 Results

The results that are considered to be most relevant for this study: identification of materials and the evaluation of the condition of the object are presented. Unfortunately, the UVF captures of the upper half of the painting are not usable due to a technical mistake made by the author during the photographic session. A visual record of the MSI results is presented in Appendix 2.

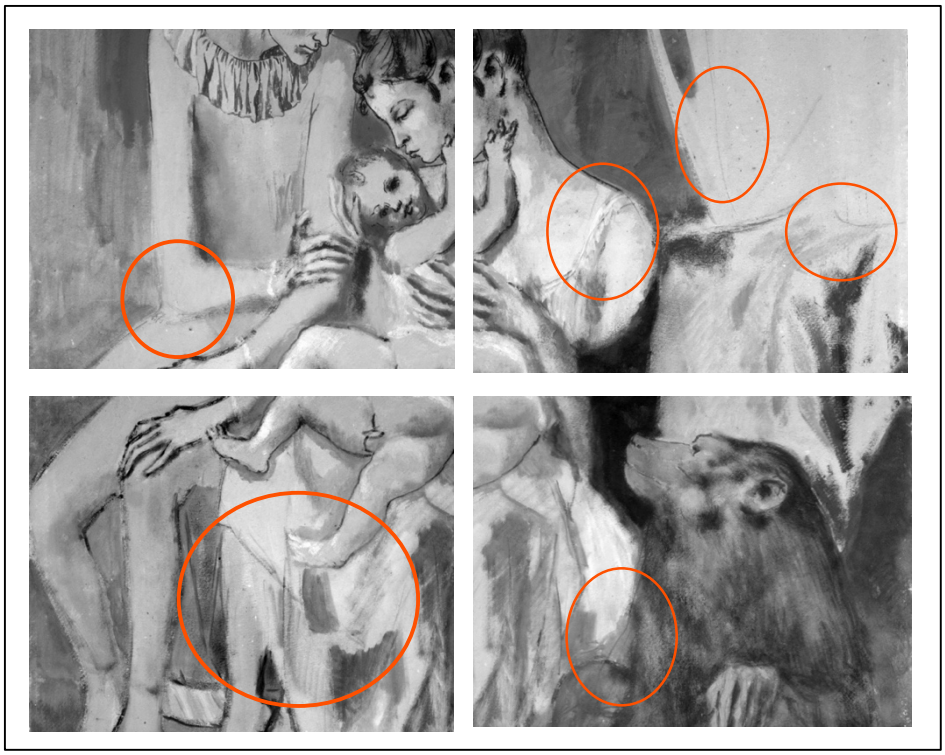


*Fig. 25 IR capture of the upper right area. The orange circles indicate the dark lines (graphite?) made more visible by the infrared investigation. The variation in the manner of application of the paint is particularly noticeable with this kind of investigation.*

The IR captures did not reveal the presence of a major, detailed preparatory sketch. Nevertheless, the infrared sharpened the presence of fine lines, presumably graphite, on some areas of the painting, which are only subtly visible with the naked eye (Figure 25). The IR imaging helped also to better distinguish the features of the brush strokes and generally to enhance observation of the way the paint is heterogeneously applied.

The comparison of results gained by IRFC (B), UVF (C) and UVR (D) imaging of a central area of the painting might help to understand the composition of the painting (Figure 26). To begin with the observation of the white paint, it can be noticed that when observed in visible light (A), the pale and bright areas of the mother's gown, the child's legs and feet and the hand of the acrobat, indicated in the figure by the orange and yellow circles, appear rather homogeneous in color. Once observed with UV light (C), the white tones highlighted in orange present a strong fluorescence while the other white areas, indicated in yellow, show no sign of fluorescence.

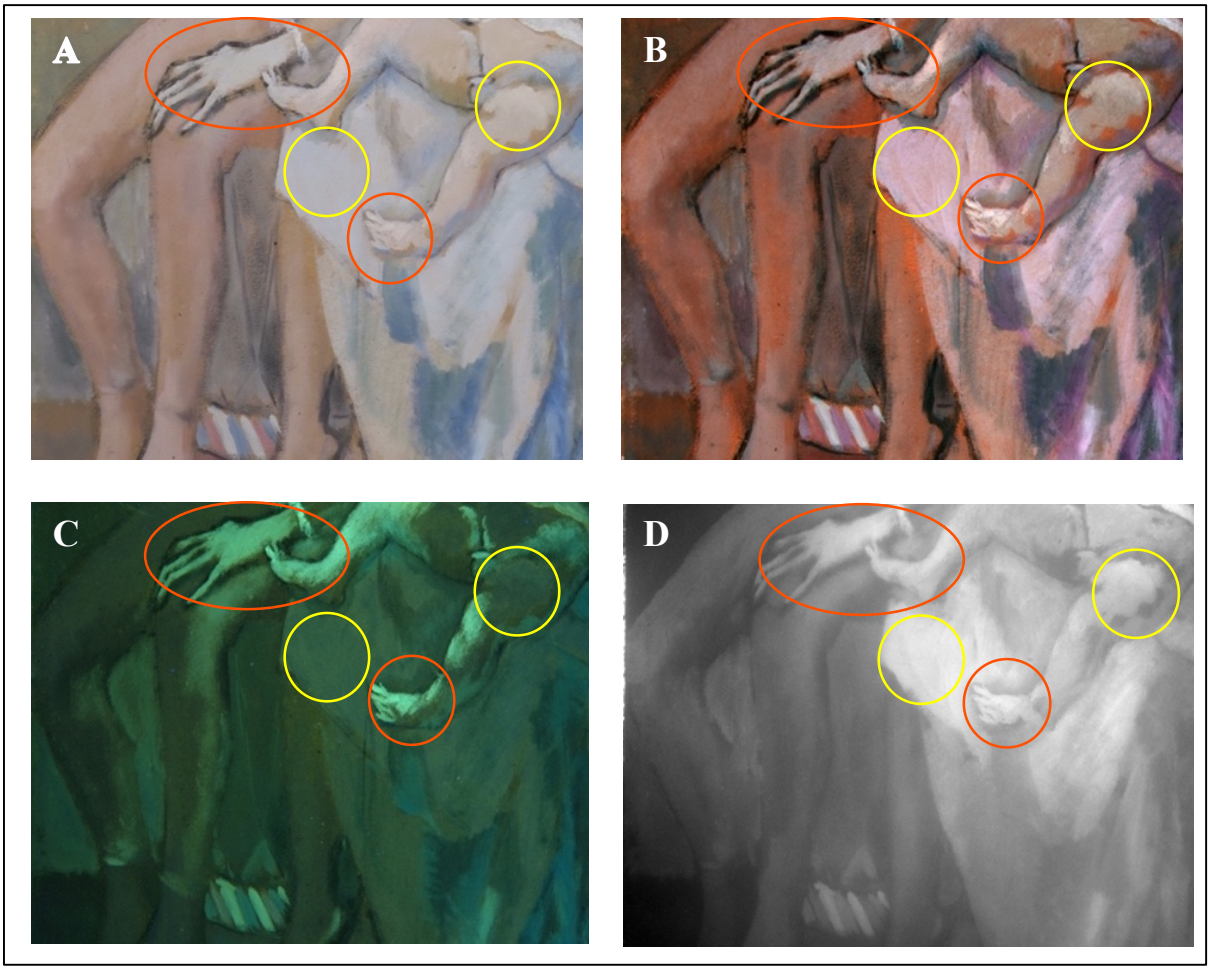



*Fig. 26 MSI captures. A: natural light; B: infrared (band 1) false colour (IRFC); C: UV fluorescence (UVF); D: UV reflectance (UVR). Orange and yellow circles highlight the different behaviour of white areas once observed at different wavelenght of the light spectrum.*

*Fig. 27 MSI captures. Left: natural light. Right: infrared (band 1) false color (IRFC). The encircled areas highlight the shift of color of the blue shades when observed with IRFC, thus indicating the presence of different blue pigments.*

The same portions appear having different when observed with IRFC (B), shifting from brighter to pinkish and to grayish white shades. UVR (D) did not reveal evident additional information about those areas, even though a variation in brightness can be noticed.
A different behavior of the blue shades when observed with IRFC could also be noticed as shown in Figure 27. The blue painted regions revealed a chromatic shift between dark blu-green to purple-violet. The same phenomenon was detected observing the "faded" drapery on the right as can be seen in captures of that area with IRFC band 1 (700-1000 nm) and with IR (Figure 28). The IRFC capture showed some areas which appear purple, violet or pink, while other brush strokes present a dark blue tone. The IR capture revealed some blue paint strokes appearing dark (red circles), others seem very bright and almost disappearing (yellow circle), while other portions present a sort of a middle tone (green circle).

*Fig. 28 IRFC captures of the drapery. On the left: the area in visible light. Middle: IRFC band 1. Left: IR. Red circles indicate blue areas which become dark blue in IRFC and dark in IR. Green circles indicate blue areas becoming purple in IRFC and greyish in IR. Yellow circles indicate blue areas becoming pink in IRFC and almost transparent in IR.*

The unpainted areas of the composition and the portions presenting a very thin paint layer, thus revealing the cardboard surface beneath, showed a strong orange coloration in the IRFC captures as it can be clearly noticed in Figures 27 and 28.

## 3.3 Fiber Analysis

Examination of fibers with a microscope, the execution of spot tests and the pH measurement, are all invasive and/or destructive forms of investigation, which require taking samples from the object and, as in the case of spot tests and pH measurement, the destruction of the collected material. Fiber analysis has been made possible because of the availability of original material which was considered expendable to be used for this purpose. In fact, due to the fragile condition of the paperboard especially around the edges, it has been possible to pick up some micro-fragments already detached (see Figures 9 and 29) from the board as a consequence of transferring the painting from the frame to the workbench.

Since the introduction and usage of fibers for the paper manufacturing process and the use of specific fibers in certain countries or regions are, to a large extent, known, fiber identification represents a precious source of information which may aid in dating the object, determining the provenance and interpreting the artist's technique. The understanding of the fiber content can also be crucial for the evaluation of the artifact's condition and consequently for the selection of appropriate conservation procedures, since different fibers present different chemical and physical properties which will affect the reaction to specific treatments. Microchemical spot tests consist of testing a small sample, removed from the artifact, with a drop of chemical reagents. Characteristic reactions, often a change in color, of these reagents can help in the identification of the fiber nature, but also of other materials constituting the artifact, as for example, additives of various origin and functions (glues, fillers, sizing agents etc.). This method of testing has some problems that need to be taken into account, as for example the difficulties of a proper interpretation of results, as it is grounded basically on visual observation of color changing. Because of that, microchemical spot tests have to be considered as a way to generally gain a clue about the composition of an artifact or as a confirmation of the results obtained by other forms of investigation.

### 3.3.1 Performed Investigation

Fiber analysis was performed by the author on April 11, 2017, in the chemistry laboratory of the Gothenburg University, Conservation Department. The criteria for the selection of samples has been based on their availability as inevitable damages during the handling of the object. Because of that, the results have to be considered as information referring to limited areas of the painting. Due to the scarcity of sampling material, it has been mandatory to select and limit the possible amount of analysis. Therefore, the undertaken spot tests were chosen primarily aiming to the determination of the fibers and lignin content of the paper pulp and the measurement of pH, considering those as leading factors affecting the condition and conservation of cellulose-based materials. The location of the collected samples is shown in Figure 29. Fibers from samples 1 and 3 were used for microscope observation and for spot tests, while 2, 4 and 5 were employed as material for pH measurement. The fibers were dispersed on a microscope slide and separated with a needle. A drop of glycerol was then put on the sample before setting down the cover slip (Meyer 1990). The so prepared samples were examinated in bright light with a Nikon Optiphot polarisation microscope at 200x magnification. The captures were taken with a Nikon Digital Sight, DS-Fi1 and visualized by the software NIS-Elements F. Spot tests were carried out applying a drop of stain on dispersed dry fiber sample on

microscope slides. After 1-2 minutes, excess solution was removed with a piece of blotting paper before setting down a coverslip (Meyer 1990).


*Fig. 29 On the left: location of the samples of cardboard used for fiber analysis. On the right: a photographic documentation of samples 2, 4 and 5.*

The samples were then observed under the microscope with the same instrumentation described before. The list of performed spot tests with respective reagents is presented in Table 3.

**Table 3.** List of performed spot tests.

| Spot test | Reagents | Purpose and guidelines for the interpretation of results |
|---|---|---|
| **Graff "C-stain"** | 20 ml aluminum chloride solution, 10 ml calcium chloride solution, 10 ml zinc chloride solution and 12,5 ml iodide-iodine solution. | Determination of lignin content. Yellow: high lignin content. Blue: well purified pulp. Red: absence of lignin. |
| **Herzberg** | Zinc chloride solution. | Determination of lignin content. Blue: chemical pulp from wood and most grasses. Pink-purple: rag and bleached manilla hemp. Yellow-green: bleached jute. |
| **Phloroglucinol** | 1 g phloroglucinol dissolved in 50 ml methanol, 50 ml concentrated hydrochloric acid and 50 ml water. | Determination of lignin content. Bright-deep red or magenta: high lignin content. The intensity of the red color gives indication of the amount of lignin. Colorless or pale yellow: no or minimal lignin content. |

The pH measuring was carried out using samples 2, 4 and 5 (Figure 29). The material was prepared using the cold extraction procedure (Tappi 509) which consists in soaking the specimen in cold water (25 ± 5°C) for an hour and then proceeding to the measuring of the hydrogen ion concentration with a pH meter. A 827 Metrohm pH meter and, in addition, Merck Millipore pH-indicator strips, were employed to assess the pH value for each sample.

### 3.3.2 Results

The observation at 200x magnification has revealed the presence of a variety of fibers which differ from each other by morphological features. Some are long and slender, other short and with chopped ends. It was possible to detect fibers of animal origin (wool?), characterized by the pattern of overlapping scales (see Figure 30 B), bast fibers showing the characteristic longitudinal striations, dislocation and cross-markings (see Figure 30 C) and cotton fibers recognizable by the typical ribbon-like, twisted structure (see Figures 30 B and D) (Pfäffli & Sisko 1995). Overall, the pulp appears composed by a blend of long and short fibers and characterized by the presence of impurities and debris (see Figures 31 A and B). Pitted vessel elements were observed as well (see Figure 31 F). Spot tests confirm the heterogeneousity of the fiber content of the pulp. Graff C-stain test showed some fibers staining yellow, revealing an high content in lignin, others pale red or blue (Fig. 31 A). The result was confirmed by Herzberg test (Fig. 31 B and C) which showed the presence of fibers staining red-pink and yellow (low lignin content) and blue-purple (high lignin content). Phloroglucinol test results revealed the different level of lignin content by the different intensity of coloration from magenta to a paler shade of red to no coloration at all (Fig. 31 D, E and F).

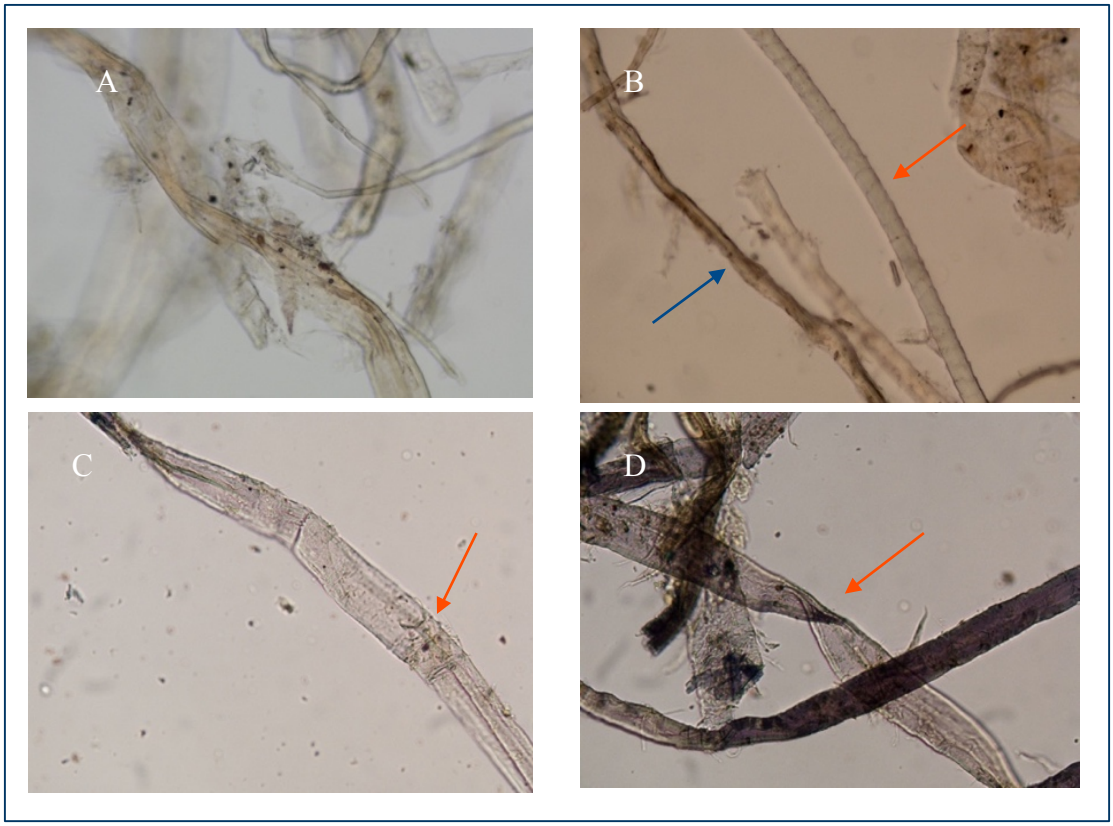



*Fig. 30 Photomicrographic record at 200x magnification of the cardboard fibers. A: fibers with no staining; impurities are visible. B: fibres with no staining; the orange arrow indicates an animal fiber with characteristic" scale" structure; the blue arrow indicates a cotton fiber, characterized by the twisted ribbon-like structure. C: C-stain capture; the arrow indicates the typical "knee" of a bast fiber. D: C-stain capture; the arrow indicates the ribbon-like feature of a cotton fiber.*

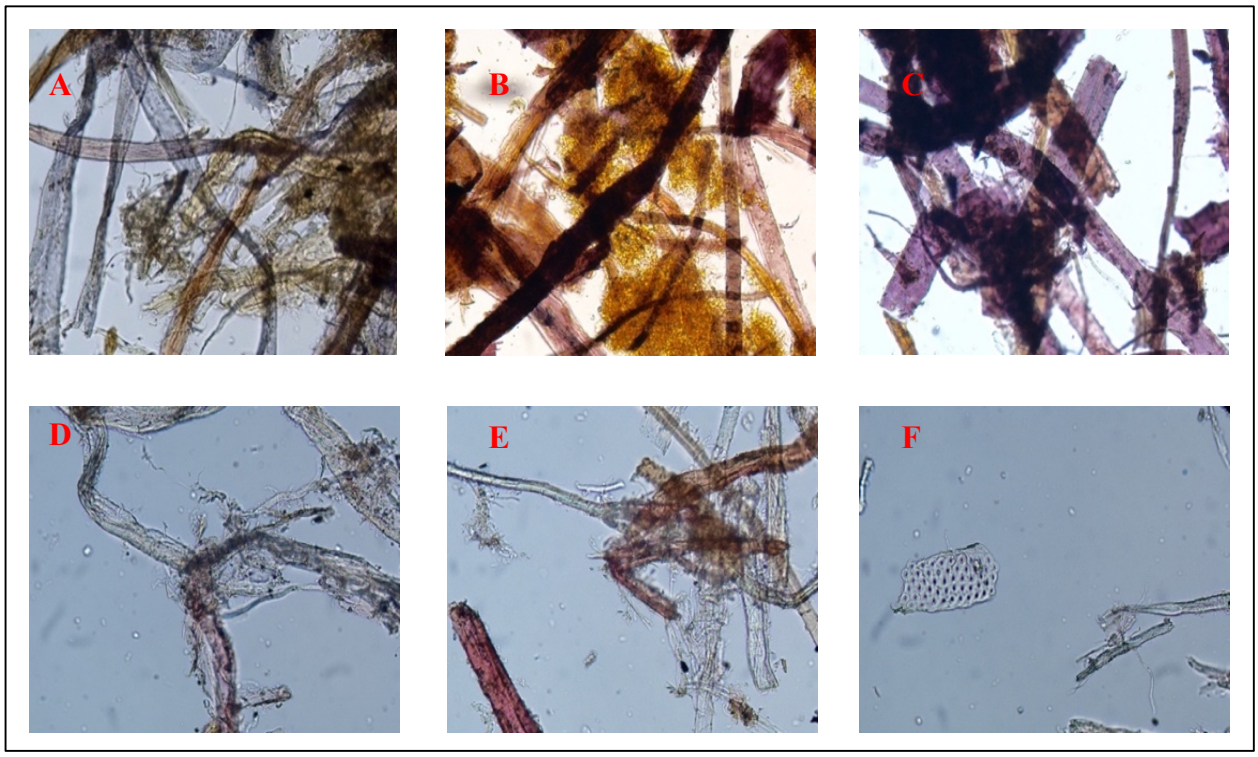



*Fig. 31 Captures at 200x magnification. A: C-Graff, fibers stained yellow, pale blue and red; B and C: Herzberg, fibers staining yellow, red and blue-purple, impurities stained yellow are also visible; D and E: Phlouroglucinol, some fibers stained different shades of red, others remained colourless; F: Phloroglucinol, a pitted vessel element can be observed on the left.*

The pH measurement undertaken on the three samples of cardboard revealed a value between 5.5 and 6, thus stating the sligthly acidic condition of the support.

# 4 Discussion

## 4.1 Interpretation of results

The literature study has enabled formulating some hypotheses about the materials used by Picasso to create his painting. Through the consultation of catalogues and analysis of the collected data, the most plausible techniques are water-based ones, such as watercolors and gouache, oil paint, possibly applied as "essence", black ink and pastels. The possible use of the pastel technique is considered to represent the most problematic issue regarding a potential loan of the object. In fact, pastel is a technique that is sensitive to vibration due to the precarious attachment of the colored matter (pigments and binding media) to the surface (see 2.5.4).

Both visual examination and fiber analysis contributed to gain an idea about the composition and the condition of the support. The layered structure visible on the margins and the presence of a uniform pattern of parallel, diagonal lines on the surface suggest the possible way of production of the cardboard. The stratified appearance of the edges could indicate the fabrication by lamination of several paper sheets pressed together. The diagonal lines being the result of the surface (of a mold?) onto which the paper sheets (or pulp) had been pressed to form the board. Alternatively, the pattern could represent the traces left by the weave of a piece of fabric which could also have been employed in the formation of the board. This could also explain the crease on the right (see 3.1.2.1), may be caused by an edge of the fabric being accidentally pressed onto the paper surface. Fiber analysis revealed the heterogeneous nature of the raw material. Microscopic examination and spot tests confirmed the presence of both short and long fibers. Animal fibers were found as well as debris, impurities and agglomerations of diverse material, probably sizing agents and/or fillers. Both high and low lignin content fibers were detected. Those evidencies led to suggest the employment of chemical wood pulp mixed with textile waste, which would explain the presence of cotton, bast and animal fibers, or the use of waste/recycled paper. Recycled paper has been a rather common raw material to produce paperboard since the beginning of the 19th century (Burns 1990; Hunter 1943). The acidity of the paper support, documented by the pH measurements, could be explained by the presence of lignin, which is a chemically unstable polymer that easily oxidizes into acidic products. Lignin promotes the depolymerization of cellulose resulting in the embrittlement of the paper (Mills 1994). Residues of chemical products employed in the manufacture of the paperboard, or the probable addition of fillers, sizing agents or coatings (as for example the possible use by the artist himself of sandarac varnish as previously mentioned in 2.4), might have contributed to hasten and worsen the process of acidification of the material. Exposure to light and the effect of fluctuations of the values of relative humidity and temperature, are other factors that have caused, through the years, the physical degradation of the cardboard. After the examination, the support is considered to be the most crucial problem regarding the stability of the object. This is due to the documented degradation of the material, especially visible by the use of the stereo microscope, in the form of delamination of the paper layers, most concentrated along the edges and corners, and the presence of cracks and impurities scattered over the whole surface of the object.

The visual observation permitted to highlight the variation in the appearance of the paint strokes. This variety can be the result of different manners in the application of the paint or/and the use of various techniques, which means the employment of different binding media. The visual examination, both with the naked eye and with the help of a stereo microscope, has produced no evidence of the use of dry pastels. Furthermore, no traces of loose, dusty, colored matter have been detected either on the surface of the painting or nearby the original framing materials. Overall the paint layer appears secure on the surface of the cardboard without showing critical signs of chipping, flaking or powdering. The opacity and the dry look of the texture of large areas suggest the use of gouache as it can be seen in Figure 32, with a visual comparison between a swatch of indigo gouache (a) with the area "A" of the

painting. Although the use of essence technique cannot be excluded, no typical halo left by the migration of heavily diluted oil product has been detected.

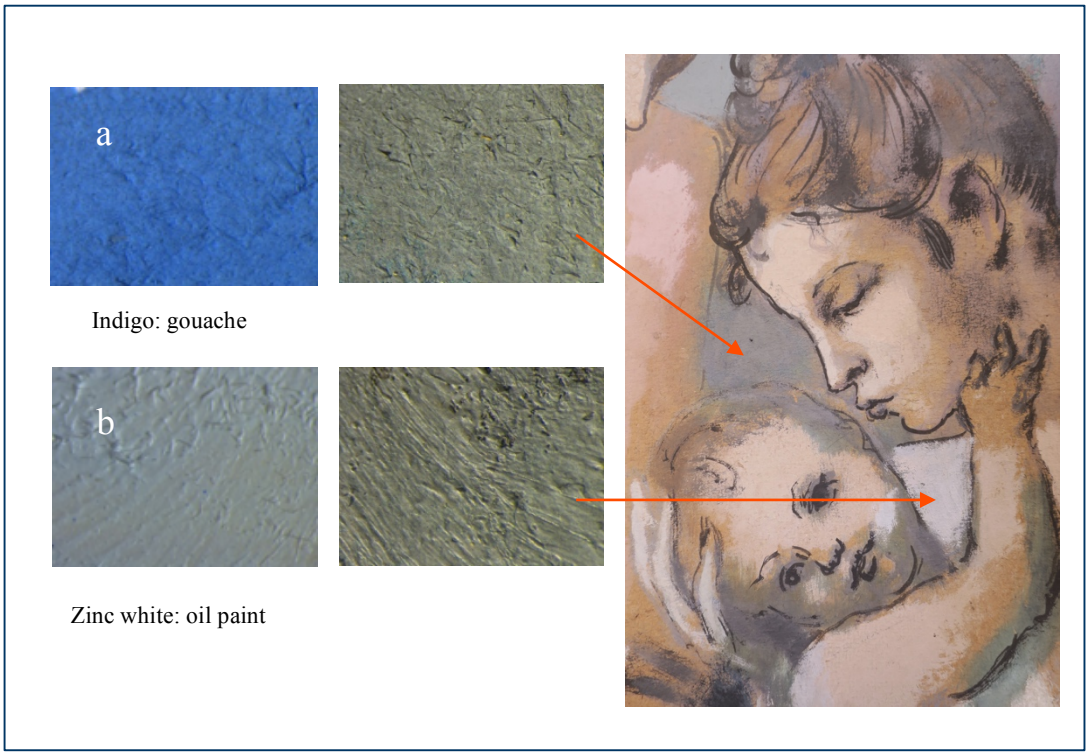
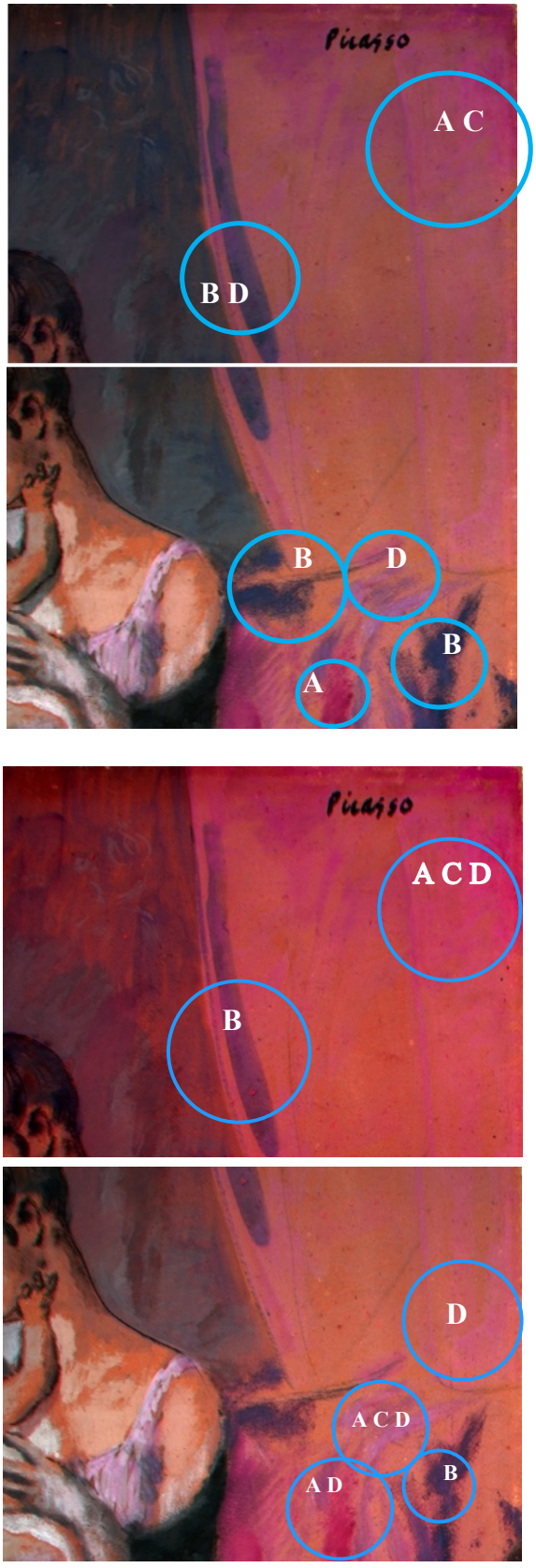



*Fig. 32. Visual comparison between gouache (a) and oil (b) paints' textures of the pigment swatches (left) with two areas (A and B) of the painting (right). The two couples "A-a" and "B-b" show similar characteristics, being the first of opaque and matt appearance and the second thick and glossy.*

More transparent areas might possibly be the result of the use of watercolor or a more diluted gouache paint (Figure 33). The bright white-ish highlight areas, which present a thicker texture and a shinier look (see Figure 32 "B" compared to zinc white oil paint "b" and Figure 34), are characterized by a strong fluorescence, while other similar white areas appeared dark under UV light. Shiny or opaque look, as well as thicker or thinner structure, could depend, again, on the use of different binding media.

*Fig. 33 The highlighted area shows the transparency of the diluited bright blue paint.*

*Fig. 34 Close-up of the brigh pink area shaping the pointed shoes of the acrobat. The thick structure of the paint is visible as well as the traces of the brush strokes.*




**A. Cobalt blue**

Oil paint | Gouache | Watercolor

**B. Prussian blue**

Oil paint + zinc white | Gouache + zinc white | Watercolor

**C.Ultramarine**

Gouache + zinc white | Watercolor

**D. Indigo**

Gouache + zinc white | Diluite gouache + zinc white

**A. Cobalt blue**

Oil paint | Oil paint + zinc white | Dilute gouache + zinc white

**B. Prussian blue**

Gouache + zinc white | Diluite gouache + zinc white | Watercolor

**C. Ultramarine**

Oil paint + zinc white | Gouache + zinc white | Watercolor

**D. Indigo**

Gouache + zinc white | Dilute gouache + zinc white

*Fig. 35 On the left: IRFC images of the drapery. On the rightt: IRFC images of blue pigment swatches. Above IR band 1 (750-800 nm), below IR band 2 (900-1000 nm). The letters in the encircled areas indicate the plausible pigments.*

Oil paint, for example, would present a shinier result compared with gouache (Fig. 32). But it could also depend on the use of different white pigments. The employment by the artist of both lead white and zinc white has been documented, among others, by three studies presented at the conference "The Blue Period: New Interpretations by Means of Technical Studies", held at the Museu Picasso in Barcelona, the 30th of January 2015. The studies were illustrated by Reyes Jiménez de Garnica, head of the Department of Preventive Conservation and Restoration of the Museu Picasso in Barcelona, Patricia Favero, conservator at The Phillips Collection, Washington DC, and Allison P. Langley, conservator at The Art Institute of Chicago. Although conducted on painting on canvas, those investigations have documented the habit by Picasso to use superimposition of layers of zinc white and lead white during the years just preceding the Rose Period (Favero; Jiménez de Garnica; Langley 2015). The employment of two different white pigments in the *Acrobat Family* would also explain the yellowish fluorescence of some bright areas, typical of zinc white, and consequently, also implies the use of lead white which, on the contrary, does not show fluorescence under UV light (see 3.2.2 and Figure 26).

To gain a reliable idea about the use of different techniques, further analysis and the employment of instrumental investigation able to detect the chemical composition of the pigments and binders, are required. IRFC imaging enabled revealing the use of different blue pigments in the realization of the drapery on the right. An attempt to identify the possible pigments used by Picasso has been done by a comparison between the IRFC captures of that area with the IRFC captures of the blue pigment swatches (Figure 35). The comparison suggests a convincing presence of cobalt and prussian blue and a possible presence of ultramarine and indigo, as well as the use of zinc white blended with the blue shades. These results have to be considered again as purely speculative as they are based on color perception which is fundamentally subjective. Nevertheless, IRFC images can efficiently be employed to map the distribution of pigments and to localize specific areas of interest that need to be examined further. The strong fading of the area can be explained by the fact that the different blue pigments have a different fastness to light. For example, prussian blue and cobalt blue tend to be more durable than indigo in terms of fading tendency. The acidity of the support might interfere with the painting media causing chemical reactions which can also be the cause of change in color or fading. A thinner application of the paint might be more sensitive to this kind of reaction, or reveal more evidently the consequent effect than thicker layers. The right area can, also, in the past, had been exposed to light for a longer period of time that the rest of the painting. Because of the impossibility to exclude, at this point, the use of dry pastel, the loss of color could also be caused by the physical detachment of colored matter from the support.

## 4.2 Conclusion

The combination of both art historical and scientific approaches towards the investigation of the *Acrobat Family*'s condition, has enabled a better understanding of the materials and techniques used by Picasso and the state of its current condition. The art-historical study has enabled placing the artifact in its historical and cultural context. Through the reconstruction of the background that has led to the creation of the painting and the study of the literary sources contemporary to the object, important information was gathered. The study was essential for the formulation of preliminary hypotheses and for setting up the focus for the consequent technical examination. Visual observation of the artifact supported by photographic documentation and the use of instrumental analysis have, to some point, clarified and confirmed some of those hypotheses, and when not, at least highlighted problems and issues that will require further studies.

After the investigations, it has not been possible to exactly identify the materials used by Picasso. A mixed technique of gouache, watercolor, ink and oil painting seem to be the most likely combination, while pastels or other methods implying the use of dry, powdery, surface medium, such as chalk or

charcoal, appear less probable after the examination of the textures and the behavior of the paint on the support surface.

The most critical issue compromising the physical stability of the artifact is believed to be the cardboard. The slightly acidic pH value in combination with fluctuations of temperature and moisture content of the environment, might have been the principal cause of the degradation of the support itself, in terms of fragility and tendency to delamine. In fact, the paper material appears discolored, of a spongy consistency and almost powdery. Furthermore, the acidity of the support might have been accelerated at a chemical level by the painting materials (pigments, binding media, fillers etc.) producing a breakdown of their chemical composition. The results of this interaction can be identified in discoloration, fading or detachment of the paint, as it can be noted in the drapery area on the right-hand side. The MSI investigation documented the use of different blue pigments and probably the use of both zinc and lead white. The possible use of especially light-sensitive pigments, such as indigo blue, for example, constitutes a fundamental issue to be taken into account during the planning of a proper conservation plan.

Regarding the evaluation of the opportunity to include the object in a possible international loan, the study has underlined several aspects that have to be taken into account. The main risk factors for the integrity of the painting appears to be the supposed, but at this point not confirmed, use of pastels, the physical fragility of the degraded support and the light fastness of the painting materials (pigments and binders). Even though visual examination did not detect any signs of the presence of pastels, further analysis need to be undertaken to exclude the eventuality of the use of surface techniques, whose particular sensitiveness to the effect of vibration might represent a serious risk to a possible loan. Because of the documented deterioration of the cardboard, the consolidation of the support certainly represents a priority. It is thus recommended to plan a series of tests in order to evaluate the most appropriate method to reinforce the cohesion of the fibrous material, mainly along the edges of the artifact. If further analysis will confirm the presence of especially light-sensitive pigments, the specification of a light policy will be even more strongly required. When discussing the loan request, it should be required from the requesting institution to guarantee the highest standards in order to offer the most stable climate conditions in term of temperature, humidity control and lighting impact. Same attention and accuracy are likewise expected during the packing and transport process. The creation of a suitable housing system, both for display and for transport, stands out as a necessary requirement in order to assure the best possible conditions for the preservation of such precious artifact for the future generations.

Lastly, a few comments for an evaluation of the employed methods of investigation and more generally for some considerations about the planning of the whole study. A major problem was represented by the time factor. MSI captures were done only once and for the first time by the author. This fact led to errors and moments of disorientation during the photographic session and later during the elaboration/interpretation of the images. A longer period of time for training in order to gain a better acquaintance with the instrumentation would have prevented mistakes which in some cases spoiled the acquisition of results and/or their quality and, consequently, their reliability. To improve the reliability of the chromatic comparisons between the blue swatches and the painting, especially for the IRFC imaging, the preparation of the pigments' chart should have been done before the MSI session at GKM. That could have facilitated obtaining captures of the two objects at the exact same conditions. Better knowledge and experience in the use of the microscope for the examination of different techniques would also have been useful.

Apart from those problems, the attempt to study such a complex yet intriguing piece of art has been a unique opportunity to challenge the author as a future conservator-restorer. This research inspired and encouraged improving knowledge and developing skills in the use of different methods of investigation.

## 4.3 Further Resarch

The present study highlighted many aspects regarding the painting under examination, which could be subjects of further studies. Such researches would benefit from the contribution of different but, indeed, related disciplines, such as conservation, conservation science and art history. To begin with, further analyses are required in order to obtain an exact identification of the materials used by Picasso. X-ray fluorescence (XRF), ultraviolet-visible fiber optical reflectance spectroscopy (UV-VIS FORS) and Fourier transform infrared spectroscopy (FTIR) are non-invasive analytical methods which seem to be the most suitable for identification purposes in this particular case.

Due to the difficulties of sampling works of art on paper, often consisting of rather thin layers of paint, the use and development of non-invasive methods of identification appear of a crucial importance. After facing the complexity in the attempt to visually identify materials and techniques, the present study could also develop into the planning of a survey of Picasso's production on cardboard. The aim would be the creation of a microscope and MSI captures' database of techniques used on this specific support. The database could represent a useful tool to enable a quick but rather reliable identification of materials without the need of turning necessarily to more sophisticated methods, which are often not easily available at museums or conservation laboratories.

Furthermore, a research about cardboard as material for artistic purposes, its production, the classification of the different typologies and their components, would be highly beneficial. The knowledge of the chemical composition of such paper material, would help to understand its interaction with diverse painting media, how the chemical composition of the support can affect the stability of the paint layer and its degradation process. The results of such research would be essential to the arrangement of efficient conservation strategies, especially designed for this specific material.

From a more art historical point of view, it would be interesting to analyze a possible correlation between Picasso's use of cardboard, the depicted subject and the use of specific techniques. Furthermore, was the employment of cardboard just accidental due to its availability, cheapness and/or because it was easily transportable, or was it an intentional choice in order to exploit its aesthetic quality? How does the physical structure of the material affects the pictorial quality of those images? A visual comparison between the production on cardboard by Picasso, supported by the study of contemporary sources may eventually answer those questions.

# 5 Summary

The subject of the study is a painting on cardboard by Pablo Picasso (1881-1973), *The Acrobat Family*. Created in Paris in the 1905, during the so called 'Rose Period', the artwork were purchased by Leo Stein at Sagot's Gallery and since 1922 is part of the collection of the Gothenburg Museum of Art. With the inventory number GKM 699, the painting measures 104 x 75 cm without the frame and the technique has been often described through the years as a mix of gouache, pastel, watercolor and India ink. A recent loan request from abroad led to the necessity to undertake an investigation of the current condition of the artifact in order to discuss and evaluate its suitability to be included in an external exhibition. The research has to be considered the first step for the arrangement of an eventual conservation plan and for the design of an appropriate strategy for the housing, transport and exhibition of the object.

The study began with a brief introduction in order to place the artwork into its original context and historical background. An initial investigation, conducted through a literature review of Picasso's contemporary production on cardboard, was undertaken in order to gain information about the plausible materials and techniques employed for the creation of the *Acrobat Family*. Because of contradictions and lack of evidence, only hypotheses about those materials could be formulated after this study. Nevertheless, the consultation and confrontation of data from the catalogues, permitted to discover a sort of correlation between the employment of cardboard as a support, the use of different techniques and the depicted motifs.

The second part of the study is dedicated to the visual investigation of the object. Ocular examination, supported by photographic documentation, was executed under natural, direct and raking light, both with the naked eye and under magnification. Multispectral imaging (MSI) was employed as well to inspect the morphological appearance of the artifact, to verify the presence of potential structural problems and to attempt a preliminarly identification of materials. Although only non-invasive and non-destructive methods were chosen from the beginning, fibre anlysis and pH measurement of the support have been made possible due to the detachment of micro-fragments of cardboard during the remove of the object from the frame. Even though more sophisticated diagnostic investigations are required in order to understand the exact composition of painting, the results provided indications and suggestions about its morphology and state of preservation.

The visual analysis and MSI enabled revealing the complex composition of the painting. It appears clear that different techniques are involved, mirrored in the variety of textures and thicknesses of the paint layers. Both water and oil based painting techniques appear plausible to have been used, variously applied and at different levels of diluition. No signs of pastel or other dry, powdery material have been detected, nor the use of varnish. The paint layer look secure on the surface of the cardboard. The IR imaging highlighted the presence of a light, quick sort of rough outline of the entire composition, likely executed with graphite. MSI captures revealed the probable use of lead and zinc white for the brighter areas, and the use of different blue pigments, such as ultramarine, prussian blue, indigo and cobalt blue. After the ocular investigation, fibre analysis and pH measurement, it can be stated that the major risk for the stability of the artifact is represented by the support. It is slightly acidic, with a pH value between 5.5 and 6, which can be seen as one fundamental cause of degradation of the material itself. Fibre analysis showed that the cardboard is likely composed by chemical woodpulp mixed with textile waste and/or recycled paper. Spot tests revealed that some of those fibres have a high lignin content which easily degrades into acidic products, speeding up the degradation process of the paper material. Other fillers and additives employed for the production of such inexpensive material can also have contributed to increase the damaging process wich goes along the natural aging of an object. The cardboard presents signs of delamination and brittleness along the edges and corners. This fragility causes the easy detachment of dust and fragments every time the

object is even slightly moved.

Considering a possible loan, the consolidation of the support in the near future appears to be the priority of an appropriate conservation plan. Furthermore, it will be essential to undertake further analysis in order to exclude the use of superficial painting techniques, such as pastels or charcoal. The presence of such tecniques, which are particularly sensitive to vibrations, would represent a serious hinder to a possible loan. Finally, if the presence of light-sensitive pigments, such as indigo blue, will be confirmed, it will be necessary to elaborate a specific conservation strategy in order to reduce the degrading effect of the light on those materials, regardless of the decision to permitt the loan of the object or not.

# 6 Sammanfattning

I studien undersöks en målning på kartong av Pablo Picasso (1881-1973), Akrobatfamilj. Målningen är skapad i Paris år 1905, under den så kallade Rosa perioden. Konstverket köptes ursprungligen av Leo Stein på Sagots galleri. Sedan år 1922 ingår den i Göteborgs konstmuseums samlingen. Målningen har där inventarienummer GKM 699. Måtten utan ram är 104 x 75 cm. Måleritekniken i konstverket har genom åren beskrivits som en blandning av gouache, pastell, akvarell och tusch. I samband med en utlåningsansökan från ett välrenommerat museum/galleri i utlandet blev det nödvändigt att påbörja en grundlig utredning av konstverkets nuvarande tillstånd. Utifrån den tillståndsbedömningen har sedan en diskussion påbörjats om lämpligheten för konstverket att ingå i en extern utställning. Denna studie bör betraktas som det första steget för att arrangera en eventuell bevarandeplan och för att utforma en lämplig strategi för montering, transporter och utställning.

Uppsatsen börjar med en kort historisk introduktion för att placera objektet i sitt ursprungliga sammanhang. En första undersökning utfördes genom en litteraturstudie av Picassos samtidiga produktion på kartong. Denna studie gjordes för att få information om tänkbara material och måleritekniker i konstverket Akrobatfamilj. På grund av motsägelser och brist på bevis kunde dock endast en hypotes om möjliga material formuleras efter denna förstudie.

I den andra delen av studien utfördes en analys och undersökningen av objektet. Okulär undersökning utfördes med stöd av fotografisk dokumentation under naturligt direktfallande ljus och släpljus samt under förstoring. Multispektralteknik (MSI) användes för att inspektera målningens uppbyggnad och för att verifiera förekomsten av potentiella strukturproblem samt för att försöka preliminärt identifiera material. Trots att endast icke-invasiva och icke-destruktiva metoder valdes inledningsvis, har även fiberanalys och pH-mätning av kartong utförts. Det senare var möjligt på grund av att mikrofragment av kartong kunde avlägsnas i samband med att ramen avlägsnades vid undersökningstillfället. Trots att mer sofistikerade diagnostiska undersökningar krävs för att förstå den exakta sammansättningen av målningen, gav resultaten från den okulära besiktningen och analyserna en indikation om målningen, dess uppbyggnad och föremålets bevarandestatus.

Den visuella analysen och MSI avslöjade målningens komplexa uppbyggnad. Det framgår tydligt att olika måleritekniker är använda. Det avslöjas av olika texturer och tjocklekar i de målade områderna. Både vatten- och oljebaserade måleritekniker förefaller trovärdiga. Dessa har applicerats på olika vis och har spätts ut i olika mängd. Inga tecken på pastell eller annat torrt, pulveriserat material har detekterats i samband med den okulära analysen. Inte heller tycks lack ha använts. Färgskiktet ser stadigt ut på kartongens yta. IR-avbildningen indikerar närvaron av en lätt, snabb sorts skiss, sannolikt utförd med blyerts. En grov skissartad kontur syns i hela kompositionen. MSI-bildbehandling avslöjade också en trolig användning av bly- och zinkvitt för de ljusare områdena. Efter den okulära undersökningen, fiberanalysen och pH-mätningen kan det konstateras att den huvudsakliga risken för konstverkets stabilitet ligger i själva Kartongen. Kartongen är lite sur, med ett pH-värde mellan 5,5 och 6, vilket kan ses som en grundläggande orsak till nedbrytning av själva materialet. Fiberanalysen visade att pappret sannolikt består av en kemisk trämassa blandad med lump och/eller återvunnet papper. Spottesterna avslöjade att några av fibrerna har ett högt innehåll av lignin som lätt bryts ner till sura produkter, vilket påskyndar pappersmaterialets nedbrytningsprocess. Andra fyllmedel och tillsatser som används vid framställningen av sådant billigt material kan också ha bidragit till att öka den skadliga nedbrytningsprocessen och påskynda objektets naturliga åldring. Kartongen visar tecken på delaminering och sprödhet längs kanterna och hörnen. Bräckligheten orsakar att fragment och damm avges vid beröring.

Med tanke på ett eventuellt lån förefaller konsolideringen av kartongen inom en snar framtid vara av prioritet samt att upprätta en lämplig bevarandeplan. Vidare är det väsentligt att utföra ytterligare analys för att utesluta förekomsten av ytlig målningsteknik, såsom pasteller eller kol, vilka är särskilt

känsliga för vibrationer. Slutligen, om närvaron av ljuskänsliga pigment, såsom indigoblå, kommer att bekräftas, kommer det att vara nödvändigt att utarbeta en särskild bevarandestrategi för att minska ljusets nedbrytande effekt på dessa material oavsett beslutet att tillåta objektets lån eller inte.

# Tables and Figures

## Tables



## Tables in Appendix



## Figures

Photos and illustrations taken by the author if nothing else indicated.

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# Appendix 1

Table I. List of Picasso's production on cardboard between 1900 and 1906.

| | Title | Whereabouts and Date of Production | Present Location | Dimensions: Height x Width (cm) | Signature | Technique |
|---|---|---|---|---|---|---|
| 1 | *Outside the Bullring* | Barcelona 1900 | Formerly in the Alexander Riera Coll., Barcelona. | 28 x 28 | Signed | Pastel |
| 2 | *The Barceloneta Bullring* | Barcelona 1900 | Private Coll., New York. | 51 x 69 | Signed | Pastel |
| 3 | *The Embrace in the Garret* | Paris 1900 | Pushkin Museum, Moscow. | 51.2 x 55.3 | Signed | Oil |
| 4 | *Young Woman with a Hat* | Paris 1900 | Art Institute, Chicago. | 36.5 x 27 | No signature | Pastel |
| 5 | *Woman with a Cat* | Paris 1900 | Léon Bloch Coll., Paris. | 45 x 51 | Signed | Pastel |
| 6 | *Woman in Blue and White* | Madrid 1901 | Alex Magny Coll., Paris. | 53.5 x 36.5 | Signed | Pastel |
| 7 | *Woman in Green* | Madrid 1901 | Metropolitan Museum of Art, New York. | 51.8 x 36.2 | Signed | Pastel |
| 8 | *Woman in Profile* | Madrid 1901 | Metropolitan Museum of Art, New York. | 51.1 x 33.7 | Signed | Oil |
| 9 | *The Red Skirt* | Madrid 1901 | Private Coll., Oslo. | 55 x 47 | Signed | Pastel |
| 10 | *The Woman with the Little Dog* | Madrid 1901 | Private Coll., Paris. | 37.5 x 42 | Signed | Oil |
| 11 | *Bullfighting Scene (The Victim)* | Barcelona 1901 | Stavros S. Niarchos Coll., Saint Moritz. | 49.5 x 64.7 | Signed | Oil |
| 12 | *Near the Water* | Barcelona 1901 | Mr. and Mrs. Paul Mellon Coll., Upperville, Virginia. | 28.3 x 35.5 | Signed | Oil |
| 13 | *The Mediterranean* | Barcelona 1901 | Heirs of the artist. | 27.5 x 36.5 | No signature | Oil |
| 14 | *Old Woman (Woman with Gloves)* | Barcelona 1901 | Museum of Art, Philadelphia. | 67.4 x 52 | Signed | Oil |
| 15 | *Portrait of Ambrose Vollard or Gustave Coquiot* | Paris 1901 | Emil G. Bührle Foundation, Zurich. | 46 x 38 | Signed | Oil |
| 16 | *The Mother* | Paris 1901 | The City Art Museum of Saint Louis, Missouri. | 74.8 x 50.8 | Signed | Oil |
| 17 | *La Toilette* | Paris 1901 | Mr. and Mrs. John A. Beck, Houston. | 26 x 28 | Signed | Pastel |
| 18 | *Selfportrait (Yo!)* | Paris 1901 | Metropolitan Museum of Art, New York. | 54 x 31.8 | Signed | Oil |

| | | | | | | |
|---|---|---|---|---|---|---|
| 19 | *Study for the Selfportrait: Yo Picasso* | Paris 1901 | Private Coll., France. | 67 x 52 | Signed | Pastel Charcoal |
| 20 | *Head of a Woman* | Paris 1901 | Museum of Art, Philadelphia. | 47 x 30.5 | Signed | Oil |
| 21 | *Nursemaids and Children in the Garden (Jardin public)* | Paris 1901 | Mr. and Mrs Silvan Kocker Coll., Soleure. | 32 x 47 | Signed | Oil |
| 22 | *The Flower girl* | Paris 1901 | Glasgow Art Gallery and Museum, Glasgow. | 33.7 x 52.1 | Signed | Oil |
| 23 | *Three Little Girls Playing (The Blonde Tresses)* | Paris 1901 | Private Coll., Paris. | 56.5 x 38 | Signed | Oil |
| 24 | *Le Roi Soleil* | Paris 1901 | European Fine Art Foundation, Geneva. | 52 x 34 | Signed | Oil |
| 25 | *Children Playing Beside a Pond* | Paris 1901 | Private Coll., Grosse Pointe, Michigan. | 50 x 65 | Signed | Oil |
| 26 | *The Crowd at the Races* | Paris 1901 | Lederlin Coll., Berlin. | 53 x 67 | Signed | Oil |
| 27 | *Women Chatting at the Races* | Paris 1901 | Private Coll., France. | 52 x 67 | Signed | Oil |
| 28 | *Groups of Ladies at the Races* | Paris 1901 | Mr. and Mrs. Joseph H. Hazen Coll., New York. | 46 x 61 | Signed | Oil |
| 29 | *Dancer Crouching* | Paris 1901 | Mr. and Mrs. Richard Rodgers Coll., New York. | 49.5 x 34 | Signed | Oil |
| 30 | *The Absinthe Drinker* | Paris 1901 | Mr. and Mrs. William B. Jaffe Coll., New York. | 65.5 x 51 | Signed | Oil |
| 31 | *Waiting (L'Attante)* | Paris 1901 | Picasso Museum, Barcelona. | 69.5 x 57 | Signed | Oil |
| 32 | *The Dwarf (La Nana)* | Paris or Barcelona 1901 | Picasso Museum, Barcelona. | 102 x 60 | Signed | Oil |
| 33 | *The Mad Woman with the Cat* | Paris 1901 | The Art Institute of Chicago | 44.5 x 40.6 | Signed | Oil |
| 34 | *The Blue Roofs* | Paris 1901 | The Ashmolean Museum, Oxford | 40 x 60 | Signed | Oil |
| 35 | *The Upper Deck* | Paris 1901 | The Art Institute of Chicago. | 49.2 x 64.2 | Signed | Oil |
| 36 | *The Enchanted Garden* | Paris 1901 | Mr. and Mrs. Paul Mellon Coll., Upperville Virginia. | 65 x 95 | Signed | Oil |
| 37 | *Mother and Baby in front of a Bowl of Flowers* | Paris 1901 | Private Coll. Paris. | 54 x 65 | Signed | Oil |
| 38 | *Mère et enfant* | Paris 1901 | Museum of Art, Berne. | 68 x 52 | Signed | Oil |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | *Peonies* | Paris 1901 | Phoenix Art Museum, Arizona. | 52 x 34.3 | Signed | Oil |
| 40 | *Head of a Woman* | Paris 1901 | Private Coll. Barcelona. | 46.7 x 31.5 | Signed | Oil |
| 41 | *Profile of a Young Woman (The Girl with the Red Flower)* | Paris 1901 | Mr. and Mrs. Jacques Gelman Coll., Mexico. | 55.9 x 35.6 | Signed | Oil |
| 42 | *The Fourteenth of Juyl* | Paris 1901 | Solomon R. Guggenheim Museum, New York. | 48.3 x 63.2 | Signed | Oil |
| 43 | *Woman Wearing a Necklace of Gems* | Paris 1901 | Ayala and Sam Zacks Coll., Toronto. | 43.7 x 36.1 | Signed | Oil |
| 44 | *Les soupeurs* | Paris 1901 | Museum of Art, Rhode Island School of Design, Providence. | 47 x 62.2 | Signed | Oil |
| 45 | *The Fugitives* | Paris 1901 | Private Coll., USA. | 56 x 73 | No signature | Oil |
| 46 | *Casagemas in his Shroud* | Paris 1901 | Heirs of the artist. | 72.5 x 57.8 | No signature | Oil |
| 47 | *The Suicide (Casagemas)* | Paris 1901 | Heirs of the artist. | 52 x 34 | No signature | Oil |
| 48 | *Scene in a Cabaret* | Barcelona 1902 | Berggruen Coll., Paris. | 30.5 x 38.7 | Signed | Pastel |
| 49 | *Guitarist Playing (Evocation of Horta d'Ebre)* | Barcelona 1902 | Emil G. Bührle Foundation, Zurich. | 26 x 35 | Signed (apocryphal) | Pen-and-ink Coloured pencil |
| 50 | *Woman with her Hair in a Topknot* | Paris 1904 | The Art Institute of Chicago. | 42.9 x 31.2 | Signed | Gouache |
| 51 | *Portrait of Gaby* | Paris 1904 | Private Coll., Paris | 101.6 x 75.5 | Signed (apocryphal) | Gouache |
| 52 | *Madeleine* | Paris 1904 | Heirs of the artist. | 69 x 52 | No signature | Oil |
| 53 | *Conjugal Scene* | Paris 1904 | Private Coll., Paris. | Unknown | Signed | Gouache India Ink |
| 54 | *Two Acrobats with a Dog* | Paris 1905 | The Hon. And Mrs. William A.M. Burden Coll. New York. | 105.5 x 75 | Signed | Gouache |
| 55 | *Boy with a dog* | Paris 1905 | Hermitage Museum, S. Petersbourg. | 57 x 41 | Signed | Gouache |
| 56 | *Acrobat and Young Harlequin* | Paris 1905 | Private Coll., Belgium. | 105 x 76 | Signed | Gouache |
| 57 | *Harlequin Making Up* | Paris 1905 | Private Coll., USA. | 69 x 54 | Signed | Gouache |
| 58 | *Seated Nude* | Paris 1905 | Museum of Modern Art, Paris. | 106 x 76 | Signed | Oil |
| 59 | *Acrobat Family* | Paris 1905 | Museum of Modern | 104 x 75 | Signed | GouachePastel |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Art, Göteborg. | | | Watercolor Indiaink |
| 60 | *Harlequin's family* | Paris 1905 | Private Coll., Montecarlo. | 60.6 x 45.2 | Signed | Gouache Indian Ink |
| 61 | *Harlequin's family* | Paris 1905 | Museum of Art, Portland. | 29.5 x 21 | Signed | Gouache Indian ink |
| 62 | *The Jester* | Paris 1905 | Private Coll., Paris. | 70 x 54 | Signed | Gouache |
| 63 | *Jester on Horseback* | Paris 1905 | Mr. and Mrs. Paul Mellon Coll., Upperville, Virginia. | 100 x 69.2 | Signed | Oil |
| 64 | *The Hurdy-Gurdy Man* | Paris 1905 | Kunsthaus, Zurich. | 100 x 70 | Signed | Gouache |
| 65 | *The Athlete* | Paris 1905 | Private Coll., Paris. | 54 x 44 | Signed | Gouache |
| 66 | *Equestrienne on Horseback* | Paris 1905 | Heirs of the artist. | 60 x 79 | No signature | Gouache |
| 67 | *Family of Acrobats* | Paris 1905 | Pushkin Museum, Moscow. | 51.2 x 61.2 | Signed | Gouache |
| 68 | *Female Nude with a Bonnet* | Schoorldam 1905 | Unknown | 75.5 x 60 | Signed | Gouache |
| 69 | *The Beautiful Dutchwoman* | Schoorldam 1905 | Queensland Art Gallery, Brisbane. | 78 x 67 | Signed | Gouache Oil Chalk |
| 70 | *Female Nude Holding Up her Hair* | Paris 1905 | Heirs of Gertrude Stein. | 55 x 50 | Signed | Gouache |
| 71 | *Boy with a Bunch of Flowers in his Hand* | Paris 1905 | Mrs. John Wintersten Coll., Villanova. | 64.7 x 54.2 | Signed | Gouache |
| 72 | *The Majorcan Girl (La Mallorquina)* | Paris 1905 | Pushkin Museum, Moscow. | 67 x 51 | Signed | Gouache |
| 73 | *Tumbler with Still Life* | Paris 1905 | The National gallery of Art, Washington. | 100 x 69.9 | Signed | Gouache |
| 74 | *Bust of a Boy* | Paris 1905 | Baltimore Museum of Art. | 51 x 41 | Signed | Gouache |
| 75 | *Head of a Boy* | Paris 1905 | Heirs of the artist. | 45 x 37 | | Gouache |
| 76 | *Blue Boy* | Paris 1905 | Mr. and Mrs. Edward M.M. Warburg Coll., New York. | 99.5 x 55.4 | Signed | Gouache |
| 77 | *Boy with Ruff in Profile* | Paris 1905 | Metropolitan Museum of Art, New York. | 79.3 x 59.5 | Signed | Essence |
| 78 | *The Boy with the Ruff* | Paris 1905 | Mr. and Mrs. André Meyer Coll., New York. | 77.5 x 65.5 | Signed | Gouache |
| 79 | *Entwined Nudes* | Paris 1905 | National Gallery of Denmark, Copenhagen. | 26.3 x 21 | Signed | Gouache Watercolor |
| 80 | *The Lovers Making* | Paris 1905 | Jacqueline Apollinaire | Unknown | Signed | Oil |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Love* | | Coll., Paris | | | |
| 81 | *The Death of Harlequin* | Paris 1906 | Upperville Virgina | 65 x 95 | Signed | Gouache |
| 82 | *Nude Boy in a Leaning Stance)* | Paris 1906 | Hermitage | 68 x 52 | Signed | Gouache |
| 83 | *Arcady (The Watering Place)* | Paris 1906 | Metropolitan Museum of Art, New York. | 37.7 x 57.9 | Signed | Gouache |
| 84 | *Portrait of Allan Stein* | Paris 1906 | Baltimore Museum of Art. | 74 x 59.7 | Signed | Gouache |
| 85 | *Head of a Boy* | Paris or Gósol 1906 | Cleveland Museum of Art. | 31 x 24 | Signed | Gouache |
| 86 | *La Toilette (Blue Versione)* | Gósol 1906 | São Paolo Museum of Art. | 52 x 31 | Signed | Oil |
| 87 | *Head of a Gósol Lad* | Gósol 1906 | Mr. and Mrs. Lee A. Ault Coll., New York. | 38 x 24.5 | Signed | Gouache |
| 88 | *Nature morte: fleurs dans un vase* | Gósol 1906 | The Solomon R. Guggenheim Museum, New York. | 70.5 x 54 | Signed | Gouache |
| 89 | *The Flower Vendor* | Gósol 1906 | Heirs of the artist. | 30 x 23.5 | No signature | Watercolour Sanguine |

# Appendix 2

Multispectral imaging (MSI) analysis of the *Acrobat Family*.

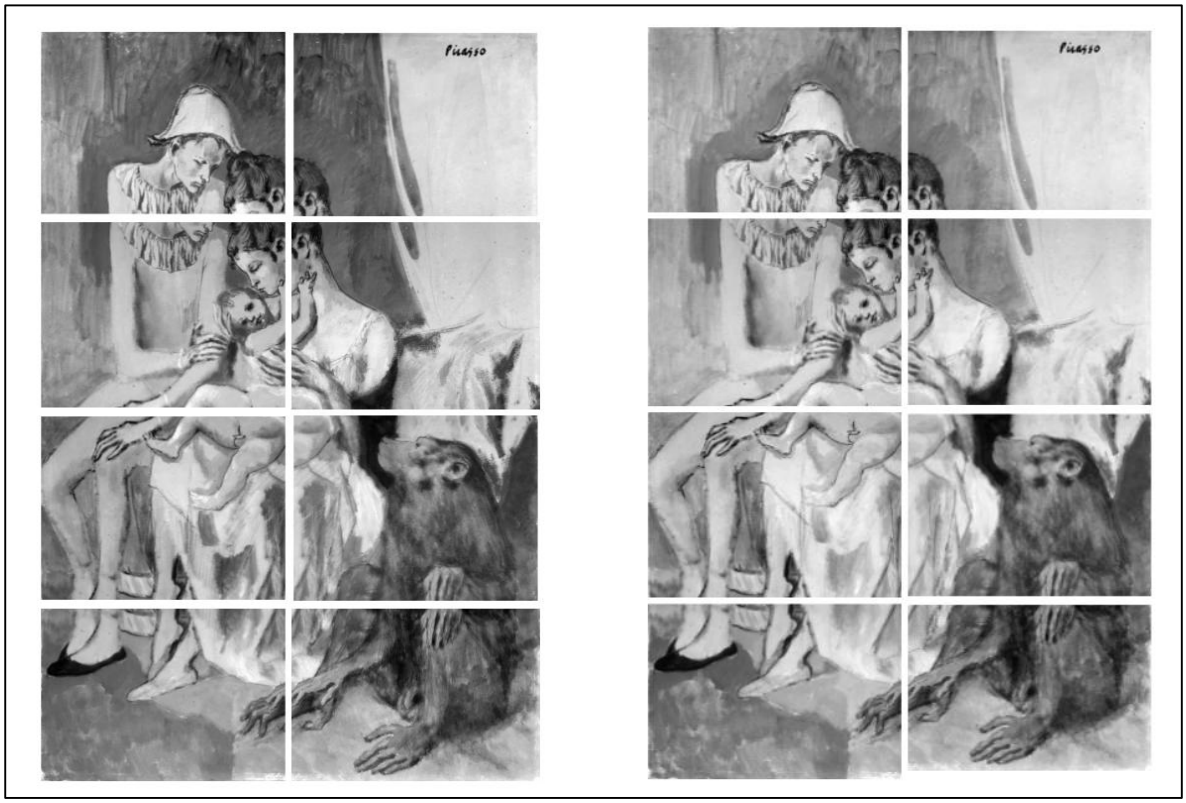


*Fig. I MSI analysis of the Acrobat Family. Left: infrared band 1 (IR1). Right: infrared band 2 (IR2).*

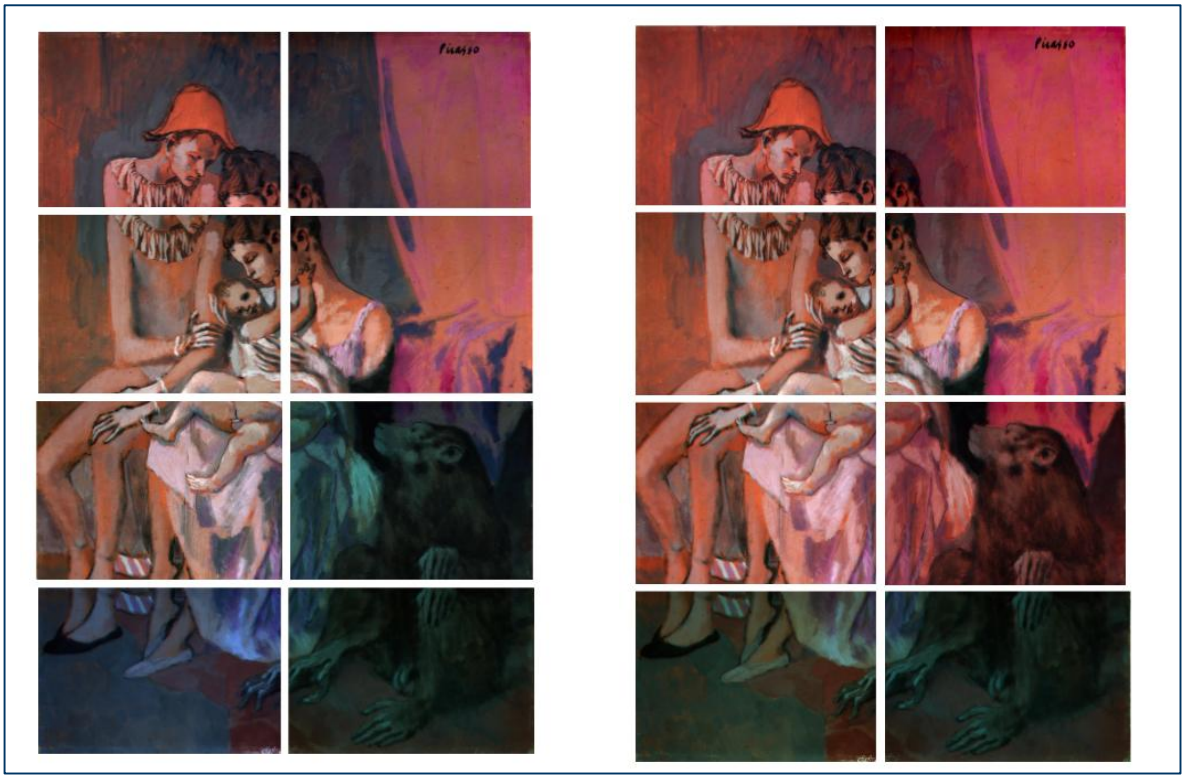


*Fig. II MSI analysis of the Acrobat Family. Left: infrared false color 1 (IR1FC). Right: infrared false color 2 (IR2FC).*

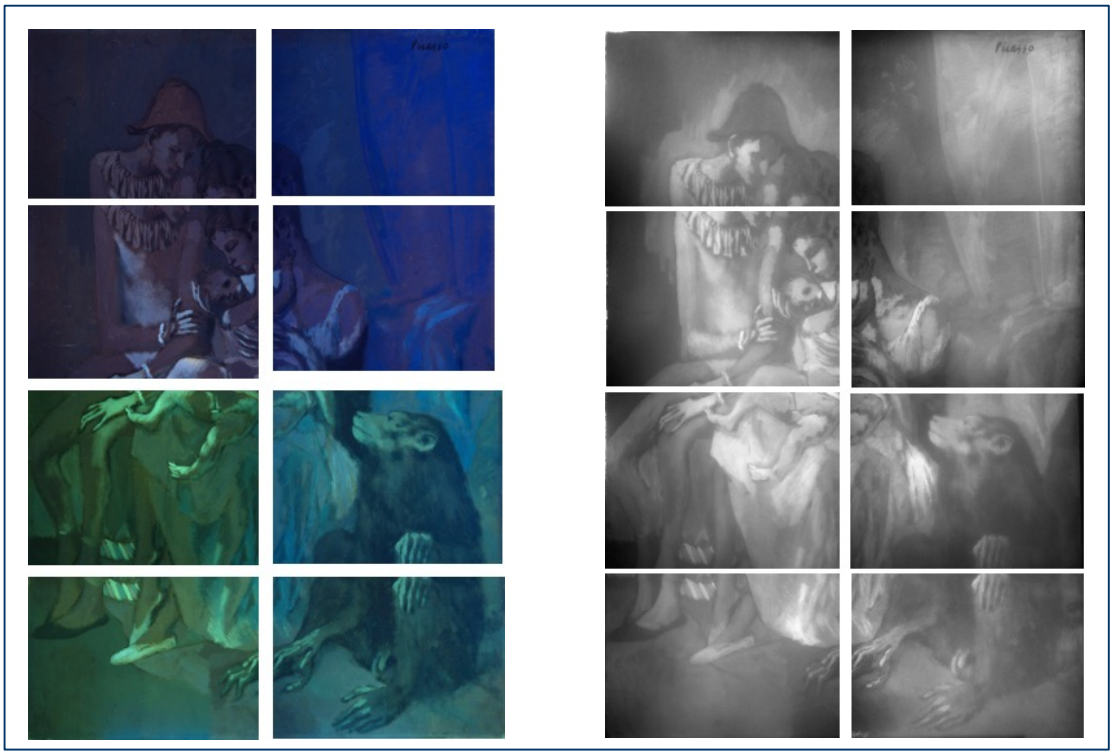
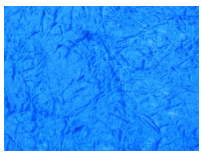
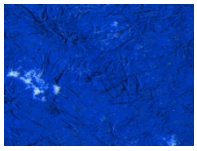
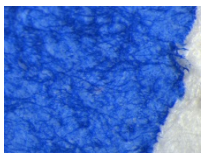
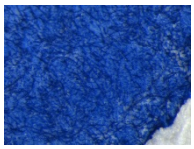
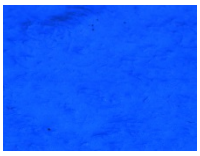
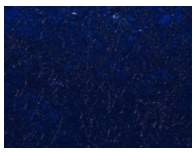
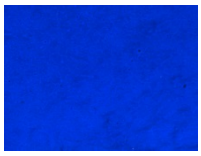
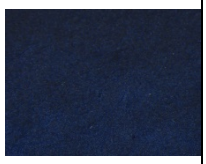
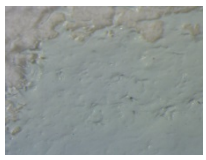
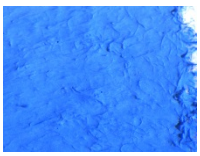
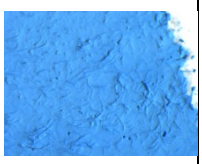
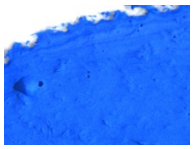
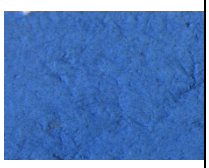
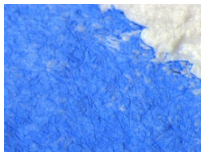
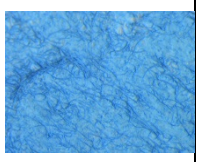
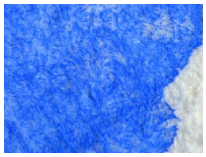
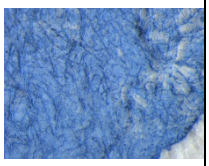
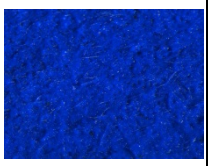
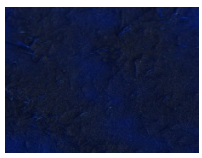
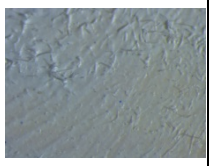
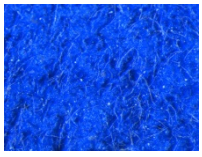
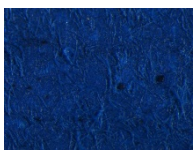
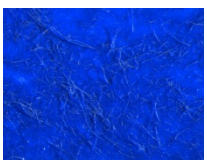
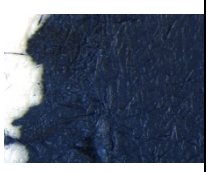


*Fig. III MSI analysis of the Acrobat Family. Left: UV- fluorescence (UVF). Right: UV- reflectance (UVR).*

# Appendix 3

Table II. Photographic documentation of the blue pigment swatches used as visual references at 25x magnification.

| Technique /Pigment | Cobalt blue | Prussian blue | Ultramarine | Indigo | Zinc White |
|---|---|---|---|---|---|
| Pastel |  |  |  | | |
| Water-colours |  |  |  | | |
| Gouache |  |  |  |  |  |
| Gouache + Zinc White |  |  |  |  | |
| Gouache +Zinc White Diluite in H2O |  |  |  |  | |
| Pigment +Linseed Oil |  |  |  |  |  |
| Pigment + Linseed Oil + Zinc White |  |  |  |  | |

# Appendix 4

Multispectral imaging (MSI) photographic documentation of the blue pigment swatches used as visual references.

Table III UV-fluorescence (UVF) of the blue pigment swatches.

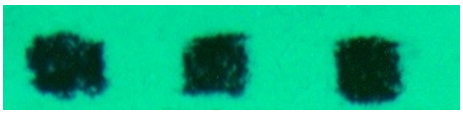
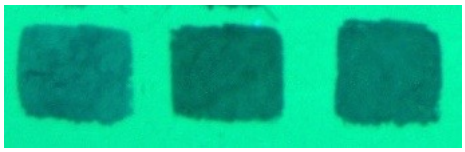
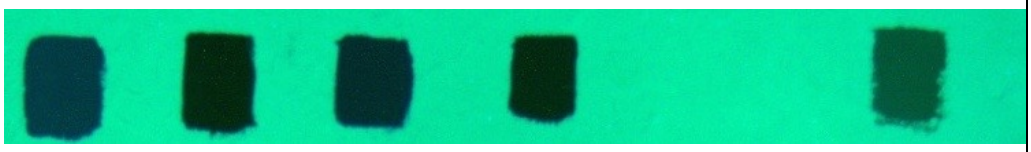
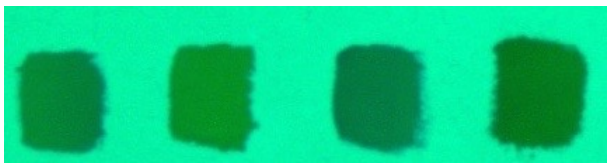
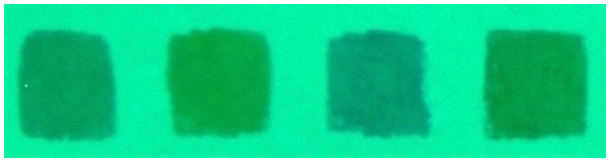
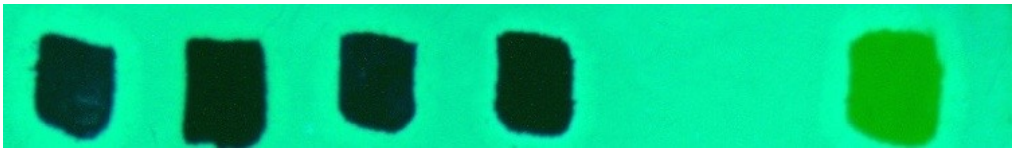
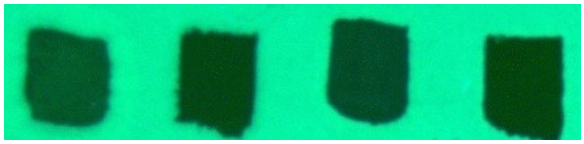
| Technique/Pigment | Cobalt blue | Prussian blue | Ultramarine blue | Indigo | Zinc white |
|---|---|---|---|---|---|
| Pastels |  | | | | |
| Watercolours |  | | | | |
| Gouache |  | | | | |
| Gouache + Zinc White |  | | | | |
| Gouache + Zinc white Diluite in H2O |  | | | | |
| Pigment + Linseed oil |  | | | | |
| Pigment + Liseed oil + Zinc white |  | | | | |

Table IV Infrared (band 1) false color, (IR1FC) of the blue pigment swatches.

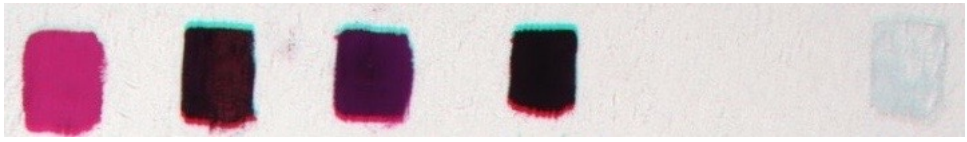
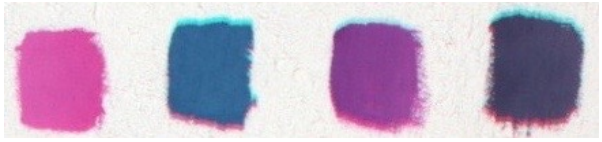
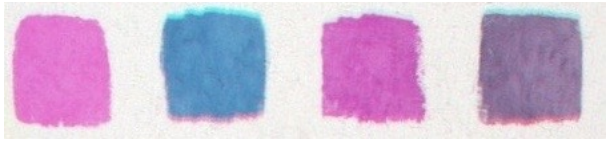
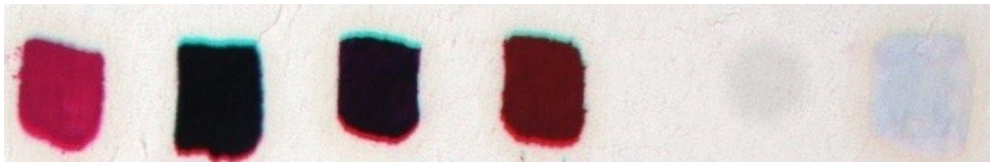
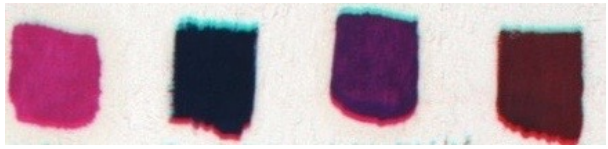
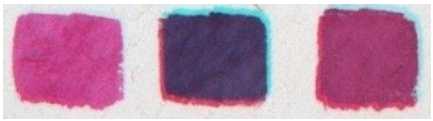
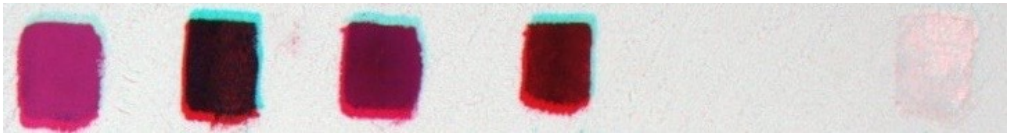
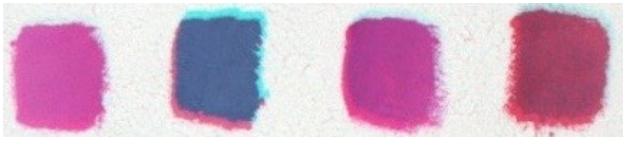
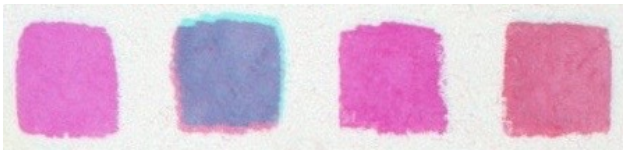
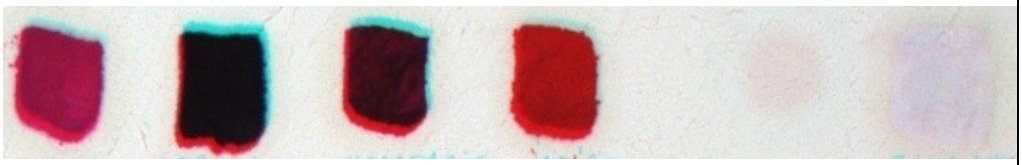
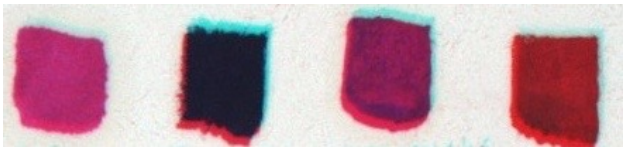
| Tecnique/Pigment | Cobalt blue | Prussian blue | Ultramarine blue | Indigo | Zinc white |
|---|---|---|---|---|---|
| Pastels |  | | | | |
| Watercolours |  | | | | |
| Gouache |  | | | | |
| Gouache + Zinc White |  | | | | |
| Gouache + Zinc white Diluite in H2O |  | | | | |
| Pigment + Linseed oil |  | | | | |
| Pigment + Linseed oil + Zinc white |  | | | | |

Table V Infrared (band 2) false color (IR2FC) of the blue pigment swatches.

| Technique/Pigment | Cobalt blue | Prussian blue | Ultramarine blue | Indigo | Zinc white |
|---|---|---|---|---|---|
| Pastels |  | | | | |
| Watercolours |  | | | | |
| Gouache |  | | | | |
| Gouache + Zinc White |  | | | | |
| Gouache + Zinc white Diluite in H2O |  | | | | |
| Pigment + Linseed oil |  | | | | |
| Pigment + Linseed oil + Zinc white |  | | | | |