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NUDE (APRÈS LE BAIN):

An Inter-Disciplinary Technical Study of an Oil Painting on Cardboard by Pierre Bonnard

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ABSTRACT

In this master thesis in paper conservation, an oil painting on cardboard (WL84, Gothenburg Museum of Art) by French artist Pierre Bonnard (1867-1947) is investigated. The painting shows signs of degradation in the form of staining, pigment loss, and discolored varnish. The study aims to identify the materials of the painting, and how the materials and condition are affecting the appearance of the painting. It also aims to explore the use of cardboard as a support for oil painting. The overall objective is to contribute to the knowledge gap in the research about Bonnard's use of materials and about conservation issues related to his paintings.

A literature review was conducted on Bonnard in an art historical context. The review involved examination of art historical sources, museum records, artist catalogs, and scientific articles. The study used various analytical methods to perform investigations of the painting. The methods include analytical imaging, microscopy, microchemical testing and spectroscopic analysis (X-ray fluorescence spectroscopy and Fourier-transform infrared spectroscopy).

The results of the investigation include the identification of four pigments (zinc white, cadmium yellow, vermillion, and cobalt chromite blue) and a dammar varnish. The results also indicate that the varnish was not applied by Bonnard himself. The examination of the cardboard showed that it consists of several different fibers (wood, cotton, bast and grass, or possibly wool, fibers) and that the cardboard is acidic. The acidity is most likely affecting the condition of the painting negatively, as does the presence of oil in the cardboard.

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1. Introduction

> The desire to know more about the whole object, to go beyond the image, the preface continues, to get "behind the picture, and even through them," is very much a feature of our era, just as the delight in finding the "real" information hiding behind our conventional views fuels so many contemporary investigative endeavors in all disciplines (Carlyle 1995).

In this master thesis in paper conservation, a painting by French artist Pierre Bonnard is investigated. The work is painted with oil on cardboard and shows signs of deterioration. The thesis delves into the art history of Bonnard and his oeuvre, the complex issue of oil paintings on cardboard, and presents a multi-analytical investigation of the painting. In the spirit of Carlyle, this study strives to go "beyond the image of the painting", to discover more about the materials and techniques which Bonnard used and how his choice of materials might have affected the present condition of the painting (Carlyle 1995).

This introductory chapter will present the background, purpose, and methodology of the thesis. Chapter two is a literature review which includes a historical overview of Pierre Bonnard, the art movements in which he was a part of, and some of the ways painting practices changed during the second half of the 19th century. The review also presents cardboard as a painting support, and includes a brief discussion on the conservation of oil paintings on cardboard. In this chapter, the provenance and context of the investigated painting is also presented. Chapter three describes the analysis methods used in this study. Chapter four is the investigative part of the thesis. In this chapter, the structure and condition of the painting are discussed in detail, presented with the results from the various analytical methods. Chapter five discusses and evaluates the findings of the study.

1.1. Background

Pierre Bonnard (1867 – 1947) was a French artist who had a long and productive career in a time where the art world was constantly changing. Bonnard is today mostly known for his colorful and decorative paintings but his style evolved significantly throughout his long painting career. In the first half of his career, Bonnard often painted intimate paintings of interior motifs and often of his partner Marthe de Méligny (Watkins 1998). Bonnard painted mainly with oil paints on canvas, but also used cardboard as a support, especially in the beginning of his career (Dauberville & Dauberville 1966).

Artists have, since the beginning of the 19th century, used cardboard as a support for oil painting. The easy accessibility and low cost of the material made it an attractive option for sketches as well for paintings. Additionally, the aesthetic results of applying oil paints on paper supports appealed to many artists, who were otherwise used to using canvas (Bower 2002). Oil paintings on cardboard have a tendency to exhibit several conservation-related problems, such as delamination of the cardboard, severe pigment flaking, and staining. They are therefore often problematic for conservators, and it has not always been obvious in which material category they belong. Cardboard is a cellulosic material but has, in many ways, been utilized as a substitute for canvas. The composition of an oil painting on cardboard is similar to oil paintings on canvas and they have, historically, been treated by painting conservators. Today, many of the past treatments are considered outdated or too aggressive, such as removing layers of the backing of the cardboard and relining on canvas with adhesives which are today considered inappropriate. In recent decades, paper conservators have become more and more involved in the treatment of these kinds of objects (Banou, Alexopoulou & Singer 2015).

The painting in this study, titled *Nude* or in some sources *Après le bain* (meaning "after the bath"), belongs to the Werner Lundqvist collection at the Gothenburg Museum of Art (GMA) and has the inventory number WL84 (which it will be referred as in this thesis). It is dated to 1903 and is painted with oil on cardboard. It has a layer of uneven varnish on the surface and the painting shows several signs of degradation, for example in the form of brown staining throughout, as well as possible pigment loss. The author of this thesis, a paper conservator with a special interest in art on paper, came into contact with the painting during an internship at GMA. Mariateresa Pullano, Paper Conservator at the museum, expressed an interest in learning more about the painting. The author had limited

previous knowledge about oil paintings on cardboard and thus, saw it as a prime opportunity to expand that knowledge, and to find out more about Bonnard's use of materials and techniques. While Bonnard is an important artist who has left a considerable mark in art history, there is very little information on the materials that he used. Such information can be integral in future conservation treatments, and would be beneficial to the art historical research on Bonnard.

1.2. Aim and Research Questions

The aim of this study is to investigate the condition and material composition of WL84, an oil painting on cardboard painted by Pierre Bonnard. The objectives of the investigation are (I) providing a historical context by conducting a literature review, (II) identifying specific materials by using analysis methods, (III) assessing the condition by using analysis methods as well as historical sources, and (IV) discussing how the choices of materials have affected the condition and aesthetic qualities in WL84.

The specific questions driving this study are following:

- What pigments and pigment mixtures did Pierre Bonnard use in WL84 and how did he apply them?
- What kind of varnish is used on WL84, and what can be established about the origin of the varnish?
- What is the composition of the cardboard support?
- What is the condition of painting and support and what impact does the condition have on the appearance of WL84?

By answering these questions, this study can contribute to the research on Bonnard and add to the knowledge gap regarding his use of materials.

1.3. Methodology

This is an inter-disciplinary study of which art conservation, art history, and conservation science are the three main fields. It is important, however, to note that the study is conducted by a paper conservator. Consequently, language and positioning is based on this field. The study comprises two main parts; a literature review and a technical investigation. Literature studies are recognized as the first and most important step in most research projects, as they offer an introduction and a basis for the study, and present what research has already been conducted in the field (Walliman 2018). Technical investigations in the field of art conservation is important for several reasons. It can provide information on material composition, technique, and authenticity of an object. Moreover, it can identify degradation processes, which is key in order to safe-keep cultural heritage objects for the future. For conservators, the information provided by analytical studies can determine the course of treatment and may prevent uninformed decisions (Ciliberto 2000).

This study is a single-object, observational study. In conservation research, observational studies are studies where the researcher observes the outcome of processes (Reedy & Reedy 1992). In this case, these processes involve conducting technical analyses on a painting, and observing and interpreting the results of the analyses. The study deals with a real object, which has many ethical implications. Using real objects usually limits the type of investigation that can be conducted, in terms of invasive and/or destructive analysis. The value of information gained by conducting invasive analyses is often not worth the possible visual damage (Caple 2000). The majority of the analyses in this study are non-invasive and conducted with portable instruments that could be brought to the object. However, some sampling has been undertaken, when the information value has been deemed worth it by author, supervisor, and GMA.

Object based conservation research can be divided into three categories; *composition* (what is the composition of the object?), *deterioration* (how will the object deteriorate / how has the object deteriorated?), and *treatment* (what is the best course of treatment for the object?) (Reedy & Reedy

1992). This study touches upon all three categories but is mainly focused on the composition and deterioration. Results from single-objects studies are only applicable to the researched object, but observations based on the results can be of help in the investigation or treatment of other objects (Reedy & Reedy 1992).

The thesis presents both primary and secondary data. Primary data are data that have been recorded or observed by the researcher, for example by conducting measurements or direct observations. When primary data are written down or recorded in some way, either through publication or reports, and the researcher makes use of the data in the recorded form, they are called secondary data. Secondary sources are potentially less reliable as the researcher does not experience them directly, but they are often the only available sources (Walliman 2018). All the historical information in this thesis, such as facts about Bonnard's life, the use of cardboard as a support in oil painting, the conservation of cardboard paintings, and provenance of the painting WL84, is based on secondary data. These data have been collected by conducting a literature-based research. For the purposes of this thesis, many different kinds of sources have been consulted; art historical publications and documents on Bonnard and his peers, artist handbooks and catalogues of materials, scientific articles about the conservation of oil paintings on cardboard, and guidelines for using specific analytical methods. The main source of the literature has been from libraries at both the University of Gothenburg and GMA, and from digital journals, accessed through the Gothenburg University Library. The literature will be further discussed in *1.6. Positioning and Previous Research*. The author also had the advantage of being able to access archival information from the digital database, and acquisition ledgers at GMA.

The technical study of the painting WL84 produces primary data, as measurement and observations have been conducted by the author. To obtain the primary data in this study, specific analytical tools, or methods have been used. The methods include imaging and macro photography, microchemical testing, X-ray fluorescence (XRF) spectroscopy, and Fourier-transform infrared (FTIR) spectroscopy. Instruments for the various methods have been provided by GMA and the Department of Conservation at the University of Gothenburg. The technical investigations of this study have been conducted and analyzed by the author but with continuous guidance from and dialogue with supervisors from the University of Gothenburg and GMA. Images in raking light and ultraviolet radiation have been provided by Hossein Sehatlou, photographer at GMA. The methods are further explained in *3. Analysis Methods.*

The need for inter- or multidisciplinary studies has long been discussed and well established in the conservation world (Caple 2000; Carlyle 1995), and in this study it was deemed important in order to contextualize the concrete findings of the technical investigation. The identification of a material in a painting is further legitimized if it can be put into a historical context, for example by confirming that the material was, in fact, commonly used at the time.

1.4. Study Object

The study material for this thesis is the painting WL84 (Fig. 1) (Bonnard 1903). It is painted by Pierre Bonnard in 1903 and has the title *Nude*, or *Après le bain*. It is painted with oil on a dense, brown cardboard and has the dimensions 68,0 x 52,0 x 0,3 centimeters (cm). The painting is mounted with a cardboard backing in an unglazed wooden frame with the dimensions 86,5 x 70,5 x 6,0 cm. A corrugated plastic board is placed on the back of the frame.

WL84 depicts a nude dark-haired woman, who is leaning over a chair, with her left foot positioned on the chair. Her body is bent over with the weight on her left leg. She has a distracted look on her face and is looking off into the distance. In the lower right corner, by the chair, there is a towel or a bright garment. On the upper edge of the painting, positioned to the left of the center, is Bonnard's signature in dark purple paint. The painting's palette mostly consists of earth tones: brown, gray, beige, and white. However, there are some areas with more vibrant colors, such as pink and purple areas on the face, arm, and hand of the woman, a dark blue on some of the body areas and in the background, and a light blue in the bright area in the lower right corner. There are also yellow and greenish hues in the

background. The painting has an uneven layer of a shiny varnish which appears to be severely discolored.

Fig. 1. Pierre Bonnard, *Nude* (or *Après le bain*), 1903. Oil on cardboard, 68 x 52 cm. Inventory number WL84, Gothenburg Museum of Art. Photo: Hossein Sehatlou, GMA.

1.5. Limitations and Delimitations

The study is limited to the examination of one painting, WL84. Because it is a single-object study, the results only apply to this specific object. If more objects of similar materials and techniques had been investigated and compared to WL84, it might have been possible to use the results in a more generalized manner. As mentioned in *1.3. Methodology*, this study deals mostly with the research categories of composition and deterioration. There is no practical treatment and the study only briefly mentions some of the options for treatment. This was an active choice by the author; before even considering treatment for an object, the composition and deterioration have to be investigated and therefore they were deemed the most important aspects of this study.

Delimitations of the literature review concern mostly the scope of historical information on Bonnard. The review provides a short overview of Bonnard's life but it is not a biographical review. Details about Bonnard's personal life might have provided more insight into his painting style and choice of imagery, but in order to limit the scope of the study, this was not included.

For the technical investigation, additional spectroscopic methods could have been used to complement the existing ones, such as Raman spectroscopy for the pigment identification. The fiber identification could also have been complemented by conducting spot testing. The analysis methods used in the study were based on what was available to the author.

It is also worth noting that only very small samples of the varnish and cardboard were taken. If more samples were taken, further analyses could have been conducted in order to further strengthen the reliability of the results. However, for the sake of the well-being of the object, this was not considered ethically justifiable.

1.6. Positioning and Previous Research

There are no known technical studies on Bonnard's paintings, and as such, there is no previous research similar to this study. However, there are many studies and publications which contain information relevant to this study. The inter-disciplinary nature of this thesis requires consulting research and information from several different fields. Art historical research on Pierre Bonnard is abundant. Following are the main sources that have been consulted for the purposes of this thesis. In 2019, a major solo exhibition on the later works by Bonnard was presented at Tate Modern, along with a publication containing several essays on Bonnard by various scholars. The publication, *Pierre Bonnard: The Colour of Memory* was edited by Matthew Gale (2019) and has served as a source of information on the life and artistry of Bonnard. Additional publications which have been used for these purposes are *Bonnard: Colour and Light*, by Nicholas Watkins (1998), and *Pierre Bonnard: Observing Nature*, edited by Gloria Groom (2003). Dita Amory, curator at the Metropolitan Museum of Art, has written the articles *Pierre Bonnard (1867-1947): The Late Interiors* (2000b) and *Georges Seurat (1859-1891) and Neo-Impressionism* (2000a), which have provided information not only on Bonnard but also on the Neo-Impressionists, who were integral in Bonnard's artistic evolvement.

All of the publications mentioned above are written from an art historical point of view, and while Bonnard's painting style is sometimes mentioned, there are rarely any discussions on the technical or conservation-related aspects of his painting and choice of materials. Studies on Bonnard's use of materials and on the condition of his paintings are scarce, both in an art historical and conservation science context. However, there are some technical studies on paintings made by some of his close colleagues, such as *Past, Present, Memories: Analysing Edouard Vuillard's 'La Terrasse at Vasouy'* (Robbins & Stonor 2012), published in the National Gallery Technical Bulletin. The study explores the art historical context of one of Vuillard's panel paintings, and it also conducts pigment identification and analysis of the paint layers. Such studies can be of use for giving some indications on which materials Bonnard used, as it is likely that artists belonging to the same art movements used similar materials and techniques.

Studies on general practices and use of materials by artists of the same time frame as Bonnard have also been of use in this thesis. Michael Swicklik, senior conservator of paintings at the National Gallery of Art in Washington D.C., has written the article *French Painting and the Use of Varnish, 1750 – 1900* (1993), which provides an overview on how varnishing practices changed during the course of two centuries in France. The article touches on several similar points as in *Absorbent Grounds and the Matt Aesthetic in Post-Impressionist Painting*, by Vojtech Jirat-Wasiutynski and Henry Travers Newton (1998). Both articles discuss how new trends led to a change in how artists viewed varnishing in the 19th century, but the latter article also delves into the use of cardboard as a support for oil painting. The study is a survey of different types of absorbent grounds and how they affected the final appearance of the paintings. It is not a study of one particular artist, but it does mention several artists relevant to the topic, among them Bonnard. Even studies on painting practices by artists in other countries have been useful for gaining an understanding of the general use of materials in the late 19th century. One of these studies is *The American Artist's Tools and Materials for On-Site Oil Sketching*, by painting conservator Alexander Katlan (1999). This article has provided information about different cardboard types, and insight into how artists used painting supplies while sketching outdoors.

In order to gather information on the complex subject of oil paintings on cardboard, various sources have been consulted. This includes surveys and overviews of different types of cardboard, catalogues and handbooks of painting supplies, descriptions of treatments, and case studies. In *A Brush with Nature: An Historical and Technical Analysis of the Papers and Boards Used as Supports for Landscape Oil Sketching*, by paper historian Peter Bower (2002), different types of cardboard used for oil painting are surveyed. The study also explains what constitutes as cardboard. Studies by conservators who have worked with oil paintings on cardboard have proven valuable for understanding the history of treatments as well as some of the main problems with the degradation of the objects. In *The Treatment of Oil Paintings on Paper Supports Considerations on the Treatment Applications Used from the Past until the Present* (Banou, Alexopoulou & Singer 2015), the structural problems of oil paintings on cardboard are described, illustrated by case studies, and past treatment practices are presented.

1.7. Ethical Considerations

The subject of this thesis is a real art object of historical, cultural, and economical value. It is a work of art belonging to a museum collection. In the ICOM Code of Ethics for Museums, the standard guidelines for museums, it is stated that collections are a public inheritance, and museums have an obligation to preserve and maintain them. The term 'stewardship' is mentioned, and the word implies that museums should not be viewed as owners of objects in collections, but rather as caretakers preserving the well-being until the next generation can take over the stewardship. "Museums that maintain collections hold them in trust for the benefit of society and its development" (ICOM 2017). There is, therefore, great responsibility in conducting research on and about objects, both for the researcher and for the institution. All handling of objects poses a risk for their well-being. Performing analyses on cultural heritage objects should always be justifiable, whether it be invasive or non-invasive analyses. The advantages should outweigh the risks and disadvantages. Justification pertains not only to the well-being of the object but also to the usage of resources that are inevitably required for such studies. Analysis is often time-consuming, and can require expensive equipment. It is important that the researcher has the knowledge required to handle such equipment, and to interpret the results of the analyses (Caple 2000).

In this case, the object was on permanent display at GMA, in an unglazed frame. From a conservation point of view, a remounting and glazing was deemed necessary to protect the painting, so the timing presented an opportunity to also examine and analyze the painting. While under investigation, the object was handled unframed, which posed a risk for mechanical damage, especially along the cardboard edges. The cardboard, while mostly stable, did suffer from some material loss in the form of crumbling. While the material loss is obviously a great disadvantage, it was used as an opportunity to take a sample of the cardboard for analysis. Minimal intervention in conservation research is desirable, but small fragments are sometimes "sacrificed" if the outcome is deemed worth it (Caple 2000). A small sample was also taken from the varnish where minimal visual damage was caused. The sampling of both cardboard and varnish was deemed worthy due to the amount of information that it could provide. Before sampling, the advantages and disadvantages were discussed and evaluated with supervisors from the University of Gothenburg and GMA.

Due to the WL84 being an object in a museum collection, some restrictions for the analyses had to be considered. All of the analyses which were performed on the painting were carried out at the museum, with portable instruments. Transporting the object outside of the museum poses too great a risk for its well-being. The only analyses which were not conducted in-situ were the ones where samples were taken. The in-situ methods were performed in a non-invasive manner. There were many restrictions in terms of methods due to ethical considerations. For example, additional sampling could have provided more reliable results but, as mentioned in *1.5. Limitations and Delimitations*, this was not considered ethically justifiable. Exposure times for the various forms of radiation were also kept to a minimum, to minimize the risk of damage. Furthermore, analyses were not repeated. It is possible that further and more reliable results could have been uncovered if analyses were repeated, but in order to keep the handling of WL84 to a minimum, this was not done. All analyses and handling of the painting were carried out with GMA staff present.

2. Literature Review

This literature review is divided into three parts: first, a background on Pierre Bonnard's life and artistry and his place in art history. The use of color and materials by him and his peers is also discussed. The second part presents the provenance of WL84. The third and last part of the chapter focuses on the material cardboard and its use as a support for oil painting, as well as conservation issues related to oil paintings on cardboard.

2.1. Pierre Bonnard: A Historical Overview

Pierre Bonnard (Fig. 2) was born on October 3rd, 1867, in Fontenay-aux-Roses, a village outside of Paris. In his early adulthood, Pierre studied to become a lawyer while spending his free time painting. During his studies, he started taking courses at the experimental art school Académie Julian, where he met fellow artists who would become very important in both his professional and personal life. Bonnard also applied and was accepted at the Ecole des Beaux-Arts in 1887, all while continuing his law studies, which he would complete in 1888. In the same year, the artistic group Les Nabis was formed by the group of artists that Bonnard met at Académie Julian. Among the artists in the Nabis were Bonnard himself, Edouard Vuillard, Maurice Denis, and Paul Sérusier (Bonnard & Groom 2003).

Fig. 2. Portrait of Pierre Bonnard, ca 1899, Musée d'Orsay (CC BY-SA 4.0).

In the beginning of his career, Bonnard worked as both a lawyer and an artist. In 1896, he had his first solo exhibition, and in the following years, Bonnard would take part in exhibitions at esteemed art galleries such as Galerie Bernheim-Jeune in Paris (Bonnard & Groom 2003). The Galerie Bernheim-Jeune was opened in 1865 by Alexandre Bernheim-Jeune and would later be run by his sons, Joseph and Gaston. The gallery showed art from some of the most prominent and avant-garde artists of the time (Chilvers & Glaves-Smith 2009). Bonnard had his first solo show at the gallery in 1906, and Joseph and Gaston Bernheim-Jeune would later become his art dealers (Bonnard & Groom 2003; Serrano 2019).

In 1893, Bonnard met his lifelong companion Marthe de Méligny, whose real name was Maria Boursin. She would later become his wife, and was a model for Bonnard during the entirety of their partnership up until her death in 1942. Bonnard painted his last paintings in 1945 and died two years later, in 1947 (Bonnard & Groom 2003; Watkins 1998).

2.1.1. Art Historical Context

In the end of the 19th century, Paris was arguably the center of the modern world. The city had recently been rebuilt and people from all over moved to the vibrant metropolis where the art scene flourished. Impressionism as an art movement emerged in the 1870s, provocatively breaking tradition with the strict academic art. The Impressionists devoted themselves to interpretations of modern everyday life in a completely new way, often painting outside and directly in front of the motif. They reinvented painting, in terms of composition and use of color, and they adopted an objective approach to their paintings, where the viewer could interpret the painting freely. The motifs and subject matter of the paintings did not intend to moralize or educate the viewers, which the academic history painting of the time was very preoccupied with. Impressionist painting gave the impression of being casual and hasty, which was quite provoking for viewers (Herbert 1988). The objective and casual interpretation of life and nature became both celebrated and critiqued. Among the critiques were artists who would later be called Neo-Impressionists. The Neo-Impressionists argued that the Impressionist approach had led to lack of form and significance, and they renounced the spontaneous painting style. Instead, they proposed a systemized painting technique which was based on color theory and science (Amory 2000a; Honour & Fleming 2009).

Fig. 3. Pierre Bonnard, *Le Déjeuner des Enfants (The Children's Lunch),* c. 1887. Oil on canvas, 27 x 33,5 cm. Musée des Beaux-Arts de Nancy. [Public domain], via Wikimedia Commons.

The Nabis took inspiration from both the Impressionist and Neo-Impressionist approach to painting. The Nabis, which means 'prophets' or 'initiates' in Hebrew, saw themselves as prophets of radical art. At the time when the Nabis were formed, the art of the Impressionists was causing outrage in Paris, and the teachers at Académie Julian were strongly opposed to it (Zutter 2003). The Nabis questioned the academic teachings of Western painting and advocated a more decorative imagery (Benesch 2019). They argued that a painting is first and foremost a decorative object, and that color is autonomous in its expressivity (Watkins 1998). In his early career, Bonnard painted mostly interior scenes, filled with small objects (Fig. 3) (Bonnard 1887). He would only paint motifs with which he

felt very familiar (Amory 2000b). This intimate, simple, and personal style was called *intimism*, and was practiced by several artists but principally by Bonnard and Edouard Vuillard (Groom 2003).

One of the most important influences for Bonnard and for the Nabis was the Japanese woodcut, *ukiyo-e*. In 1890, an exhibition with Japanese prints at the Ecole des Beaux-Arts made an impression on all of the Nabis, and was possibly the start of the decorative style in Bonnard's artistry. What Bonnard found most inspiring was the colorful aesthetic and unusual compositions of the prints, completely different from European painting. (Benesch 2019; Bonnard & Groom 2003). The Nabis parted ways in 1900, and Bonnard's artistry moved in some ways closer to the Impressionist style. The importance of the decorative remained integral but he started painting exterior motifs with streets and landscapes (Groom 2003).

Throughout his career, Bonnard also painted intimate, sensual images of nudes. Most of his nude paintings are of Marthe, in the bathroom, bedroom, or in the bath, in a style that was inspired by artists such as Edgar Degas (Fig. 4a-b) (Bonnard 1908; Degas 1886). He also took many nude photographs of Marthe in the same settings. Bonnard always painted Marthe as a young woman with a healthy body, even in the end of her life when she suffered chronic illness. Bonnard's paintings with nude motifs are considered progressive and distinguishable from other nude paintings of the same era, as they were unorthodox in their sensual depiction of the female body (Zutter 2003).

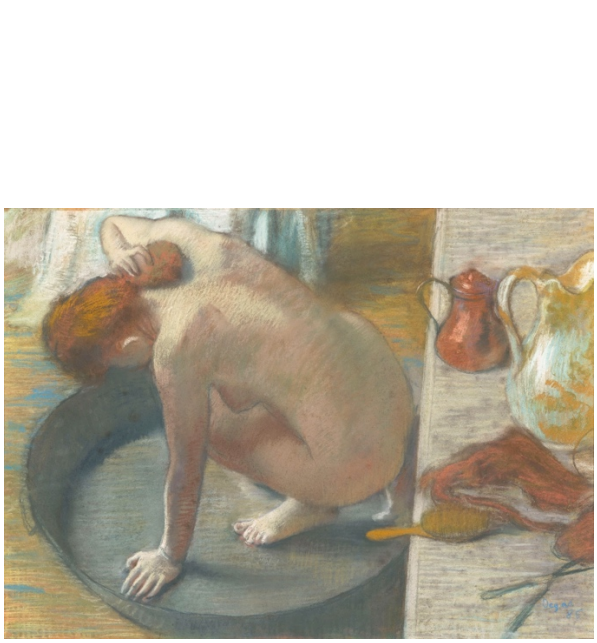


Fig. 4a. Edgar Degas, *Le Tub (The Tub)*, 1886. Pastel on board, 60 x 83 cm. Musée d'Orsay, Paris. [Public domain], via Wikimedia Commons.
Fig 4b. Pierre Bonnard, *Nu à Contre-Jour (Nude Against the Light)*, 1908. Oil on canvas, 125 x 109 cm. Musées Royaux des Beaux-Arts, Brussels. [Public domain], via Wikimedia Commons.

Bonnard's mark on art history is in many ways contradictory. There is no doubt that he was a prominent artist of his time, well-respected in his community. He was represented by prominent galleries and dealers, and his art was bought by some of the most important collectors of the time, such as the Stein siblings.[1] Despite these accomplishments, Bonnard was also often criticized, most famously by Picasso, who called Bonnard's painting "a potpourri of indecision" (Watkins 1998). This was a time when some of the most explosive and radical movements in art history were taking place.

[1] The Stein's (Leo, Gertrude, and Michael) were Americans who established themselves in Paris at the end of the 19th century. They would become known as pioneers in recognizing and collecting modern and avant-garde art, and were some of the main promoters of artists such as Pablo Picasso and Henri Matisse (Rabinow 2011). In 1906, Gertrude and Leo Stein bought Bonnard's painting *Siesta* and hung it in their Paris apartment (Bonnard & Groom 2003).

Though Bonnard and his peers were self-proclaimed prophets of a more radical art form in the end of the 19th century, they were considered quite conservative among more avant-garde art movements (Zutter 2003). Their push for the decorative did not seem all that radical in light of what was happening around them in the art world. Nevertheless, Bonnard is today considered integral to the colorist movement and is viewed as a fascinating and multi-faceted figure in art history (Amory 2000b).

2.1.2. Color and Materials

The art movements of the late 19th century brought an awareness to color and light in completely new ways. Impressionists deliberately brightened the palette, which Neo-Impressionism developed even further by attempting to systematize the palette, making it into a science that could be taught through color theory. Their main approach to painting was to apply colors separately on the canvas, without mixing them on the palette. They believed in optical mixture, meaning the observer would perceive the colors as mixed, and that this technique would result in more vibrant colors compared to mixing the paints beforehand (Amory 2000a). Bonnard, while certainly inspired by both the Impressionist and Neo-Impressionist approach to color, strongly felt that such theories were limiting, and based his painting on feeling and reaction to the colors on the palette. The palette was very important for Bonnard; he saw it almost as a painting in itself and he divided the colors on it between warm and cool. Even though Bonnard's imagery was bright and vivid, he often used black to emphasize certain objects in his paintings, as he believed darks and lights had a strong ability to express feeling, autonomously. Black was rarely used in the Impressionist palette (Groom 2003; Watkins 1998).

Yet another aspect that distinguished Bonnard from the Impressionists was that he did not paint in front of his motif. He is quoted as saying: "The presence of the object, of the motif, is extremely distracting for the painter at the moment of painting" (Benesch 2019). He would often start his working process by making small sketches in pencil or watercolor, and after some time he would paint the motifs (Amory 2000b). He worked on several paintings simultaneously, often on one big piece of canvas that he would place on his wall. He came back to the paintings and made small adjustments, sometimes even after he signed them, as he rarely saw his paintings as finished (Watkins 1998). One of Bonnard's models, a woman named Dina Vierny, once recalled a time when she accompanied him to one of his exhibitions in Paris:

> We were looking at these paintings, which belonged to private collectors or museums, when suddenly I saw him take out a small can of oil and his brushes in the middle of this huge hall – and he started to touch them up. No one saw us. He explained that a painting was never finished. As he was correcting it, he said: "It lacks depth." (Schwabsky 2019).

The art historical research on Pierre Bonnard is extensive, but there is limited research on his use of materials. His palette is often discussed, but rarely in terms of specific pigments. Two brief mentions of specific pigments have been found in two different publications; cadmium yellow in a handbook of artists' pigments from 1986, and cobalt violet in a study on cobalt violet pigments from 2002 (Corbeil, Charland & Moffatt 2002; Feller 1986). In a study where one of Edouard Vuillard's panel paintings was examined, some of Vuillard's favored pigments are presented. Vuillard claimed to use cheap, low-quality pigments but the results of the study show that the used pigments were, in fact, quite expensive. Among the pigments he favored were cobalt blue, cobalt violet, and cadmium yellow (Robbins & Stonor 2012). It is likely that the two colleagues and close friends used similar techniques and materials. Bonnard painted mainly with oil on canvas, but often used cardboard as a support as well, as did Vuillard. Based on the catalogue raisonné of his oil paintings, it seems as though Bonnard used cardboard as a support mainly in the beginning of his career (Dauberville & Dauberville 1966; Young Randolph 1984).

While his decorative paintings and use of bold color is what Bonnard is most known for today, his career was long and he went through many phases of inspiration and production. His early intimate paintings with interior motifs are generally quite dark with much use of shadows, though often with a splash of bright and bold color somewhere (Watkins 1998). In 1898, Maurice Denis described Bonnard's artistry as having a "somber palette" and being suitable for placing in dark apartments. It

was not until after the Nabis had disbanded that Bonnard really started to transcend to a more colorist aesthetic (Groom 2003). Gradually, his imagery became more decorative, and by the 1910s he had fully matured into the colorist he would be known as. *The Dining Room in the Country* (Fig. 5) (Bonnard 1913), completed in 1913, is generally conceived as his first masterpiece as a colorist (Watkins 1998). Bonnard was preoccupied with color in his entire artistry, and his relationship with color and light evolved and changed over the course of his lifetime.

Fig. 5. Pierre Bonnard, *The Dining Room in the Country*, 1913. Oil on canvas, 168 x 204 cm. Minneapolis Institute of Art, Minneapolis. [Public domain], via Wikimedia Commons.

Shortly before Bonnard died in 1947, he wrote in his diary "I hope my painting will endure without craquelure. I should like to present myself to the young painters of the year 2000 with the wings of a butterfly" (Bonnard & Groom 2003). While this quote does not provide information on the specifics of his material use, it does speak to Bonnard's wish to maintain a level of quality in his art, both in terms of artistic content and material sustainability.

2.1.3. A New Aesthetic: Breaking Tradition from Academic Painting

It has already been mentioned that the art world was evolving in rapid ways during the 19th century. This did not only pertain to style and imagery; choice of materials and how to use them was also undergoing development. A significant change was the use of varnish in oil painting. A varnish is a transparent liquid coating applied to the surface of the finished painting. It serves as a protection from dirt and mechanical abrasions, and it alters the aesthetic appearance of the painting by making colors appear more intense (Plester 2004). There are several types of varnishes with varying properties, both compositional and aesthetical. Varnishes used as a finishing coating in oil paintings are called picture varnishes, but will be referred to only as 'varnishes' in this study (Mayer 1962). The practice of varnishing paintings has been common since the 16th century. At that time, there were mainly two types of varnish: oil varnishes containing oil and resin, and spirit varnishes containing resin dissolved in a spirit (Swicklik 1993). Resins exist in both natural and synthetic form and they can have very differing properties. Natural resins are hardened secretions from either trees or the earth (fossil resins).

Tree resins are the ones that are most commonly found in varnishes. They are partially or fully soluble in oils, alcohols, and turpentine, but not in water (Mayer 1962).

Oil varnishes were the first to be in common use, and they produced a thick and glossy coating to paintings. Spirit varnishes became more popular in the 17th century, and they could be applied in thinner layers which gave a less glossy appearance (Swicklik 1993). In the 19th and early 20th century the most common varnish was mastic, often mixed with turpentine. Mastic is a triterpenoid tree resin and its popularity as a varnish depended on its ability to add brightness to the colors and to protect the paint layers from dirt and abrasions. It was also easy to prepare and to remove (White & Kirby 2001). Another very popular varnish during this time was dammar, which is also a triterpenoid tree resin. Dammar varnish was introduced somewhat later in European painting, but quickly became popular due to its low price. Compared to mastic, it has less tendency to crack, and is not as prone to yellowing and often remains mostly colorless upon ageing (Mayer 1962; White & Kirby 2001). However, most varnishes usually darken and become discolored over time, and are often removed and replaced. It is very common that paintings are re-varnished with a fresh coating. Consequently, the varnish layer on paintings is seldom original (Mills & White 1994).

Artists' use and preference of varnish has varied over the centuries, and the topic of varnish has, maybe surprisingly, caused a great deal of controversy in the art world. For many years, fine art was synonymous with art produced at the art academies. Artists were schooled in very regulated painting practices, with specific instructions on how to practice good craftsmanship. If artists wanted to exhibit their work in exhibitions held by the academies, they had to adhere to these rules, and if they wished to experiment with other techniques, they would have to do so outside of the academies (Swicklik 1993).

In the 19th century, academic painting favored a glossy and highly polished surface of paintings. There were manuals and lectures given at the academies on how to properly varnish. It was not uncommon that paintings were given a single coat of varnish after being hung in the exhibition halls, right before opening. The final varnishing in the exhibition hall was not always carried out by the artists themselves; it was common that artists' colormen performed the varnishing. Colormen were advisers on technical matters, whom the artists frequently relied upon. Sometimes one colorman varnished all of the paintings, even when the exhibitions featured multiple artists. They were often in a hurry, and would apply the varnish "with large fat brushes, in abundance but unevenly" (Swicklik 1993). This inevitably led to some frustration among artists, and many became increasingly opposed to these practices and decided to forego varnishing altogether. Artists had also become concerned about the discoloration they had begun to observe over time in varnished paintings. They believed that the permanency of the condition would improve if there simply was no varnish layer (Swicklik 1993).

At this time, many of the Impressionists strived for a more matt surface in their paintings for aesthetic reasons as well. They opted for flat and bright surfaces, in stark contrast to the traditional use of *clair-obscur* (the use of contrast between light and dark). This visual approach could be implemented not only by eliminating the use of varnish but also by using absorbent, rough grounds to paint on, such as cardboard. The use of media was also important for creating the matt effect; artists often lowered the ratio of oil compared to pigment, resulting in a dryer paint layer. Evaporating spirits could also be added to the paints for a matt effect (Jirat-Wasiutynski & Travers Newton 1998).

By the 1880s, most Impressionists had stopped varnishing their paintings, some being more adamant about it than others. However, they were still glazing (framing with glass) their paintings. Neo-impressionists also preferred not to varnish their paintings, but more because of their fear of the paintings becoming discolored than for aesthetic reasons (Swicklik 1993). As previously mentioned, Neo-impressionists had very precise and systematized painting techniques where the perception of color was incredibly important (Amory 2000a). A risk of discoloration, thus altering the colors, would have been a great concern for them. Georges Seurat made his opinions on varnish clear in an 1887 letter to his friend:

> It is appropriate that I tell you of my horror of varnish. Often some paint shop proprietor will apply varnish without being told to, thinking he's doing the right thing and sending in his little bill. VETO. I'm against any varnishing of my canvases, either free or for a fee (Swicklik 1993).

The Nabis were among the artists' who favored this aesthetic. Their affinity for decorative painting likely played an important part in this, seeing as matt painting techniques had previously been most commonly used by painter-decorators for large decorative paintings. Paul Sérusier encouraged the other Nabis to paint thin layers on absorbent grounds, without varnishing. In 1921, he published *ABC de la peinture*, where he specifically advocated for a ground made of chalk or calcium hydroxide mixed with glue. The presence of glue would lessen the need for oil and resin, which are both sources of glossiness as well as of possible discoloration. By not applying varnish to the paintings, retouching after finishing the painting was made possible. Some of the Nabis, particularly Vuillard, used distemper as a medium on various absorbent surfaces, sometimes with ground and sometimes without (Jirat-Wasiutynski & Travers Newton 1998). Distemper paints are aqueous paints based on glue- or casein binders, often used for decorative wall paintings (Mayer 1962). In several of Vuillard's paintings, many of which he did not varnish, the paint layers have suffered cracking and flaking due to detaching from the ground. Bonnard occasionally used distemper (Jirat-Wasiutynski & Travers Newton 1998).

2.2. WL84: Provenance and Context

The painting at the heart of this study (Fig. 1) is painted at a time when Bonnard was moving towards a new phase in his artistry, right after the Nabis split up. In most sources, including the records at GMA, the title of the painting is *Nude*. However, in the catalogue raisonné of all oil paintings by Bonnard, the title is *Après le bain*, which means "after the bath" (Dauberville & Dauberville 1966). This title provides some context to the painting, adding it to one of the many bath paintings that Bonnard made. It is most likely that the woman is Marthe, as most of his sensual, intimate nude portraits were of his wife (Zutter 2003).

According to the catalogue raisonné, *Nude* was bought from 'Hessel' by the Galerie Bernheim-Jeune in 1919 (Dauberville & Dauberville 1966). The name 'Hessel' probably refers to Jos Hessel, who was an art dealer and a cousin of the Bernheim-Jeune sons. Hessel and his wife, Lucy, were friends with Edouard Vuillard and most likely with Bonnard as well (Robbins & Stonor 2012). After being bought by the gallery in 1919, the painting was sold to 'Zborowsky' (Dauberville & Dauberville 1966). It is likely that 'Zborowsky' refers to Leopold Zborowski, a Polish poet and art dealer who was active in the avant-garde art scene of Paris from 1913 until his death in 1932. Zborowski became a friend and dealer of many of the most prominent artists at the time, and is credited with popularizing the art of Amedeo Modigliani (Johnson 2017).

According to the acquisition ledger at GMA, the painting was bought in 1937 at the Swedish-French Art Gallery's exhibition, held at the Gothenburg Art Union. The painting is listed as a donation by Werner Lundqvist, but it is unclear if Lundqvist personally bought and donated the painting or if it was bought with funds provided by him. Werner Lundqvist (1868 – 1943) was an important figure for the collection at GMA. Lundqvist was a shipowner based in Gothenburg with a passion for art and music. He made a considerable donation of art works to GMA in both 1918 and 1919, and contributed financially to the building of the new museum, which was completed in 1925 (Werner 2012). The 'WL' in the painting's inventory number indicate that it belongs to the Werner Lundqvist collection.

Upon taking down the painting for examination, many labels and stamps were discovered on the back (Fig. 6), all which provide some more information on the provenance of the painting. On the back of the frame, there is an exhibition label from the Royal Academy of Arts in London, from 1966. There is also a stamp, presumably from the French Customs Office. There is severe bleeding of the ink of the stamp and the letters are very blurry, but it is possible to discern the word 'PARIS' in the middle of the stamp. The word above PARIS is likely 'DOUANE' (which means 'customs' in French). The

word underneath PARIS is ‘CENTRAL’. There is an identical stamp on the verso of the painting (Fig. 7).

On the cardboard backing there is a Swedish exhibition label from 1954, a stamp with the words ‘FRIHAVNENS TOLDKONTROL’, a stamp with the number four, and various handwritten letters and numbers. The FRIHAVNENS TOLDKONTROL stamp is likely a customs stamp from the port of Copenhagen, Denmark (Hovedstadshistorie n.d.). Among the handwritten numbers and letters are ‘G.K.M. WL. 84’, which is the painting’s inventory number from GMA. To the left of the inventory number is the inscription ‘N.M. 14.’. This could stand for a number of things but one possibility is ‘National Museum’. However, attempts at finding out more information about this have been unsuccessful. On the painting verso there are multiple stamps and labels from customs, exhibitions, and shipping companies (Fig. 7). There is also a stamp from the Galerie Bernheim-Jeune. The customs stamps on the verso, cardboard backing, and frame are from France, Italy, Sweden and probably Denmark. Beside the customs stamp from Stockholm, Sweden, the numbers ‘19/7-27’ are written, likely meaning that it arrived in Stockholm on the 19th of July 1927. If correct, this means that the painting had been in Sweden for ten years before being acquired by GMA.

Fig. 6. Verso of the frame and cardboard backing. Labels, stamps, and inscriptions are visible. Along the lower edge of the frame is the blue 'Paris douane' stamp which can also be seen on the painting verso. Two strips of metal tape are present on the upper half of the frame. Photo: Hossein Sehatlou, GMA.

Fig. 7. Verso of the painting, which contains many labels, stamps, and inscriptions. The blue 'Paris douane' stamp is present on the lower half. Metal tape is present along the sides. Photo: Hossein Sehatlou, GMA.

WL84 is not one of Bonnard's most famous paintings. It is rarely mentioned in sources and is not featured in many exhibition catalogs. Only two historic photographs of the painting have been found; one from a monography published in 1923 (Fig. 8a) and another from an exhibition catalog published in 1955 (Fig. 8b) (Silvana Editoriale 1955; Werth 1923).

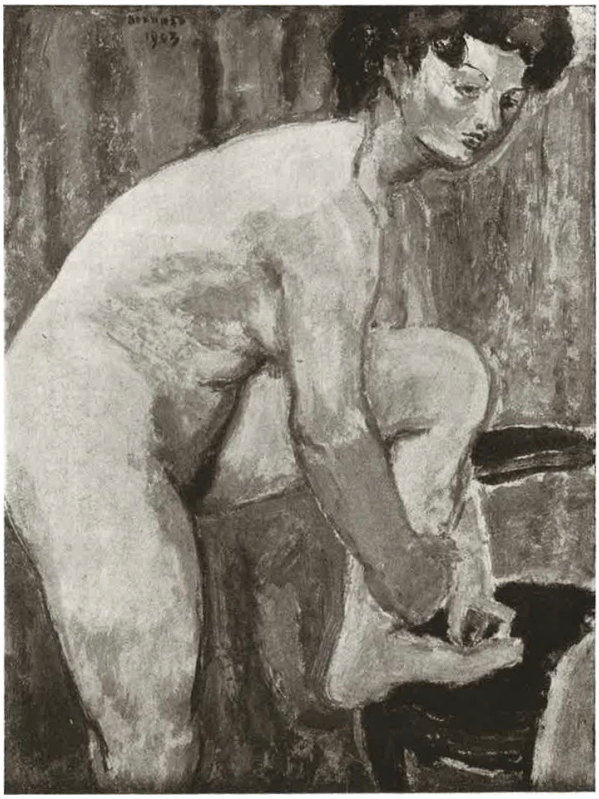


Fig. 8a. Photo of WL84 from 1923 (Werth 1923).

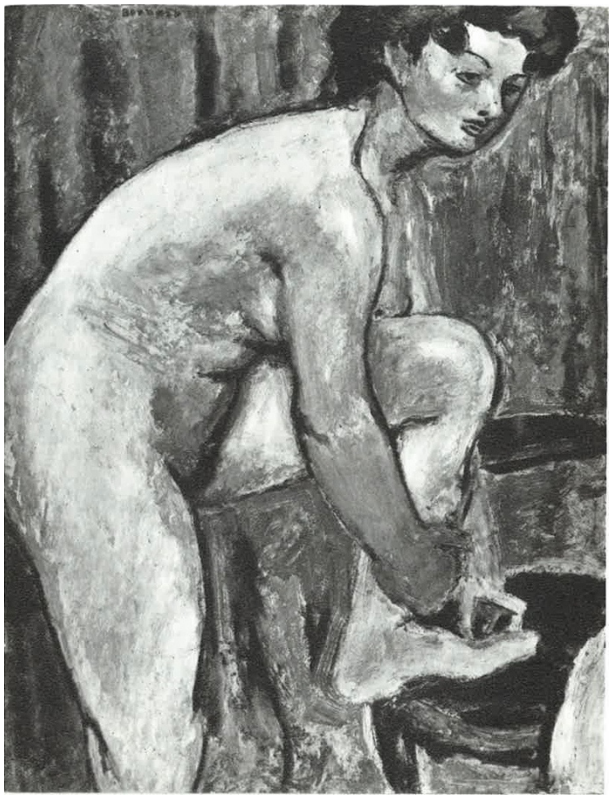


Fig. 8b: Photo of WL84 from 1955 (Silvana Editoriale 1955).

In the 1923 and 1955 photographs of the painting, no frame can be seen. However, the edges of the painting are not visible in these photographs, so the images are likely cropped. Thus, it is still possible that the painting was framed at the time when the photographs were taken. The fact that there are two identical Paris Customs stamps on the frame and on the painting verso suggests that the painting was framed in the current frame from at least the time it was exported from France. It might be the original frame but there is no way confirming this. The cardboard backing was likely added later, and the corrugated plastic board is a recent addition. According to Paper Conservator Mariateresa Pullano, the corrugated plastic boards have only been used at the museum for about ten years.[2]

On the painting verso, there are several strips of metal tape or foil (Fig. 7). On top of and on the sides of the tape is a yellow varnish. There are some traces of the metal tape on the frame (Fig. 6). The purpose of the tape is not entirely clear, but the most reasonable explanation is that it has functioned as a security measure. The tape was likely applied on both the painting and the frame in one complete piece, meaning that to open the painting, breaking the tape would be required.

2.2.1. Exhibition History

Based on the catalogue raisonné, the GMA database, and the stamps and exhibition labels on the painting, cardboard backing, and frame, the known exhibition history is:

- Galerie Bernheim-Jeune, Paris, France, unknown period of time.
- Galerie Druet, Paris, France, 1924.
- *Esposizione Internazionale d'Arte della Città do Venezia*, Italy, 1922.

[2] Mariateresa Pullano, Paper Conservator at GMA, personal communication, March 31st , 2020.

- *Bonnard Exhibition,* The Gothenburg Art Union, Sweden, 1938.
- *Cézanne till Picasso. Fransk Konst i Svensk Ägo*, Liljevalchs Konsthall, Sweden, 1954.
- *Bonnard, I dipinti e l'opera grafica del maestro in mostra a Milano,* Italy, 1955.
- *Bonnard Exhibition*, Royal Academy of Arts, London, United Kingdom, 1966.

When the painting was taken down for examination for this study, it had been on permanent display on the sixth floor of GMA for an unknown number of years (Fig. 9). GMA in the third biggest art museum in Sweden. It was initially part of Gothenburg Museum, which was founded in 1861. The Art Society of Gothenburg donated their art collection to the Gothenburg Museum in 1865, and that became the foundation for GMA (Göteborgs Stads Kulturförvaltning 2020). The museum has a vast collection of both Nordic and international art, spanning from the 15th century to today. Art from prominent Parisian artists from the end of the 19th century and beginning of 20th century is well represented in the collection. There are currently three paintings and five lithographs by Pierre Bonnard in the collection.

Fig. 9. WL84 on display on 6th floor at GMA.

2.3. Artist Materials: Oil Painting on Cardboard

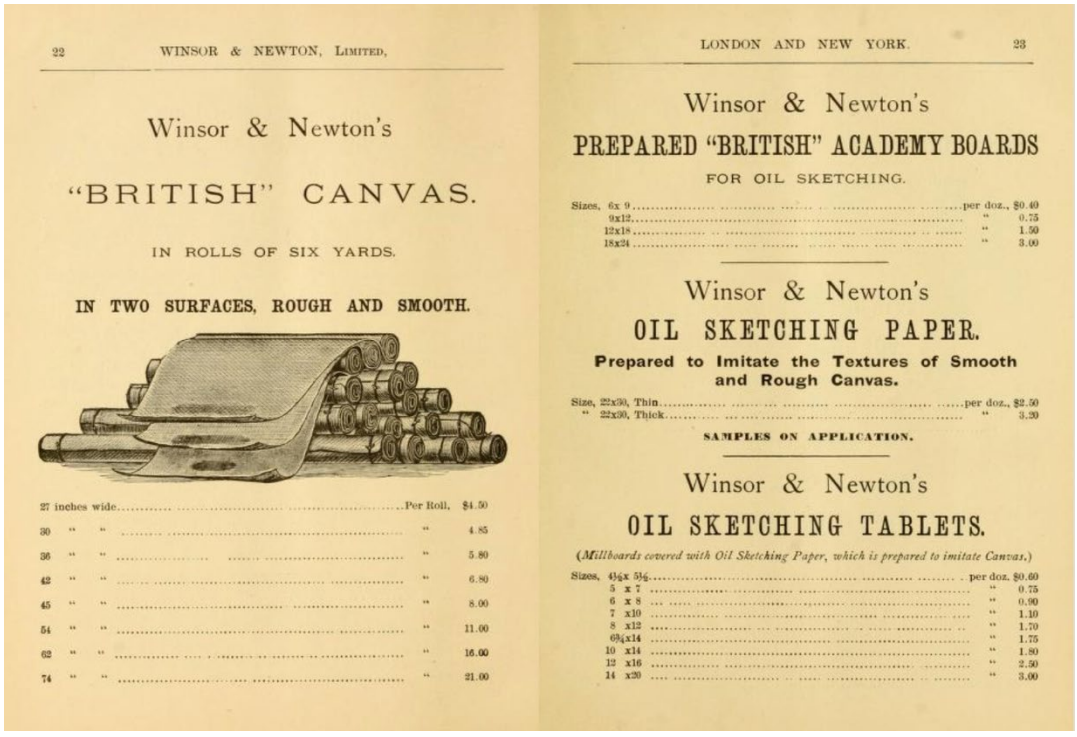
Oil painting has been one of the leading painting techniques for artists since the 15th century. The practice of mixing pigments with oil for painting had long been used, but it was in the early 15th century that artists started combining oils and resins with pigments to produce a fluid medium that dried slowly, allowing artists the time to add precise details (Honour & Fleming 2009). There is a great deal of variation in techniques for oil painting, in terms of achieving different effects. There is flexibility in the use and manipulation of the paints, which are some of the advantages. Additionally, the colors do not change very much upon drying, which is quite common for other types of media. Some of the disadvantages of oil painting are the risks of discoloration of the oil and flaking or cracking of the paint layers. The choice of materials and techniques of oil paintings greatly affect the quality outcome of the finished painting. Oil paints consist of pigments dispersed in drying oils (Mayer 1962). Drying oils are highly unsaturated oils that form a solid film upon drying. In European painting, the most commonly used oils are linseed, walnut, and poppyseed (Mills & White 1994). According to old instruction books on oil painting, it was recommended that linseed oil was applied to

dark colors, while poppy or nut oils were used for light colors, the reason being that linseed oil has a darker color (Carlyle 1995).

Originally, pigments were made into powders and added to the liquid binding medium by the artists themselves, but in the 16th century commercially prepared oil paints became available to purchase by specialist colormen (Honour & Fleming 2009). Oil paints in metal tubes, which Bonnard and his peers most likely used, became available in the 19th century. The mobility and easy usability of oil paints in metal tubes was important for artists who painted outdoors, which is further discussed below. (Winsor & Newton 2015).

2.3.1. Cardboard

In the beginning of the 18th century, paper supports for oil painting became common. A major contributing reason for this was that artists started painting outdoors, also called 'plein air painting'. These paper supports, which could be many different kinds of papers and boards, were originally not intended to be used for painting, but became increasingly popular for artists. Their popularity was a result of several factors, such as the fact that boards being rigid were easy to carry. They were also attainable at relatively low cost. Additionally, many artists appreciated the visual effects of applying oil paint on the absorbent paper support (Bower 2002). The absorbency of the cardboard lead to the paints drying more quickly, which was used as an advantage for outdoor painting (Jirat-Wasiutynski & Travers Newton 1998). In the beginning, small boards were most often used, and they could be used both with and without a prepared ground. The rise in demand led to the production of paper supports which were specifically made for oil sketching, but it took until the middle of the 19th century for that to happen. By this time, it was also possible to buy boards that had already been prepared for oil painting, from suppliers such as Winsor & Newton (Fig. 10) (Winsor & Newton 1895). However, many artists also fashioned their own board by gluing sheets together (Bower 2002).



22 WINSOR & NEWTON, LIMITED,

Winsor & Newton's

"BRITISH" CANVAS.

IN ROLLS OF SIX YARDS.

IN TWO SURFACES, ROUGH AND SMOOTH.

27 inches wide..... Per Roll, $4.50
30 " " ..... " 4.85
36 " " ..... " 5.80
42 " " ..... " 6.80
45 " " ..... " 8.00
54 " " ..... " 11.00
62 " " ..... " 16.00
74 " " ..... " 21.00

LONDON AND NEW YORK. 23

Winsor & Newton's

PREPARED "BRITISH" ACADEMY BOARDS

FOR OIL SKETCHING.

Sizes, 6x 9 ..... per doz., $0.40
9x12 ..... " 0.75
12x18 ..... " 1.50
18x24 ..... " 3.00

Winsor & Newton's

OIL SKETCHING PAPER.

Prepared to Imitate the Textures of Smooth and Rough Canvas.

Size, 22x30, Thin ..... per doz., $2.50
" 22x30, Thick ..... " 3.30

SAMPLES ON APPLICATION.

Winsor & Newton's

OIL SKETCHING TABLETS.

(*Millboards covered with Oil Sketching Paper, which is prepared to imitate Canvas.*)

Sizes, 4½x 5½ ..... per doz. $0.60
5 x 7 ..... " 0.75
6 x 8 ..... " 0.90
7 x10 ..... " 1.10
8 x12 ..... " 1.70
9¾x14 ..... " 1.75
10 x14 ..... " 1.80
12 x16 ..... " 2.50
14 x20 ..... " 3.00

Fig. 10. Image from Winsor & Newton price catalog from ca 1895. On the right side, cardboards prepared for oil sketching are listed (Winsor & Newton 1895).

The distinction between paper and cardboard is often unclear and has changed during history. According to modern ISO standards, sheets with a grammage under 150 g/m^2 are labelled paper, and sheets with a grammage over 250 g/m^2 are boards. Sheets with grammage between 150 and 250 g/m^2 can be both. Paper is usually formed as one sheet, while cardboard is made of layers of papers that are

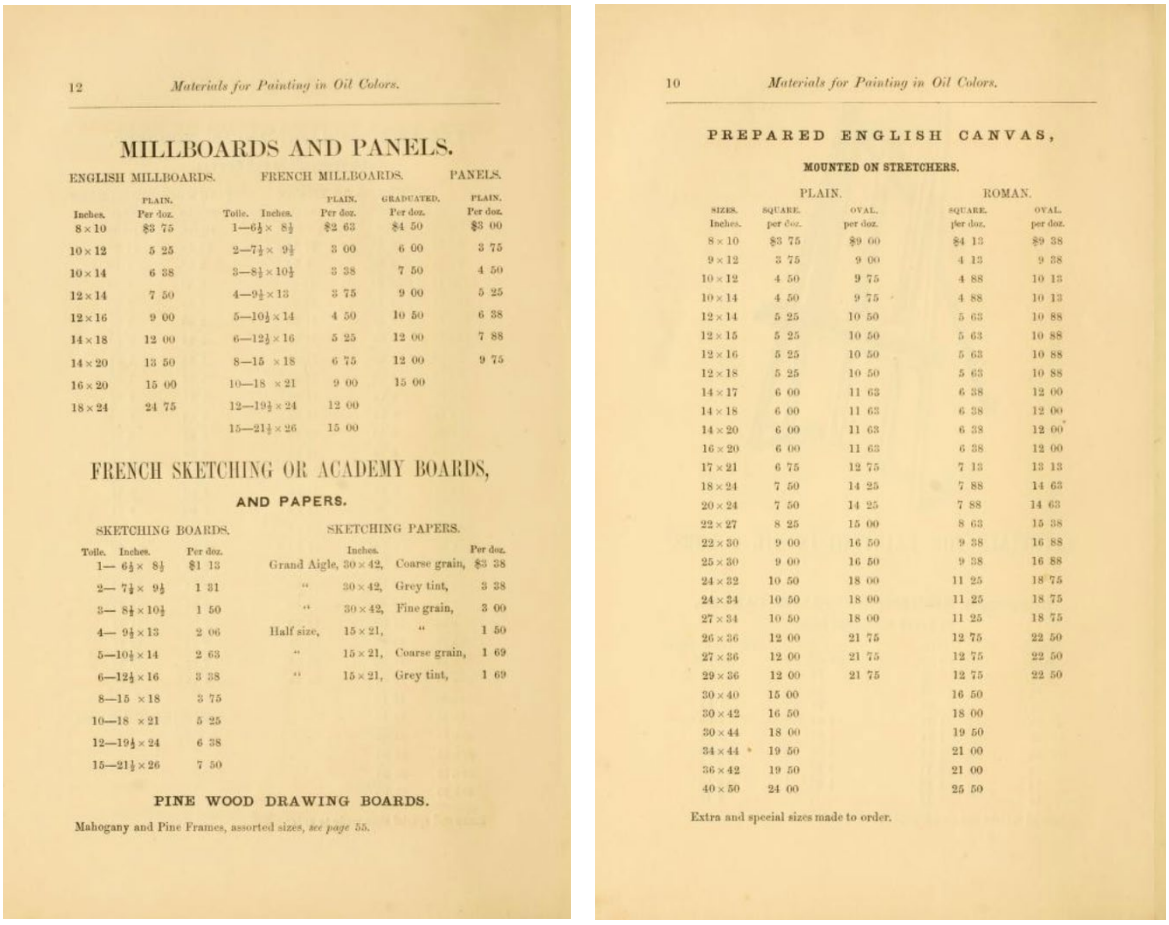
laminated, pressed, and glued together. Cardboard can be made as a single sheet as well, using a board mold, but it usually consists of layers (Bower 2002; Elfeky & Hassan 2008).

There are three main types of cardboard; pasteboards, pasteless boards, and millboards. Pasteboards were the earliest boards having been commercially made in Europe since the 1580s (Hunter 1978). They are made by pasting sheets of paper together, using animal glue or starch paste, and extreme pressure. Depending on the intended use of the finished board, different kinds of papers were used and the thickness and rigidity varied. They were made by laminating everything from two to eight sheets of hot-pressed drawing paper together, and then glazing the board by placing it between two smooth metal plates. Pasteless boards were made by couching (relocating the wet sheet from the mold onto a felt) several fresh sheets of paper together. By couching them together while they were still wet, no glue was required, and the finished product was strong and rigid. The term 'millboard' is often used as an overall term for all kinds of board, but millboards are actually boards made from thick, solid sheets which are 'milled' together between heavy iron rolls. Metal plates for glazing were not used for millboards, as the milling resulted in a hard surface. Millboards were often made from waste papers and fiber refuse, and they could be made with or without glue (Bower 2002). Millboards of higher quality are often made from flax and hemp fibers only (Jaques 1999).

During the 19th century, a common cardboard used for painting outdoors was the academy board, which was a variation of a millboard. Academy boards were initially made for students in art schools and not for professional artists. They were primarily intended for sketching and not for finished paintings. Academy boards were inexpensive and generally of lesser quality than other cardboards made for painting. They were often primed with a gray or white ground based on lead pigments. The priming would serve as stiffening layer to the board. Because of their low price, academy boards also became popular among professional artists. They were initially sold mostly in small sizes, and would often fit into artists' sketching boxes. In England, academy boards were probably available from around 1820 from Winsor & Newton. Despite their popularity, they were largely replaced by canvas boards by the end of the century, although they were still available in the beginning of the 20th century. Artists were noticing that the thick layers of paint were causing the semi-rigid boards to warp and twist. Canvas boards, cardboards lined with canvas, were stiffer and thus less prone to warping (Katlan 1999).

By the end of the 19th century, there were many different cardboards to choose from. In price catalogs from companies selling artist materials, millboards and academy boards appear to be most common. Some companies offered both 'French millboards' and 'English millboards'. French millboards were available in 'graduated tints' and 'plain', while English millboards were only available in 'plain' (Katlan 1999). They also differed in size, as the French millboards were sold according to French standard sizes for oil paintings on canvas.[3] In a price catalog of artists materials from 1857, English millboards ($24,75 for a dozen 18 x 24 inch boards) are listed at more than twice the price of French millboards ($12,00 for a dozen 19,5 x 24 inch boards), which in turn are almost twice the price of academy boards ($6,38 for a dozen 19,5 x 24 inch boards). Surprisingly, canvas mounted on stretchers are only slightly more expensive than the academy boards ($7,50 for a dozen 18 x 24 inch boards) (Fig. 11) (Goupil & Co. 1857).

[3] During the 19th century, a new system of standard sizes for oil paintings on canvas was introduced in France. The system included three different formats; figures (F), landscape (paysage, P), and marine (M). The sizes range from 0 (toile de 0) to 120 (toile de 120), with 20 sizes for each format (Dinh Dang 2015).



12 *Materials for Painting in Oil Colors.*

MILLBOARDS AND PANELS.

ENGLISH MILLBOARDS. FRENCH MILLBOARDS. PANELS.

Inches.	PLAIN. Per doz.	Tolle.	Inches.	PLAIN. Per doz.	GRADUATED. Per doz.	PLAIN. Per doz.
8×10	$3 75	1—	6½ × 8½	$2 63	$4 50	$3 00
10×12	5 25	2—	7½ × 9½	3 00	6 00	3 75
10×14	6 38	3—	8½ × 10½	3 38	7 50	4 50
12×14	7 50	4—	9½ × 13	3 75	9 00	5 25
12×16	9 00	5—	10½ × 14	4 50	10 50	6 38
14×18	12 00	6—	12½ × 16	5 25	12 00	7 88
14×20	13 50	8—	15 × 18	6 75	12 00	9 75
16×20	15 00	10—	18 × 21	9 00	15 00	
18×24	24 75	12—	19½ × 24	12 00		
		15—	21½ × 26	15 00		

FRENCH SKETCHING OR ACADEMY BOARDS,

AND PAPERS.

SKETCHING BOARDS.

Tolle.	Inches.	Per doz.
1—	6½ × 8½	$1 13
2—	7½ × 9½	1 31
3—	8½ × 10½	1 50
4—	9½ × 13	2 06
5—	10½ × 14	2 63
6—	12½ × 16	3 38
8—	15 × 18	3 75
10—	18 × 21	5 25
12—	19½ × 24	6 38
15—	21½ × 26	7 50

SKETCHING PAPERS.

	Inches.		Per doz.
Grand Aigle,	30×42,	Coarse grain,	$3 38
"	30×42,	Grey tint,	3 38
"	30×42,	Fine grain,	3 00
Half size,	15×21,	"	1 50
"	15×21,	Coarse grain,	1 69
"	15×21,	Grey tint,	1 69

PINE WOOD DRAWING BOARDS.

Mahogany and Pine Frames, assorted sizes, *see page* 55.

10 *Materials for Painting in Oil Colors.*

PREPARED ENGLISH CANVAS,

MOUNTED ON STRETCHERS.

SIZES. Inches.	PLAIN. SQUARE. per doz.	PLAIN. OVAL. per doz.	ROMAN. SQUARE. per doz.	ROMAN. OVAL. per doz.
8×10	$3 75	$9 00	$4 13	$9 38
9×12	3 75	9 00	4 13	9 38
10×12	4 50	9 75	4 88	10 13
10×14	4 50	9 75	4 88	10 13
12×14	5 25	10 50	5 63	10 88
12×15	5 25	10 50	5 63	10 88
12×16	5 25	10 50	5 63	10 88
12×18	5 25	10 50	5 63	10 88
14×17	6 00	11 63	6 38	12 00
14×18	6 00	11 63	6 38	12 00
14×20	6 00	11 63	6 38	12 00
16×20	6 00	11 63	6 38	12 00
17×21	6 75	12 75	7 13	13 13
18×24	7 50	14 25	7 88	14 63
20×24	7 50	14 25	7 88	14 63
22×27	8 25	15 00	8 63	15 38
22×30	9 00	16 50	9 38	16 88
25×30	9 00	16 50	9 38	16 88
24×32	10 50	18 00	11 25	18 75
24×34	10 50	18 00	11 25	18 75
27×34	10 50	18 00	11 25	18 75
26×36	12 00	21 75	12 75	22 50
27×36	12 00	21 75	12 75	22 50
29×36	12 00	21 75	12 75	22 50
30×40	15 00		16 50	
30×42	16 50		18 00	
30×44	18 00		19 50	
34×44	19 50		21 00	
36×42	19 50		21 00	
40×50	24 00		25 50	

Extra and special sizes made to order.

Fig. 11. Images from Goupil & Co. price catalog from 1857. On the left page, English and French millboards, as well as academy boards, are listed. On the right page, prepared canvas mounted on stretchers are listed (Goupil & Co. 1857).

2.3.2. Conservation Issues

As in any artistic practice, the choice of materials and the process of preparation affects the quality of the outcome. Cardboard can be a good support for oil paintings, if it is of good quality. If the cardboard is sized and covered in a ground, the paint layers are less likely to suffer from cracking and chipping. If a layer of varnish is applied, the painting will be more protected from abrasion and dirt. In ideal conditions, cardboard does not warp or crack and it should not be affected by humidity. However, as demonstrated in the discussion about matt painting, these steps have often been consciously ignored by artists. Furthermore, while high-quality cardboard can be found, it is often made of waste paper of low quality. It is very common that oil paintings on cardboard are severely degraded (Banou, Alexopoulou & Singer 2015; Elfeky & Hassan 2008).

In oil paintings on cardboard, there are two main problems that are cited. One is the dynamics between the layers, both within the media and between the media and support. The other is the degradation of the cellulosic paper support. In a study on the aging and deterioration of oil-painted Fabriano paper and cardboard, results show that cardboard is more sensitive to thermal and UV aging than paper, resulting in loss of strength (Elfeky & Hassan 2008). Paintings on cellulosic supports are by nature complex due to their heterogeneous composition and structure. The presence of the acidic oil binder is often problematic as it can cause discoloration and mechanical deterioration of the paper support (Banou, Alexopoulou & Singer 2015). The most common problems of oil media on paper supports are absorption of the oil which causes staining, diffusion of the oil around the paint areas, discoloration of the support as a result of the absorption, and poorly bound paint layers. The problem of diffusion is less apparent in cardboard than in paper, due to the thickness of the material. However, there is risk for delamination of the cardboard, due to the loss of cohesion between the layers in the board (Banou & Singer 2016). When oil is applied to a cardboard support, it penetrates the fibrous structures and

eventually dries. Upon drying, the oil turns into a solid form, filling the pores in the cardboard. This leads to a changed structure in the board and may affect the ageing. The cardboard often becomes acidic, and both the oil and the cellulose in the cardboard can oxidize (Banou et al. 2016). Oxidation results in fragility, embrittlement, and loss of mechanical strength. The loss of mechanical strength seems to be enhanced by the presence of wood fibers in the paper support. High temperature and humidity can influence hydrolysis of oil, which in turn speeds up the oxidation (Banou & Singer 2016).

Absorption is likely affected by the drying of the oil. Oils are mixtures of fatty acids, and the process of drying is extremely complex, but the transformation from liquid to solid film occurs when the oil is exposed to oxygen, triggering a free radical chain reaction, or a cross-linking. Various factors influence the drying reaction, such as the thickness of the oil- and paint layer, and exposure to light, temperature, and humidity (Mills & White 1994). Specific pigments also affect the speed of drying, for example pigments containing zinc or lead speed up the drying process, while some black pigments have been shown to slow drying. The type of oil itself also factors in, as they have different inherent drying speeds. For example, linseed oil dries more rapidly than poppy seed oil (Banou & Singer 2016). Slow drying can lead to increased absorption of oil on the paper support. The absorption does not seem to be affected by the manufacture process or fiber content of the paper support, as these problems are frequent in all sorts of paper supports. However, the thickness and porosity of the support, as well as sizing and additives in the pulp, are influencing factors on the absorption (Banou & Singer 2016).

Treating oil paintings on paper supports is a problematic area in conservation. The deterioration associated with these objects can be closely related to that of oil paintings on canvas. Historically, oil paintings on cardboard have been treated as oil paintings on canvas, by easel painting conservators. The treatments often include surface cleaning, partial or complete removal of the varnish layer, and consolidation of the painting layers. Sometimes paintings on cardboard have been lined with canvas, possibly after removing some of the layers of the paper support, followed by retouching. Conservation materials used in the treatments have primarily been materials used in painting conservation. These treatments have, generally, been conducted with the paint layer as the primary focus. The paper support has often not been taken into consideration. In the study by Banou, Alexopoulou and Singer (2015), a painting conservator stated that it has been common to attempt to remove the paper support to a large extent, and to replace it with canvas. Another important aspect of the conservation of cardboard painting is that, historically and to some extent even today, canvas paintings have been considered of higher value than cardboard paintings. This is a contributing factor to how the paintings have been treated, and why conservators have attempted to remove the paper support (Banou, Alexopoulou & Singer 2015).

In the last decades, the issue of treating oil paintings on cardboard has gained attention. It has gradually transitioned toward the field of paper conservation, where treatments have been adjusted to include materials that have been developed and used for paper conservation. The removal of oil stains in the paper support has also been raised as an issue, with different methods tested. The absorption of oil in the paper is the most serious cause of deterioration, and has historically been overlooked (Banou, Alexopoulou & Singer 2015).

3. Analysis Methods

Several analytical methods are used in this study, all providing different and often complementary information about WL84. These complementary methods are based on the use of imaging, portable instrumentation for in-situ analysis and the analysis of microsamples.

3.1. Analytical Imaging Methods

Imaging methods are an important tool in art conservation, both for their potential for revealing hidden information such as underdrawings and retouching, as well as identifying materials. Imaging methods are considered safe and non-invasive, and can be used in situ, as long as radiation is kept to a minimum (Cosentino 2015). This study used raking light photography, ultraviolet (UV) fluorescence photography, and infrared (IR) reflectography. Raking light photography can provide information about texture and distortion that can otherwise be difficult to see and record in regular diffuse light. UV and IR photography both provide information about an object based on the behavior of paint and varnish in different regions of the electromagnetic spectrum (Stuart 2007).

When UV radiation is used to illuminate a material, molecules or atoms in this material may absorb, transmit, or reflect the radiation. When absorbed, electrons in the molecules or atoms may be consequently excited to a higher state. When they thereafter relax back into their ground state, they can emit a photon, which has a specific energy that is the difference in energy between the excited state and ground state. This energy is often manifested in the form of visible light, often referred to as UV fluorescence. The fluorescence observed under UV illumination mainly comes from the top highly absorbing layer in paintings, and is rarely affected by the underlying layers (Cosentino 2015). Both organic and inorganic pigments emit characteristic fluorescence which can be used to identify or localize them (Stuart 2007). It is important to note that the presence of many compounds in a small area, as is often the case in paintings, affects the results of the spectral emission. The presence of varnish also strongly affects the results for UV fluorescence, as varnish often has a strong fluorescence that may change with time (Cosentino 2015). Additionally, impurities in the materials can emit strong fluorescence, and some substances can affect the results by absorbing or quenching the fluorescence for other substances (Stuart 2007). All of these factors should be taken into consideration when interpreting the results. UV fluorescence photography is considered a complementary technique for identification, as the results are neither quantitative nor conclusive (Cosentino 2015).

In IR reflectography, radiation is reflected from the painting, in contrast to the excitation of electrons as seen in UV fluorescence. A different range of the electromagnetic spectrum is employed (800 – 2000 nanometers (nm) for IR and 10 – 400 nm for UV). While UV is mainly absorbed by the top layers of a painting, IR penetrates many pigments, with the exception of dark pigments like charcoal and graphite. It is in fact the reflected image produced from the ground or paper that is recorded in IR reflectography (Stuart 2007).

In this study, UV fluorescence photography was performed with Mercury 365 nm UV lamps from Art Innovation instruments using a multispectral camera (see below). For the examination, the painting was placed on an easel and the room was made completely dark (Fig. 12). IR reflectography (IRR) was performed with an Artist Camera, a multispectral imaging system, from Art Innovation, with a low resolution 5 megapixels (MP) Panchromatic CMOS sensor with a Schneider Kreuznach Xenoplan 1.4/23 CCTV-lens (400-1000 nm). The camera was calibrated on a 17% grey card. Images were captured in Infrared 1 (IR1) and Infrared 2 (IR2). A ‘mosaic imaging’ function was used to acquire multiple images across the surface of the painting. With mosaic imaging, overlapping images are captured in several rows and columns, which can then be stitched together using image processing programs. In this study, Adobe Photoshop CS5 Version 12.0 was used. By using this function, a high-resolution image of the whole painting could be obtained. The results of the imaging methods are shown and discussed in *4.1. WL84: Structure, Technique, and Condition*, and in *4.3. Varnish Identification*. The IR images did not provide much information and are only shown on one occasion in *4.1. WL84: Structure, Technique, and Condition.*

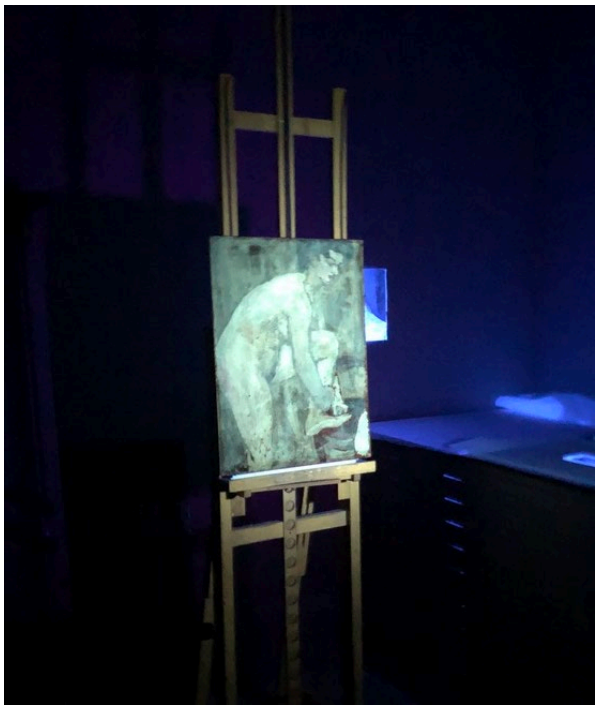


Fig. 12. UV photography of WL84 at GMA: the painting is placed on an easel in a completely dark room.

3.2. Macro Images and Optical Microscopy

Visual examination and close observations of an object with the help of a microscopy provide critical information. In this study, the painting was closely studied through a microscope throughout the investigation (Fig. 13). Macro images were captured with a Leica M80 routine stereo microscope, with a maximum magnification of 60x (Leica Microsystems 2020a).

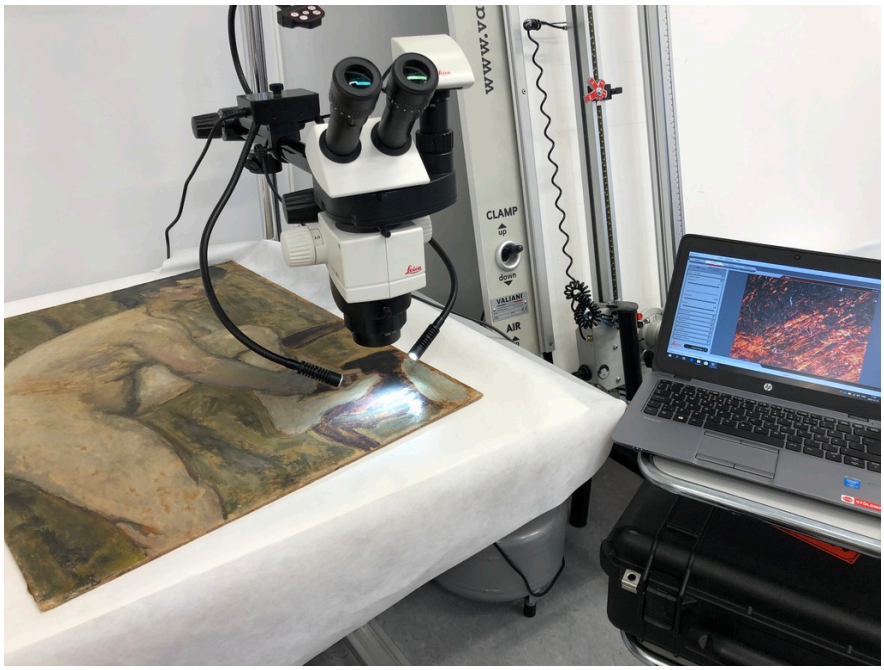


Fig. 13. Examination of WL84 under stereo microscope, at GMA.

Additionally, optical microscopy was used for analysis of the fiber samples. Fiber identification was performed using a Leica DM2700 upright light microscope (Leica Microsystems 2020b). A few fibers from a sample of the cardboard were dispersed on a microscopy slide, sometimes using a drop of water to separate them. The results of the fiber identification can be seen in *4.4.1. Fiber Identification*.

3.3. Microchemical Testing and Acidity Measurement

Microchemical spot testing is carried out with a small sample from the object that is reacted with chemical reagents. Based on the reactions of the testing, conclusions can be drawn about the composition of the material (Meyer 1990). The lignin content in the cardboard was evaluated by performing a Phloroglucinol stain spot test. For this test, a small sample of the cardboard was used. If lignin is present in a sample, a magenta color develops when in contact with the Phloroglucinol. The intensity of the color indicates the amount of lignin (Meyer 1990). The stain was prepared by dissolving 0,1 g phloroglucinol in 5 ml methanol. 5 ml deionized water was added to the mixture, followed by 5 ml concentrated hydrochloric acid. Before performing the test on the cardboard sample, the reliability of the stain was successfully tested by applying it to two different papers, one that was expected to have no lignin and one that was expected to have at least some amount of lignin. The cardboard sample was placed on a microscope glass and the fibers were slightly separated. One drop of the stain was added to the sample, and excess liquid was removed with filter paper. The results of this test can be seen in *4.4.2. Lignin Test*.

To test the acidity of the cardboard, an Abbey pH Pen from Bookkeeper was used on a small sample of the cardboard. This test is not precise and does not provide any specific pH levels, but it is a quick and efficient tool in determining if the material is acidic or not. In this case, the main inquiry was if the cardboard was acidic or not, rather than to determine the exact pH. The pen is used directly on paper, and if the paper is acidic, a pale yellow color will occur. A purple color indicates a neutral or alkaline paper (GMW 2020). The pen was tested on a control paper of archival quality, which should not be acidic. Microscope images were captured before and after testing on both the control paper and the cardboard sample. The results of this test can be seen in *4.4.3. Acidity Test*.

3.4. Spectroscopic Analysis

Spectroscopy is the analysis of the interaction between electromagnetic radiation and specific materials. The basic principle of spectroscopy is that atoms and molecules can be identified by characteristic emissions of energy levels caused by absorbed, emitted, or scattered radiation. Atomic spectroscopy provides information about specific elements, or atoms, and molecular spectroscopy provides information about molecules (Stuart 2007).

3.4.1. X-Ray Fluorescence Spectroscopy

X-ray fluorescence (XRF) spectroscopy is an atomic spectroscopy method that can be used to identify elements in a material, by recording characteristic fluorescence emission from specific elements after X-ray excitation. A photon is released from the X-ray source and penetrates the material, interacting with the atoms. As a result of the interaction, an electron from the inner K-shell leaves the atom. The vacancy in the K-shell is quickly filled by another electron from one of the outer shells. The K-shell has a lower energy level, so when an electron moves from a shell with a higher energy level to a shell with a lower energy level, excess energy is released. The energy is emitted as a fluorescent photon, and the amount of energy is characteristic of each element. Not only is the energy specific to the element, it is also dependent on which shell the electron moves from. In theory, an XRF spectrometer can detect all elements except hydrogen (H) and helium (He), but in reality, the detection of light elements is compromised by the presence of atmospheric gases that absorb the emitted X-rays and the low energy of the emissions. XRF is thus a method that is mainly used for identifying inorganic elements with atomic numbers above 13 (Mantler & Schreiner 2000).

XRF produces spectra, where elements are shown in distinctive peaks, called emission peaks. One element can produce several peaks. The location and intensity of the peaks are used to identify elements in the sample area. However, sometimes other factors affect the observed fluorescence, such

as the detector and hardware in the spectrometer, so the elements observed in the spectrum are not always from the sample itself. It is very common to detect small traces of minor elements in the spectra. These are known as trace elements and can originate from both the sample or the spectrometer (Bezur, Lee, Loubser & Trentelman 2020). Paints are often made up of mixed pigments, and the pigments can contain many different elements. With XRF, a pigment is often identified by its heaviest elements, but in cases where several pigments have the same heavy elements, it is recommended to consider the entire elemental composition that is reflected in the spectra. Identification of varnishes and binding media can generally not be conducted by using XRF, as they contain organic molecules and light elements. There have been many successful studies on pigment identification with XRF, and by using a handheld or portable spectrometer, it is possible to conduct non-invasive analyses. However, it is important to note that paintings are heterogeneous objects with a layered structure and paint areas of varying size, which can complicate the analysis (Mantler & Schreiner 2000).

In this study, XRF spectroscopy was used for semi-quantitative pigment identification. XRF spectra were captured using a portable Elio ED-XRF spectrometer with a Rhodium-source, from XG LAB (XGLab 2020). The spectra were captured in manual acquisition mode with a measurement time of 60,0 seconds, a voltage of 50 kV, and a current of 20 μA. Analysis points were marked out on a digital image beforehand. The points were divided by color. In total, 54 points were analyzed (51 on the recto and three on the verso) (Fig. 39 and Table 1). The painting was placed on a piece of non-woven fabric on a table with the XRF spectrometer situated above the painting, as close as possible without touching the surface. The spectrometer was held in place by a tripod, standing beside the table (Fig. 14). Whenever new areas were recorded, the painting was moved. By pulling on the non-woven fabric, the handling of the painting was kept at a minimum. Analysis of the spectra and attribution of peaks to specific elements was performed using the automatic assignment function of the Elio software (XGLab 2020).

Fig. 14. Setup for XRF spectroscopy of WL84 at GMA.

3.4.2. Fourier-Transform Infrared Spectroscopy

Fourier-Transform Infrared Spectroscopy (FTIR) is based on the recording of an infrared spectrum from specific compounds, and is a commonly used method for qualitative analysis and for identifying materials. When a molecule interacts with IR radiation, some of the radiation will be absorbed and some will be transmitted or reflected.

In FTIR, the spectrometer detector receives a signal from the reflected or transmitted radiation, in the form of a spectrum that is a molecular 'fingerprint' of the analyzed material. Each molecule has a unique spectral fingerprint (RTI Laboratories 2015). Most compounds have a unique and characteristic infrared spectrum, and identification is made by comparing the chosen spectrum with a reference spectrum. FTIR spectra may be strongly affected by oxidation and hydrolysis and factors such as age can influence the spectral bands (Mills & White 1994). FTIR is a common and effective tool for identifying organic materials in varnishes and paints (Ford, Rizzo, Hendriks, Frøysaker & Caruso 2019)

A common form of FTIR is Attenuated Total Reflection (ATR), where IR radiation passes through a transparent crystal and interacts with the sample a number of times before exiting and being collected by a detector (RTI Laboratories 2015). ATR-FTIR requires a physical sample of the analyzed material. When sampling is not possible, reflectance-FTIR can be used instead. With reflectance-FTIR, the spectrum of IR radiation that reflects form a surface is recorded, in this case the painting surface. Paintings usually have rough and uneven surfaces where the light is reflected in all directions, or diffusely. The detector in the spectrometer measures the reflectance of the scattered IR beam from the painting surface (Derrick, Stulik & Landry 1999).

In this study, both ATR- and reflectance-FTIR were used in order to obtain as much information as possible regarding the molecular composition of the varnish and paper support. Reflectance-FTIR spectra were acquired in Diffuse reflectance using a benchtop Bruker Alpha portable FTIR instrument. The acquisition parameters were as follows: Resolution 4 cm^{-1}, 60 scans, range 4000 - 400 cm^{-1}, RT-DLaTGS detector (Bruker 2020a). The spectrometer was placed on a table, with the painting standing on an easel beside the table (Fig. 15). The instrument was approximately 1 cm from the surface of the object. The easel on which the painting was placed could be moved up and down, which was helpful when accessing different analysis points on the painting. In total, 22 points were analyzed (18 points on the recto and four on the verso). The spot locations for the reflectance-FTIR can be seen in Appendix I.

Fig. 15. Setup for FTIR spectroscopy of WL84 at GMA.

For the ATR analysis, the same portable instrument was used but with a Platinum ATR single reflection diamond module. A very small sample of the varnish was placed on the crystal and compressed with the pressure applicator. A scan was run several times and showed similar results each time. The acquired spectra from both reflectance- and ATR-FTIR were compared in the OPUS

Spectroscopy Software to reference samples from the Infrared & Raman Users Group website (Bruker 2020b; IRUG 2020b). On some of the spectra, a Kramers-Kronig transformation was applied for legibility to convert reflectance spectra into pseudo transmittance spectra for comparison with the IRUG database (Derrick, Stulik & Landry 1999). The results of the FTIR analyses can be seen in *4.3. Varnish Identification.*

4. Investigation

In this chapter, the technical investigation conducted on WL84 is presented. In the first part, the structure, technique, and condition of the painting will be discussed. The second part discusses the pigment identification, which is followed by the varnish identification. Lastly, the analysis of fibers, lignin, and acidity tests of the cardboard support are presented.

4.1. WL84: Structure, Technique, and Condition

Assessing and describing the technique and condition of WL84 is complex, as it is sometimes difficult to distinguish damage from technique. The painting is overall stable but a closer look reveals many concerning issues in terms of condition.

In some areas, thin gray lines are visible underneath the paint layer, most noticeable in the area featured in Fig. 16a-c. The lines are visible in regular light (Fig. 16a) but stronger in UV light (Fig. 16b), and almost invisible in IR (Fig. 16c). The lines could be part of an underdrawing made with what appears to be pencil. However, pencil lines should be visible in IR, if they are carbon based (Stuart 2007). The UV image also shows three dark lines on the woman's foot, which are not visible in regular light (Fig. 17a-b).

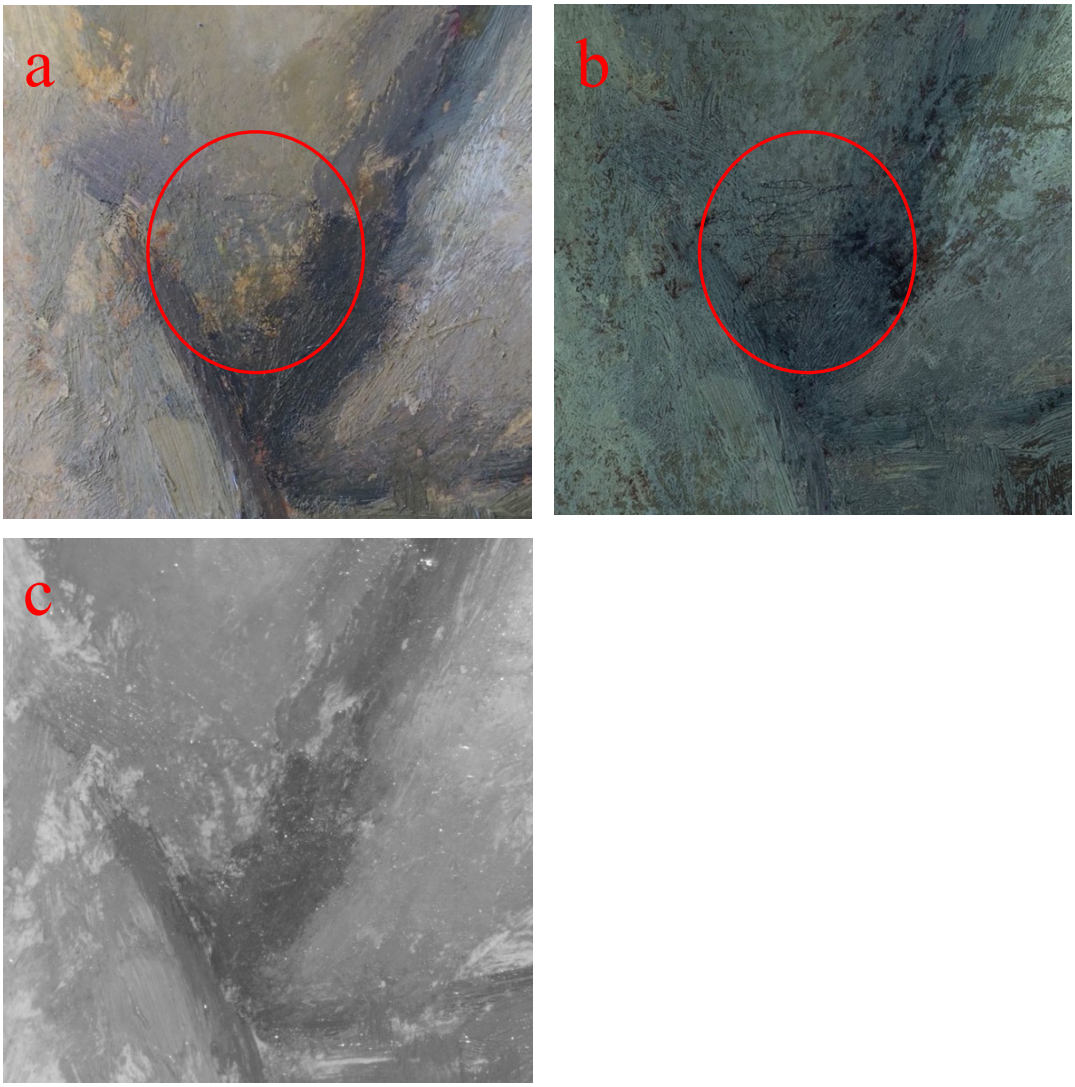


Fig. 16a. Image of area with gray lines, indicated with red circle. In regular light, the lines are visible but not very clear.
Fig. 16b. UV image of area with gray lines, indicated with red circles. In UV, the lines are clearly visible.
Fig. 16c. IR1 image of area with gray lines. In IR, the lines are barely visible.

Fig. 17a. UV image of area with three dark lines, only visible in UV.
Fig. 17b. Same area as 18a but in regular light, where the three dark lines are not visible.

Overall, the paint is applied in seemingly rapid and imprecise brush strokes. The brush strokes are clearly visible in the paint layers (Fig. 18) and it appears that Bonnard used several brushes of varying width, with finer brushes for the more detailed areas. In most areas, the paint is applied in quite thin layers, but there is pastose paint in specific areas. In Fig. 18, both thin and pastose areas are visible. Occasionally there are thin indentations where the paint has been 'scraped', possibly with the end tip of a paint brush or with a palette knife (Fig. 19). The unevenness of the paint layer is clearly visible in raking light (Fig. 20).

Fig. 18. Detail image of brush strokes visible in both thin and pastose areas of paint.

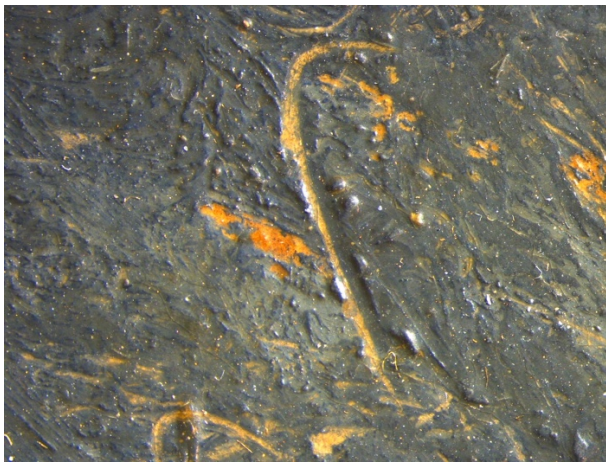


Fig. 19. Macro image (magnification 7.5x) of indentation in the paint layer, possibly from palette knife.

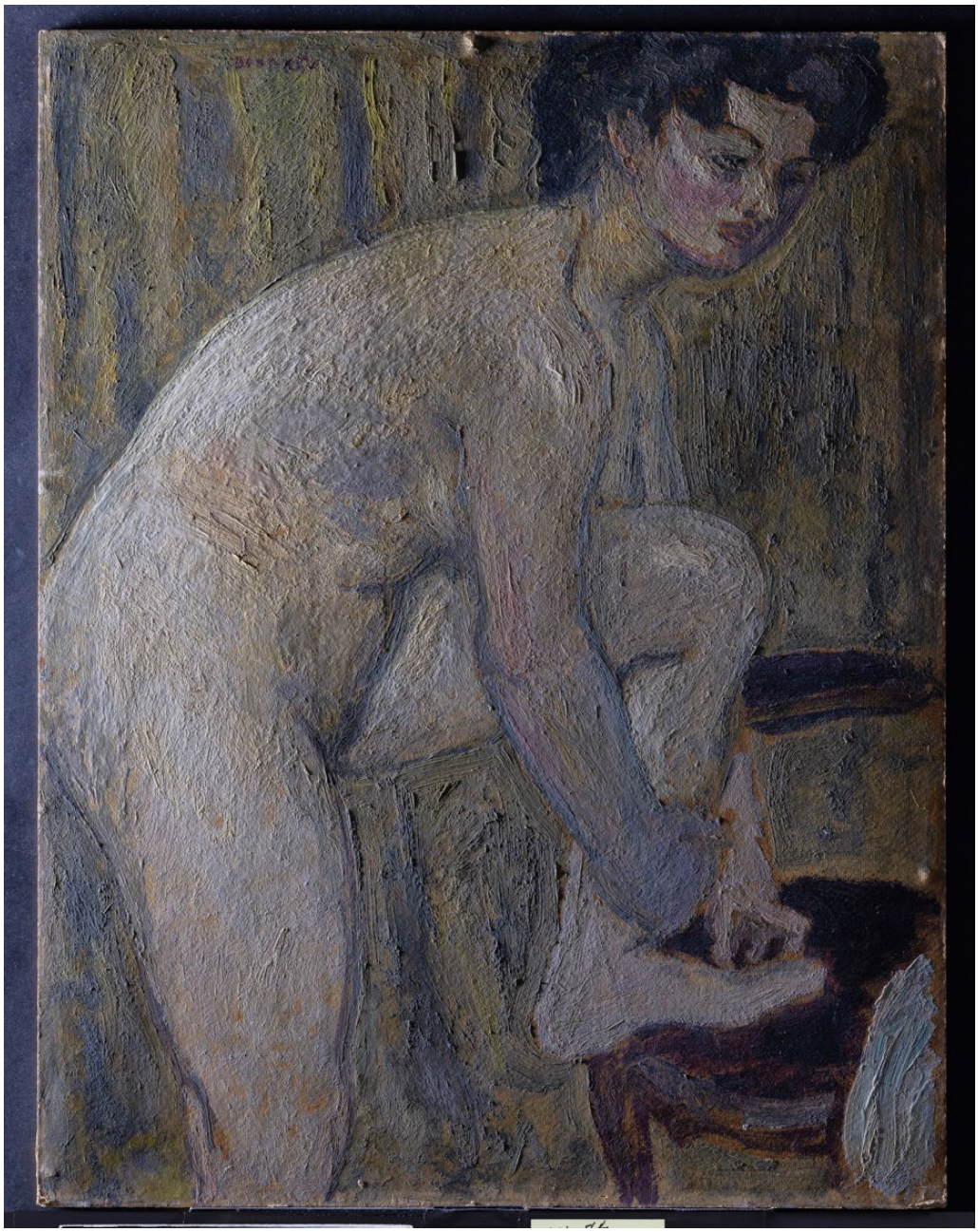


Fig. 20. Raking light image of WL84. The unevenness in the paint layer is more visible in raking light. Photo: Hossein Sehatlou, GMA.

The cardboard is exposed in many places, which is probably a result from both painting technique and damage. The paint is applied in thin washes, and built up in layers. Additionally, some areas appear to be completely unpainted, especially along the edges (Fig. 21). The unpainted areas and the thin washes of paint are most likely due to Bonnard's painting technique; using what appears to be an unprimed cardboard as a color or effect in itself. However, some of the exposed areas appear to be a result of pigment loss. In some of these places there is a clear edge on the paint layer, where it is obvious that the paint has been chipped or flaked off (Fig. 22). In other areas where the cardboard is exposed, it is difficult to determine if there is pigment loss or if there is simply no paint applied (Fig. 23). Bonnard might have used thick, dry paints with more pigment than binding media in order to achieve a matt effect, and the paint binder could also have been absorbed by the cardboard. If so, the result could be a patchy layer of paint with many small unpainted areas.

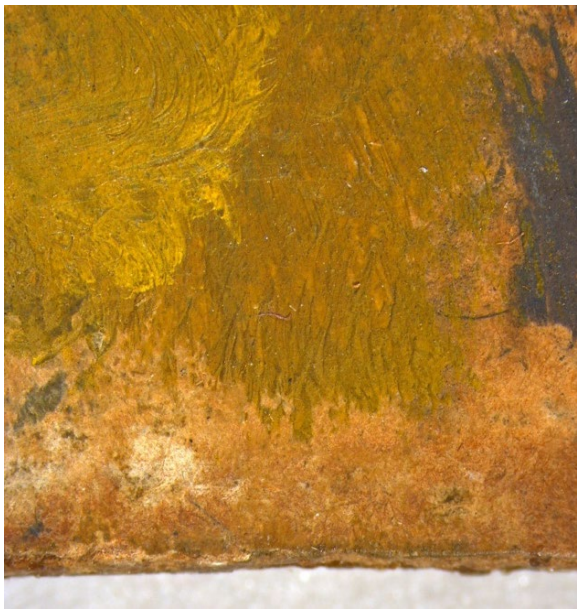


Fig. 21. Macro image (magnification 7.5x) of edge, where the cardboard can be seen without any paint layer.

Fig. 22. Macro image (magnification 7.5x) of area with pigment loss, where the paint appears to be chipped off. Varnish seems to be present even in area of loss.

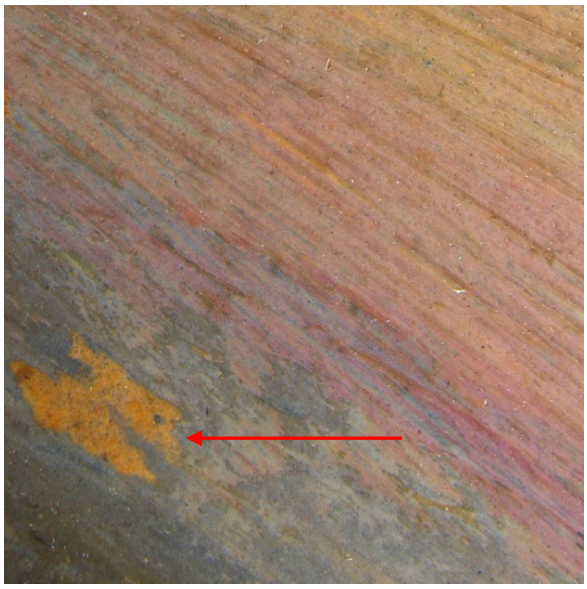


Fig. 23. Macro image (magnification 7.5x) of area where the exposed cardboard can be seen but where it is not clear if it is due to pigment loss or not.

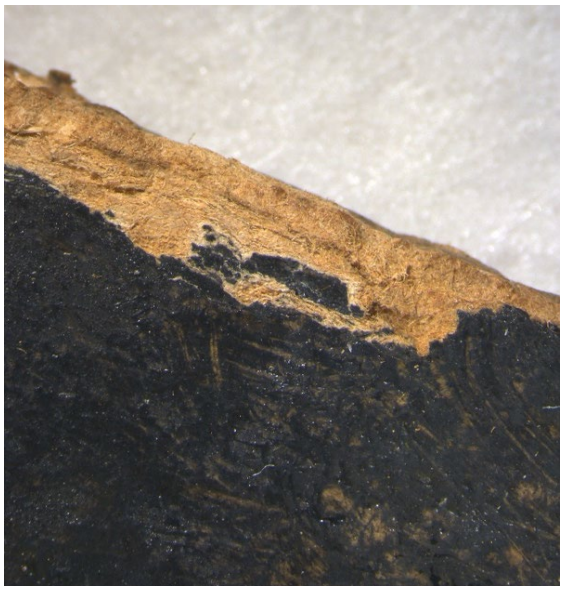


Fig. 24. Macro image (magnification 7.5x) of edge where there is both pigment and fiber loss, due to flaking cardboard.

There is some flaking of the paint and cardboard along the edges (Fig. 24). In the lower, right corner, there is a stain with clear tidelines (Fig. 25). Occasionally, there are dents and abrasions in the cardboard, for example under the woman's chin (Fig. 26). There are many brown stains throughout the painting, mostly in the exposed areas of cardboard. Two areas where the staining is particularly distracting are in the lower left leg (Fig. 27) and the face of the woman (Fig. 28). The stains are dark brown and are situated all over the cardboard, but are more frequent on the standing leg, around the chair and hands, and in the woman's face. Not all areas of exposed cardboard are stained. In the upper left part of the painting, there are several brown areas which are similar to the brown stains, but upon closer inspection it is evident that there is actually brown paint on the surface (Fig. 29). Whether this effect was intentional or not is not clear; it is possible that these areas have become discolored over time.

Fig. 25. Macro image (magnification 7.5x) of stain in the cardboard with clear tidelines.

Fig. 26. Macro image (magnification 7.5x) of dent in cardboard and paint layer.

Fig. 27. Detail image of left leg and knee, where there are many brown stains in the cardboard.

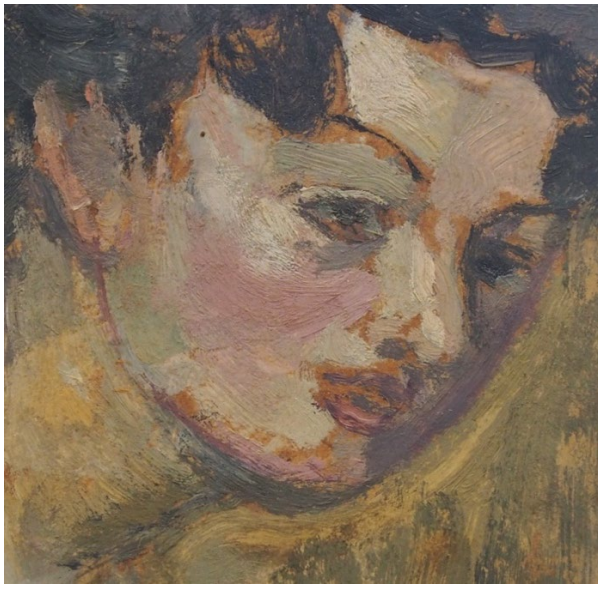


Fig. 28. Detail image of face, where there are many brown stains in the cardboard that are visible in unpainted areas.

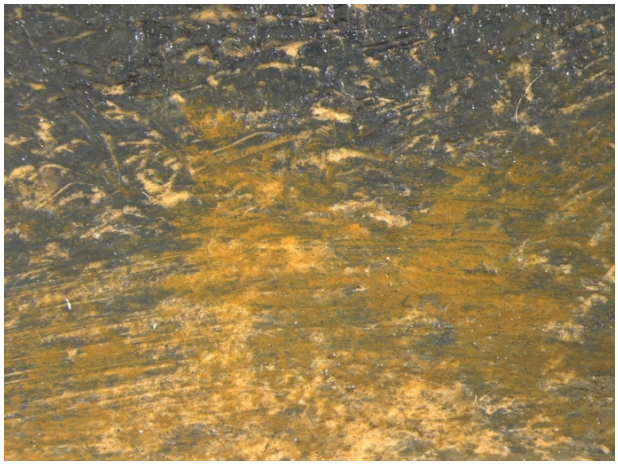
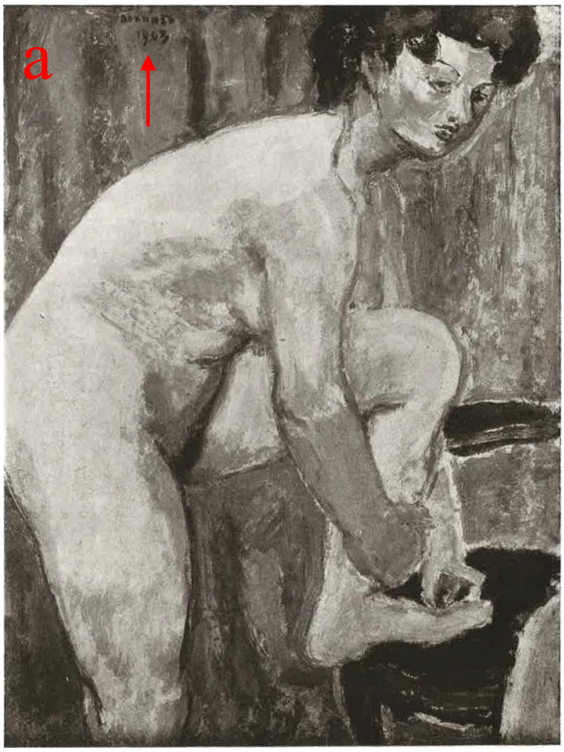
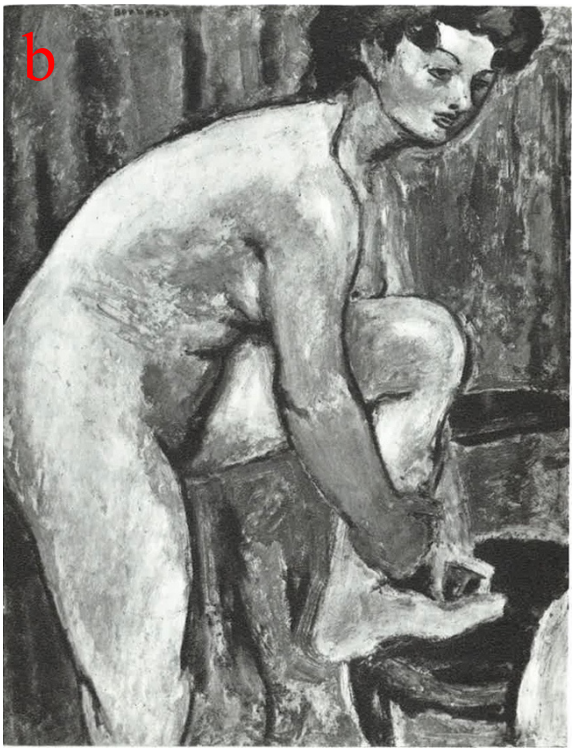


Fig. 29. Macro image (magnification 7.5x) of a greenish area that looks like staining at first appearance, but where macro images clearly reveal that it is a layer of brown/yellow paint.





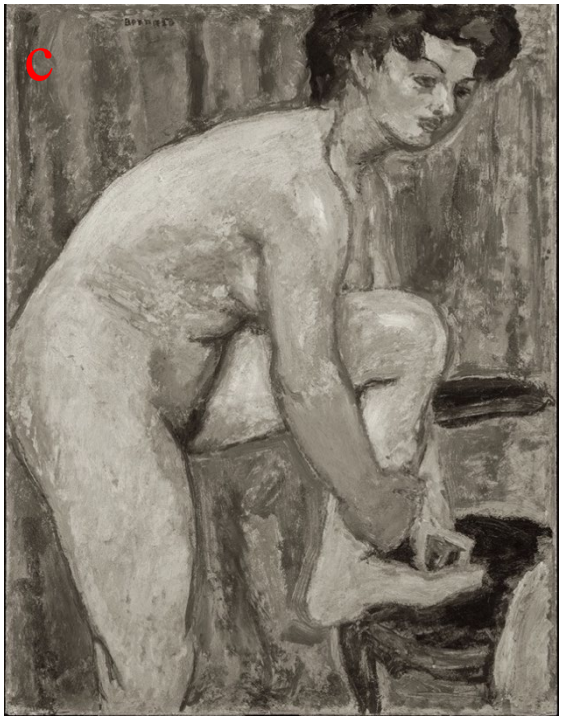


Fig. 30a. 1923 photo of WL84. The date '1903' can be seen under the signature, marked with red arrow.
Fig. 30b. 1955 photo of WL84, where the date is no longer visible.
Fig. 30c. WL84 in current state but in grayscale. Photo: Hossein Sehatlou.

The 1923 and 1955 photographs of WL84 (Fig. 30a & b), while not of very good quality, provide some information on the deterioration of the painting. The unpainted areas which are dark and stained in the current condition appear to be very bright in the 1923 photo. The unpainted areas which are not stained in the current condition (Fig. 30c) do not have the same bright appearance in the 1923 photo. This might suggest that in the original condition, the stained areas were covered by something, perhaps paint. The difference is especially striking in the woman's face; the eyes are much darker and duller in the current condition. In the 1955 photo, some of the darkening around the eyes and in the

face appears to have already occurred. There also seems to be some staining on the body, but not to the same extent as the current state. It is clear that the painting has undergone some form of degradation since the 1923 photo, but there does not seem to be any great difference in the paint layers. The paint appears to be uneven, just as it is in the current state. This suggests that either pigment loss had already occurred when the 1923 photo was taken, or that the uneven paint layer is deliberate. In Fig. 30a-c, all three stages of the painting are compared. Fig. 30c features the painting in its current state but in a grayscale.

Another notable difference in the photos is the presence of a painted date, '1903', underneath the signature in the 1923 photo. It appears to be painted on with the same color of paint as the signature. In the 1955 photo, the date is not visible. In the painting's current state, the date is almost invisible with the exception of a very vague one and nine (Fig. 31). Records at GMA state that the date has been painted over, but it is not mentioned if this was done prior to or after being acquired by the museum. In UV radiation, the area underneath the signature is completely dark, emitting no fluorescence (Fig. 32). This means that there is probably no varnish on this particular area, or that something has been painted on top of the varnish layer.

Fig. 31. Detail image of signature and area under signature where the date '1903' has once been visible. A very vague one and nine can be seen under a yellow-green layer of paint.

Fig. 32. UV image of same area as in *Fig. 31*. In the area where the vanished date should be, no fluorescence is emitted from the surface.

The painting is varnished with a shiny, yellowed varnish. The shiny appearance varies in intensity (Fig. 33), and it seems as though the varnish layer is applied without much precision. Some areas appear to be completely matte and are probably unvarnished. The varnish is severely discolored, which is evident in the areas where the varnish layer is thick (Fig. 34 and Fig. 36a). In some of these thicker layers, the varnish also appears to be suffering from craquelure (Fig. 35). In places, the varnish appears to have dripped while it was still wet (Fig. 36b). In the areas where there is possible pigment loss, there appears to be varnish (Fig. 22). This suggests that the varnish was applied after pigment loss had occurred, possibly as a means to protect the painting once pigment loss was noticed.

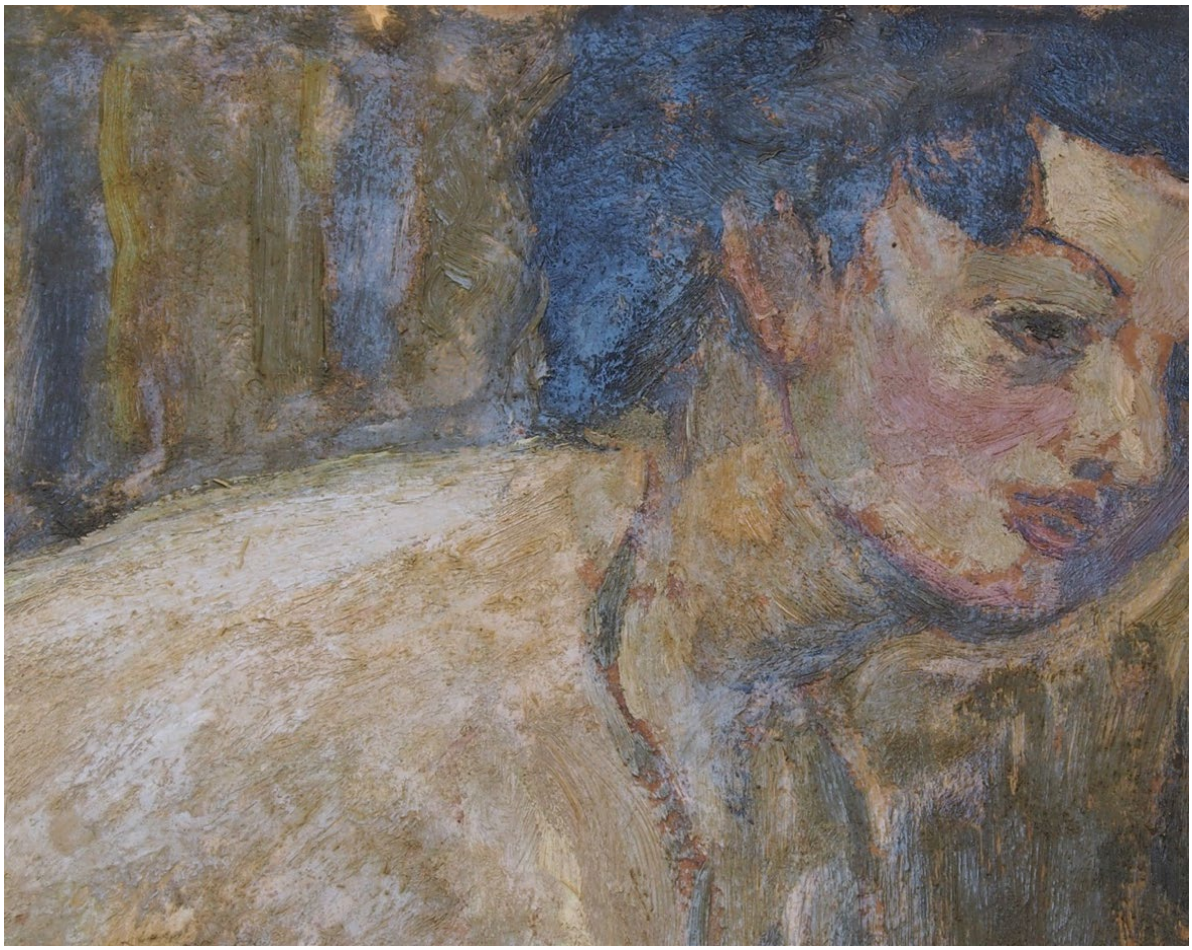


Fig. 33. Detail image where the unevenness of the varnish can be seen on the surface. The shiny appearance is very varied.

Fig. 34. Macro image (magnification 7.5x) of area with thick layer of varnish in the furrows left by the brush. In these thick layers, the discoloration of the varnish is prominent.

Fig. 35. Macro image (magnification 7.5x) of area with thick layer of varnish, where obvious craquelure can be seen.

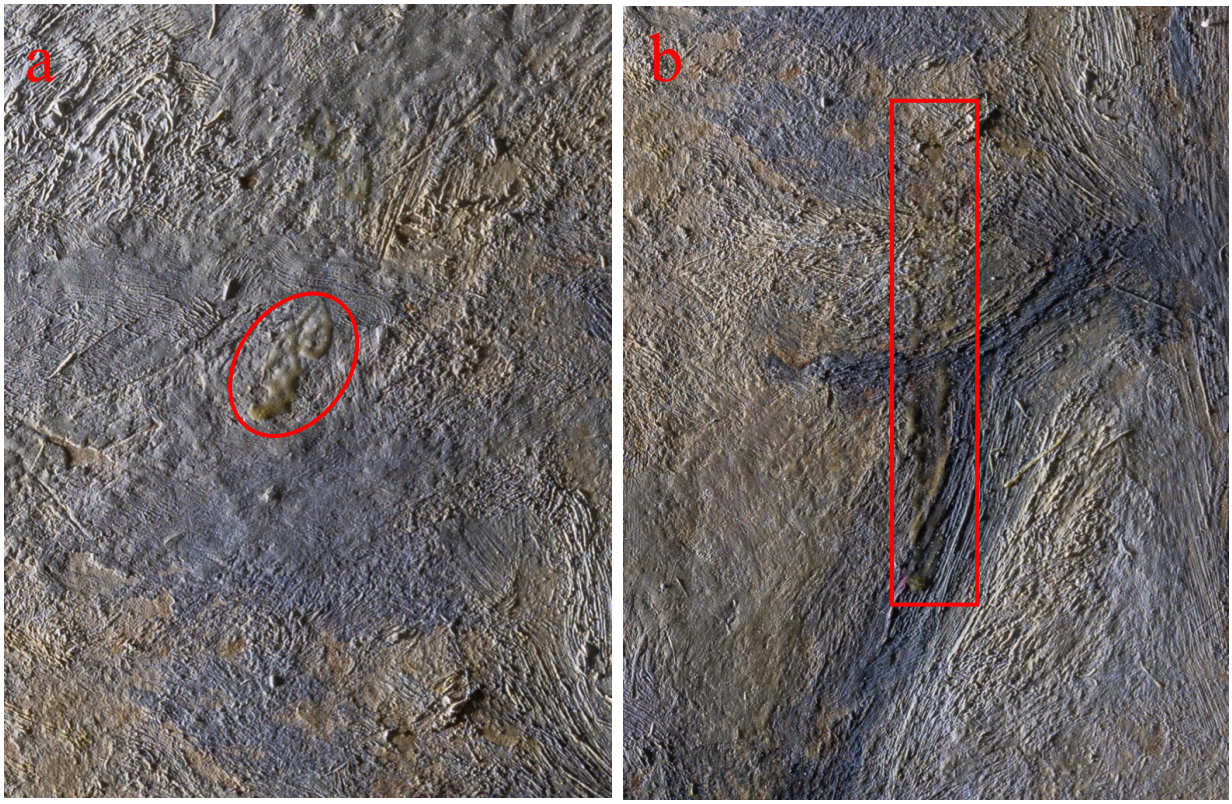


Fig. 36a. Detail image in raking light of area with thick layer of varnish.
Fig. 36b. Detail image in raking light of area where the varnish has run down along the surface.

The cardboard support is mostly intact but shows signs of degraded fibers. There is flaking along the edges and some delamination in the corners (Fig. 37 and Fig. 38). The structure of the cardboard appears to consist of layers of sheets pasted together. Fig. 38 shows the lower left corner of the cardboard, which appears to be abraded, probably due to mechanical handling. The fibers have a powder-like appearance and are sensitive to friction.

Fig. 37. Detail image of a corner of the cardboard, where there is slight delamination.

Fig. 38. Macro image (magnification 7.5x) of lower left corner of the cardboard, where the paper layers are abraded.

4.2. Pigment Identification

Five color groups are presented in the pigment identification; white, black, yellow, red, and blue. The spot locations for the XRF measurements are shown in Fig. 39, and the results are shown in Table 1. No pigment identification has been attempted in gray, beige, and brown areas, as they most likely consist of a mixture of several pigments. It is also worth noting that there are several elements which are present in most samples (e.g. zinc, calcium, iron, chromium, and traces of copper and nickel). Many of these elements are likely impurities in either the pigments or in the cardboard. Consequently, it is when there are elements that stand out that a more confident identification can be made.

Fig. 39. Spot locations for the XRF readings.

The most striking result of the XRF measurements is that there is zinc in all analyzed areas. In the white areas, the zinc peaks are even higher. This indicates that Bonnard has used a zinc-based white

pigment, which has also been used for mixing with the other pigments and may have been added to the paint as an extender. The abundancy of zinc in all areas makes for a difficult identification of other pigments, as the zinc content overshadows other elements. However, there are still conclusions that can be drawn based on the results. Two other elements that are notably present in almost all samples are calcium and iron. Both elements can be products of fillers in the cardboard, or additions to paint. Calcium is a commonly found in paper, usually in the form of calcium carbonate, $CaCO_3$ (Manso & Carvalho 2007). Calcium carbonate is also commonly found in pigments (Eastaugh, Walsh, Chaplin & Siddall 2008). The presence of iron can also be a result of the paper production, as corrosive metal ions can be introduced in the process of pulp beating (Strlič, Kolar & Scholten 2005). The XRF data shows that the peaks for iron and calcium are generally higher in the unpainted areas, which further supports the conclusion that they are elements of the cardboard.

Table 1. XRF results table with numbers for spot locations, a description of the spot location area, and list of the elements detected. The highlighted elements are those that are significant for the interpretation of the results. The elements which are not highlighted are trace elements, or are present in such low amounts that they cannot be considered significant.

Spot location	Description	Elements detected
x14	White paint	**Zn**, **Ca, Pb, Fe,** Ti, Ni, Co
x26	White paint	**Zn,** Cl, S, Ni, Fe, Co
x30	White paint	**Zn,** S, **Ca, Pb, Fe,** Ni, Co
x34	White paint	**Zn,** S, Ti, Ni, Fe, Co
x46	White paint	**Zn,** S, Ni, Fe, Cr, Co
x11	Black paint	**Zn, Ca, Fe,** Cu, Cr, Ni
x20	Black paint	**Zn, Ca,** S, P, **Fe,** Cu, Ti, Cr, Ni, As
x37	Black paint	**Zn, Ca, Fe,** Sr, Cr, Ni
x41	Black / dark purple paint	**Ca, Zn, Fe,** Cu, Sr
x1	Dark gray paint	**Zn, Ca,** K, **Fe,** Ti, Ni, Nb
x13	Gray paint	**Zn,** S, **Ca, Fe,** Cr, Ni
x27	Gray paint	**Zn,** Cl, **Ca, Fe,** Ti, As, Ni, Cr
x9	Light gray / beige paint	**Zn, Fe, Ca,** Ti, Ni, Co, Cr
x32	Gray / beige paint	**Zn,** S, **Fe, Ca,** K, **Cd,** Ti, V, Ni, As
x25	Gray / beige paint	**Zn, Fe, Ca,** Ti, Ni, Cr
x15	Flesh tone / beige paint	**Zn, Ca, Fe,** Cu
x10	Flesh tone / beige paint	**Zn,** S, **Ca, Fe,** Ti, Ni, Co
x21	Beige / yellow paint	**Zn, Cd, Fe,** Sr, Ni
x2	Yellow / beige paint	**Zn,** S, **Cd, Fe, Ca,** Ni, Cr, Sr
x7	Yellow paint	**Zn, Cd, Fe,** Sr, Ni, Cr, Co
x44	Yellow paint	S, Cl, **Zn, Pb, Cr, Ca, Fe**, Sr
x5	Yellow / green paint	**Zn,** Cl, **Cd, Cr, Fe,** Pb, Ni, Mn
x4	Yellow paint on top of purple paint	**Zn,** S, Cl, K, **Fe, Cd,** Cr, Pb, Mn, Ni
x12	Flesh tone / pink paint	**Zn,** Cl, **Hg, Ca, Fe,** Ni, Co
x18	Pink paint	**Zn, Hg,** S, **Ca, Fe,** Ni, Co
x19	Pink / purple-ish paint	**Zn, Ca, Fe,** Ni, Co
x23	Pink /purple paint	**Zn, Hg,** S, **Ca, Fe,** Cr, Ni, Co, As
x31	Flesh tone / pink paint	**Zn, Hg, Ca, Fe**
x33	Flesh tone / pink paint	**Zn,** Cl, K, **Cd, Fe,** Ti, Sr, Ni, Cr
x3	Dark purple paint	**Zn, Fe, Ca,** Ni, Ti, As, Cr
x22	Purple paint	**Zn, Ca, Fe,** Cr, Ni
x36	Dark purple / black paint	**Zn, Ca, Fe,** Ni, Y
x45	Dark purple paint	**Fe, Zn,** Cl, **Ca,** Ni, Ti, Cu

x43	Purple paint	**Zn, Ca, Fe**, K, Ti, Sr, Cr
x35	Blue / purple paint	**Zn,** S, **Ca, Cr, Fe,** Ti, Ni, As, **Co**
x40	Blue / purple paint	**Zn,** Cl, S, **Ca, Cr, Fe,** Ni, **Co**
x28	Blue and brown paint	**Zn, Ca, Fe, Co,** Ti, Mn, As, **Cr**
x47	Light blue paint	**Zn,** S, **Cr, Co,** Ni, Fe
x49	Light blue paint	**Zn,** S, **Pb, Cu,** Ni, **Co,** Fe
x51	Light blue paint	**Zn,** Cl, S, **Ca, Cr,** Cu, Fe, Ni, **Co**
x29	Brown paint, maybe some blue	**Zn, Fe, Ca,** Tc, Ti, Pb, Cr
x42	Brown paint, maybe some blue	**Zn,** S, **Ca, Fe**, Ti, Sr, Cr
x24	Brown / gray paint	**Zn,** S, **Fe, Ca,** K, Ti, Pb, Cr, Ni
x8	Brown area (stain?)	**Zn, Fe, Ca, Cd,** Ti, Cr, Mn, As, Ni
x17	Brown area (stain?), exposed cardboard	**Ca, Zn, Fe, Cu,** As
x38	Brown area (stain?), exposed cardboard	**Ca, Fe, Zn,** Ti, Cu
x39	Brown area (stain?), exposed cardboard	S, **Ca, Fe, Zn,** Cu, Sr
x16	Area with thick layer of varnish, on flesh tone / beige-white paint	**Zn, Ca, Fe,** Ni, Ti, Co
x48	Area with thick layer of varnish, on white / blue paint	**Zn,** S, **Ca, Cu,** Fe, Ti, Cr, Ni
x6	Area without any apparent varnish, yellow paint	**Zn,** Cl, K, **Fe,** Tc, **Cd,** Cr, Pb, Ti, Ni, Mn
x50	Area without any apparent varnish, exposed cardboard	Si, **Ca, Fe, Zn,** Cu
	Exposed cardboard on verso	**Ca, Fe, Zn,** Sr
	Exposed cardboard on verso	S, **Ca, Zn, Fe**, As
	Exposed cardboard on verso	S, **Ca, Fe, Zn**

4.2.1. White Pigments

There are two main white pigments based on zinc: zinc white and lithopone. The presence of zinc in itself cannot be used as a sole identifier, as it is present in all areas. However, for WL84, the placement of the zinc lines in the XRF spectrum can be of use in identifying a white pigment. Zinc oxide reveals zinc lines at 8,65 (K_α) and 9,57 (K_β), which correlates with the captured spectra for white areas in WL84 (Fig. 40). Strengthening this hypothesis is the presence of cobalt in the analyzed white areas. Cobalt is a known impurity in zinc oxide and is revealed at around 6,9 (K_α) and 7,7 (K_β) (Larsen, Coluzzi & Cosentino 2016). Of all white pigments used for artistic and decorative painting, the three most used are lead, zinc, and titanium white. Zinc white, or zinc oxide, has been known as a material since ancient times, but was not used as an artist pigment until the end of the 18th century and was not in popular use until the middle of the 19th century. Zinc oxide can be used purely in paints or in combination with other pigments; it has often been added to colored pigments to brighten them (Feller 1986). Generally, zinc white has poorer hiding strength than lead white, but it has less tendency to yellow. To improve the hiding strength, zinc white has often been used in combination with lead white, and later titanium white (Osmond 2012). Zinc oxide in oil paints can become very brittle over time. However, the addition of lead white usually lowers the risk of embrittlement (Baty 2017). Lead is present in some of the white areas of the paintings (Table 1: spot location 14 and 30).

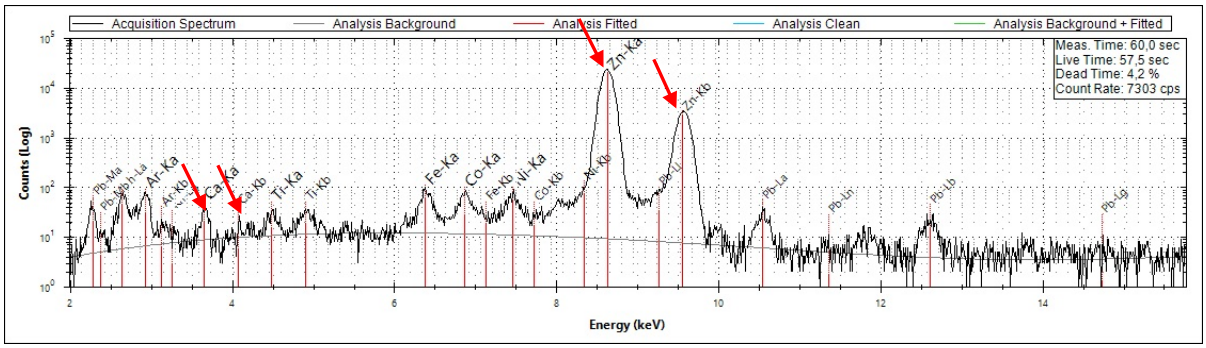


Fig. 40. Detail of XRF spectrum for white area (spot location 14). Zinc and calcium peaks are marked with red arrows.

4.2.2. Black Pigments

The spectra for the black areas do not show any characterizing elements. However, the absence of elements can be of help for ruling out commonly used pigments. For example, there are no manganese or magnesium peaks in the spectra, ruling out manganese black and spinel black (Eastaugh et al. 2008). The presence of iron could be indicative of a specific pigment, if iron were not present in most samples. The absence of any specific inorganic elements could indicate that the black pigment is organic, for example bone black or carbon black. In reference samples for bone black, there were trace elements of calcium, iron, zinc, and strontium (Larsen, Coluzzi & Cosentino 2016). All are present in the analyzed black areas in WL84, except strontium. On the other hand, there are both K_α and K_β lines for chromium (Fig. 41), which could indicate copper chromium iron oxide, or it could be iron zinc oxide (Larsen, Coluzzi & Cosentino 2016). Without further analysis, no probable identification can be given for the black pigment.

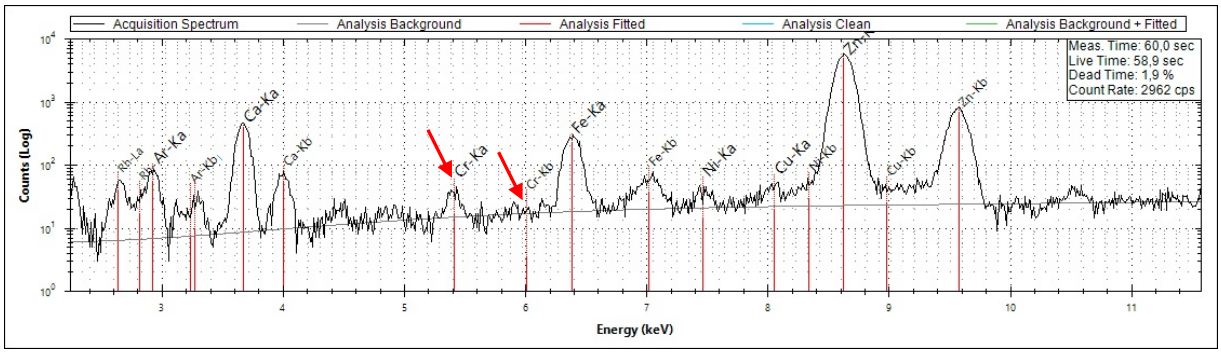


Fig. 41. Detail of XRF spectrum for black area (spot location 11). Chromium peaks are marked with red arrows.

4.2.3. Yellow Pigments

In all but one of the spectra for the yellow areas, cadmium is present at around 23 KeV (K_α) and 26 KeV (K_β), indicating cadmium yellow (Fig. 42). The area where no cadmium was detected is on the lower edge of the painting (spot location 44). Cadmium yellow, a paint based on cadmium sulfide, was widely used by artists in the end of the 19th century due to its high tinting strength and vivid hue. Cadmium sulfide was developed as a yellow pigment in the middle of the 19th century and by the 1920s it was in wide use, in several colors. It has become evident, over time, that cadmium yellow has a tendency to become severely degraded and discolored (Comelli et al. 2019). Degraded cadmium yellow paints can appear brownish or gray in color, or they can have become very powdery (Mass et al. 2012). The yellow areas in WL84 are all very dull and have the appearance of being very faded.

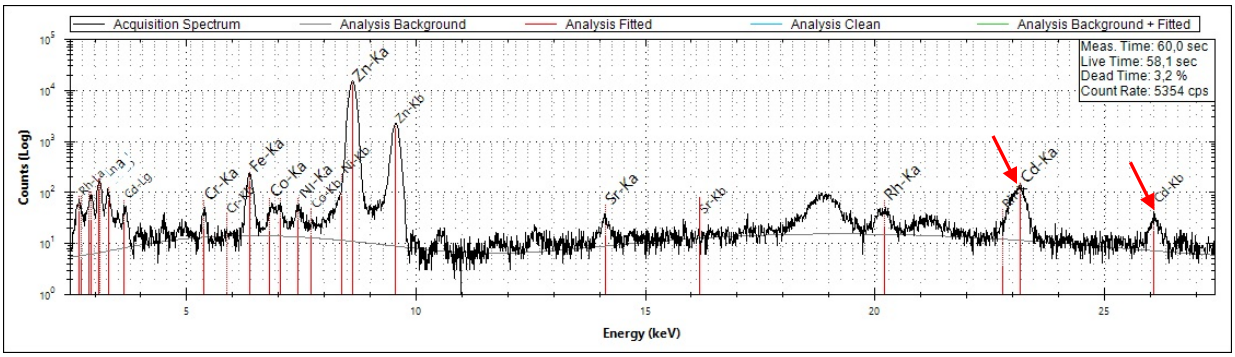


Fig. 42. Detail of XRF spectrum for yellow area (spot location 7). Cadmium peaks are marked with red arrows.

4.2.4. Red Pigments

There are no distinct red areas in the paintings, but there are many pink and purple tones. They have been categorized as red, as they would have to be based on a red pigment. The pink areas are mainly in the woman's face and arm. There are two different shades of purple in the painting; one pale, blue-ish purple along the edges of the face, mouth, and body, and one black-red purple on the chair. All of these areas appear to consist of mixed paints, evident in detail images of the woman's lower lip (Fig. 43) and of the purple chair (Fig. 44).

Fig. 43. Macro image (magnification 7.5x) of the woman's lower lip, where a mix of purple, red, and white pigments can be seen.

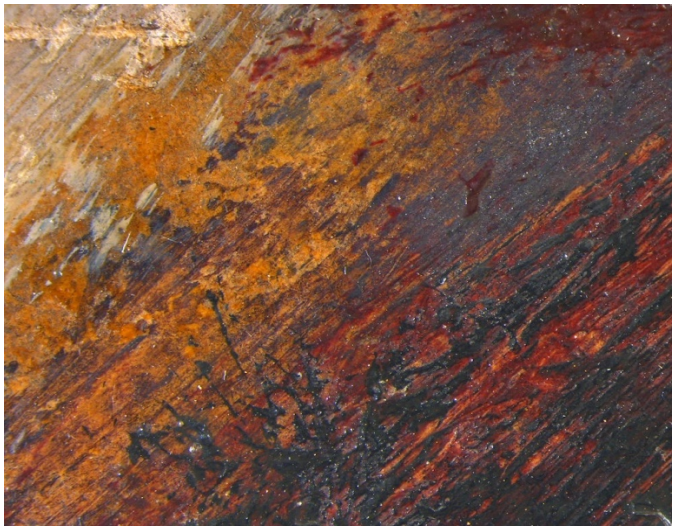


Fig. 44. Macro image (magnification 7.5x) of detail of the purple chair, where a mix of black, red, and blue-ish paint can be seen.

In most of the pink areas, mercury is present. In the XRF spectra, the mercury lines are identified at the L-lines: 10 (L_α), 11,8 (L_β) and 13,8 (L_χ) (Fig. 45). (Larsen, Coluzzi & Cosentino 2016). Mercury is not present in any of the other analyzed areas, including the purple areas, so it is highly likely that the red pigment in the pink areas is mercury-based. The most commonly used mercury-based red pigment is vermillion (mercuric sulfide). Vermillion exists as both natural and synthetic pigments. The natural pigment is derived from cinnabarite, a red mineral. Vermillion has often been used in combination with a white pigment to create rosy flesh tones in oil paintings. Synthetic vermillion is generally considered less stable than natural vermillion. The pigments is photosensitive and can turn black when exposed to sunlight (Nöller 2015). The XRF data from the purple areas does not show any characterizing elements apart from those which are present in most samples. This could indicate that the red pigment used in the purple areas is an organic pigment.

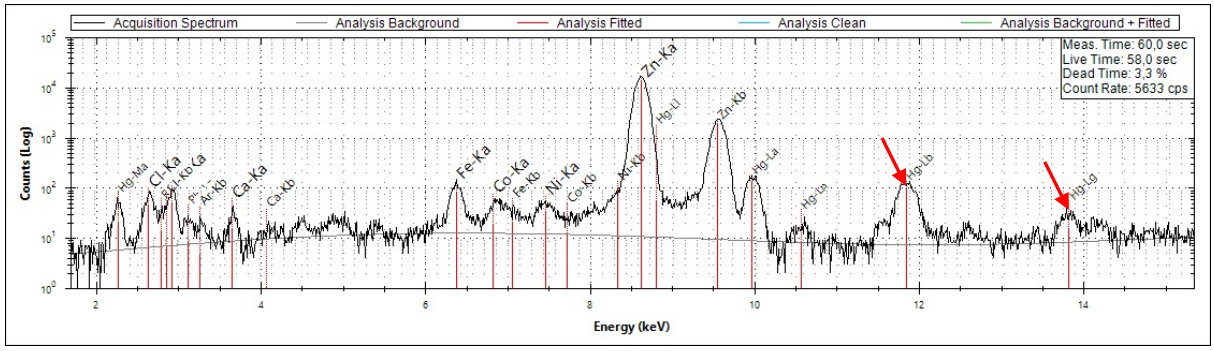


Fig. 45. Detail of XRF spectrum for pink area (spot location 12). Mercury peaks are marked with red arrows.

4.2.5. Blue Pigments

The blue areas consist of a light blue in the lower right corner of the painting, and a darker blue in some of the flesh areas as well as the background. The blue in the corner is bright, mixed with a white layer of paint and has an almost turquoise hue. The blue on the body and in the background is paler and duller. Based on visual appearance, they look like two different pigments, but all but one of the analyzed areas show similar spectra, with chromium lines at 5,4 (K_α) and 5,9 (K_β) and cobalt lines at 6,9 (K_α) and 7,7 (K_β) (Fig. 46). These lines are indicative of cobalt chromite blue. The pigment is sometimes referred to as cerulean blue, but can be confused with cobalt cerulean blue. Cobalt cerulean blue is a cobalt stannate and contains tin, which was not detected in any of the blue areas (Larsen, Coluzzi & Cosentino 2016). There are trace elements of nickel and arsenic in some of the blues, which can be impurities of both cobalt and smalt (cobalt potassium silicate glass) (Feller & Roy 1993). However, smalt was replaced by cobalt pigments in the 19th century so it is unlikely that Bonnard used it (Barnett, Miller & Pearce 2006).

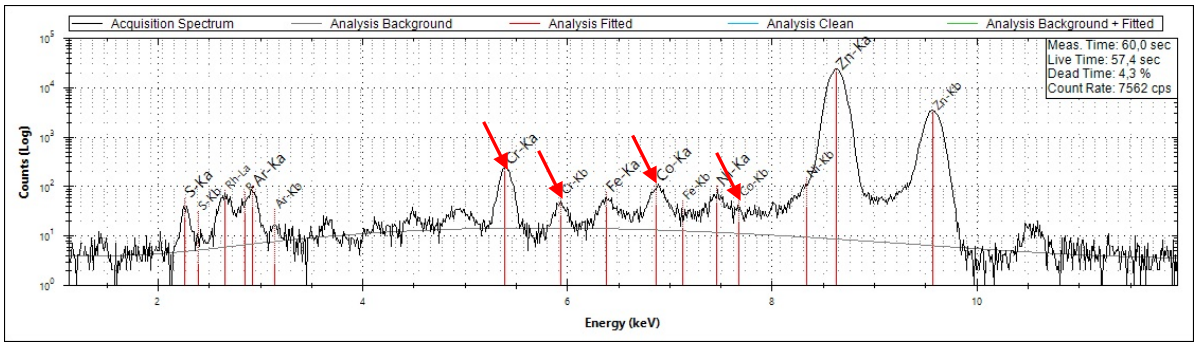


Fig. 46. Detail of XRF spectrum for blue area (spot location 47). Cobalt and chromium peaks are marked with red arrows.

The deviating area is spot location 49, which does not show any peaks for chromium. It does, however, show peaks for lead, which is not present in any of the other blue areas. This area does have a lot of white paint, and the high amount of zinc could possibly overshadow the presence of chromium. It is also possible that the lead is a peak from the white paint and not the blue.

4.3. Varnish Identification

A small sample of varnish was analyzed with ATR-FTIR. The ATR-FTIR spectrum, while quite noisy, revealed some distinctive peaks which were used for identification (Fig. 47). The spectrum was compared with reference spectra for various varnishes in the IRUG database. Reference spectra were chosen based on which varnishes that could have been used when the WL84 was painted, as well as

which varnishes were used by conservators at GMA.[4] Based on the position of the peaks, the most probable identification for the varnish is dammar (Fig. 48). The two spectra show very similar peaks at 2900 cm^{-1}, along with a shoulder at 2860 cm^{-1}. There is also a strong peak at 1700 cm^{-1} and a slight curve at around 1100 cm^{-1} in both spectra. The two peaks at around 1400 cm^{-1} in the reference spectrum are possibly present in the WL84 spectrum but it is too noisy to clearly distinguish them.

The spectra from the reflectance-FTIR were all similar, indicating that the reflectance was indeed coming from the varnish and not the paint layers underneath. By converting one of these spectra to a Kramers-Kronig transformation, similarities between the WL84 spectrum and a reference spectrum for dammar could be observed (Fig. 49). The two spectra are not a perfect match, but the most intense peaks are at the same location on the x-axis. It is important to note that the varnish on WL84 is old, and possibly mixed with other compounds.

Images in UV radiation reveal that the fluorescence of the varnish is not very strong. The fluorescence has a dull blue, milky appearance (Fig. 50). Generally, natural resins can fluoresce in a 'blue-ish haze' if they contain linseed oil (Simpson Grant 2000). Both mastic and dammar have a tendency to become brittle and cracked, and are often prone to severe yellowing when the varnish is applied in thick layers (Dietemann et al. 2009). Both yellowing and brittleness in thick layers were observed in the varnish on WL84 (Fig. 35).

[4] The following varnishes have been used by the museum's conservators during the 20th century: ketone resin AW2, dammar, Laropal K80, and the wax varnishes Céronis and Ceramatt (Malin Borin, Painting Conservator at GMA, personal communication, April 7th 2020).

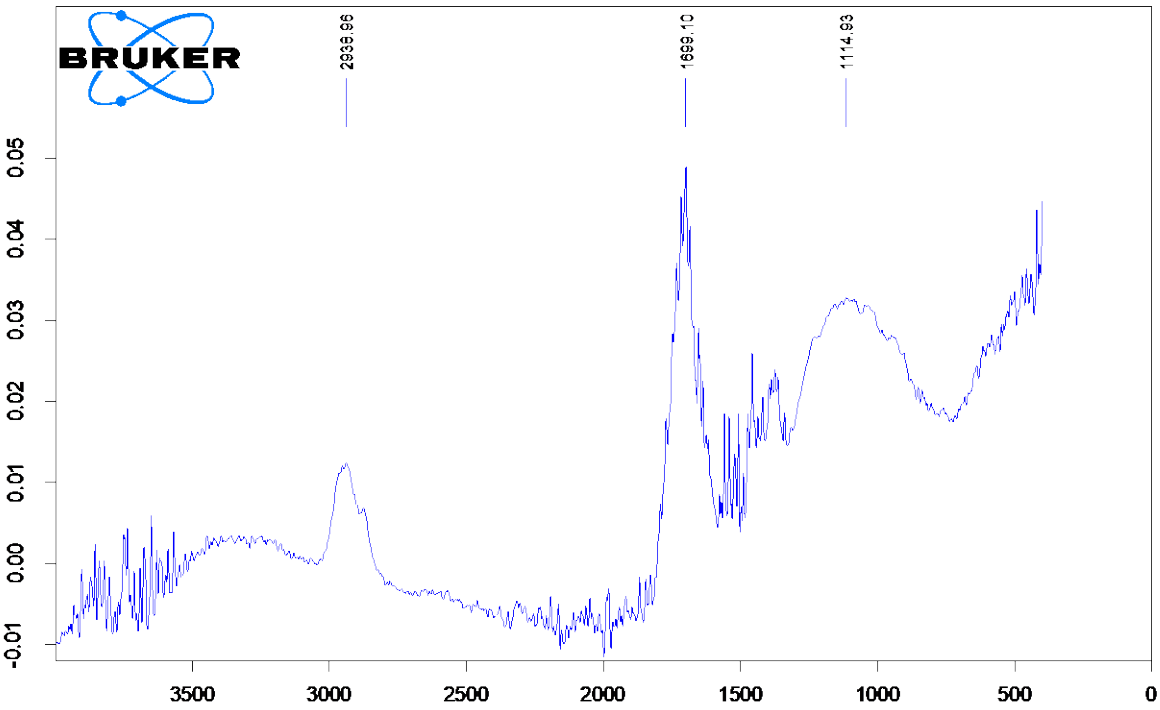


Fig. 47. ATR-FTIR spectrum of WL84 varnish.

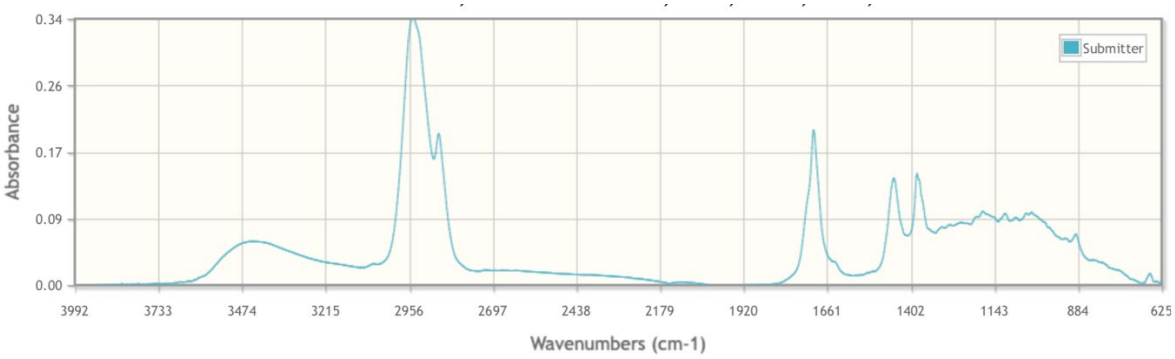


Fig. 48. Reference spectrum INR00116 Dammar (IRUG 2020a).

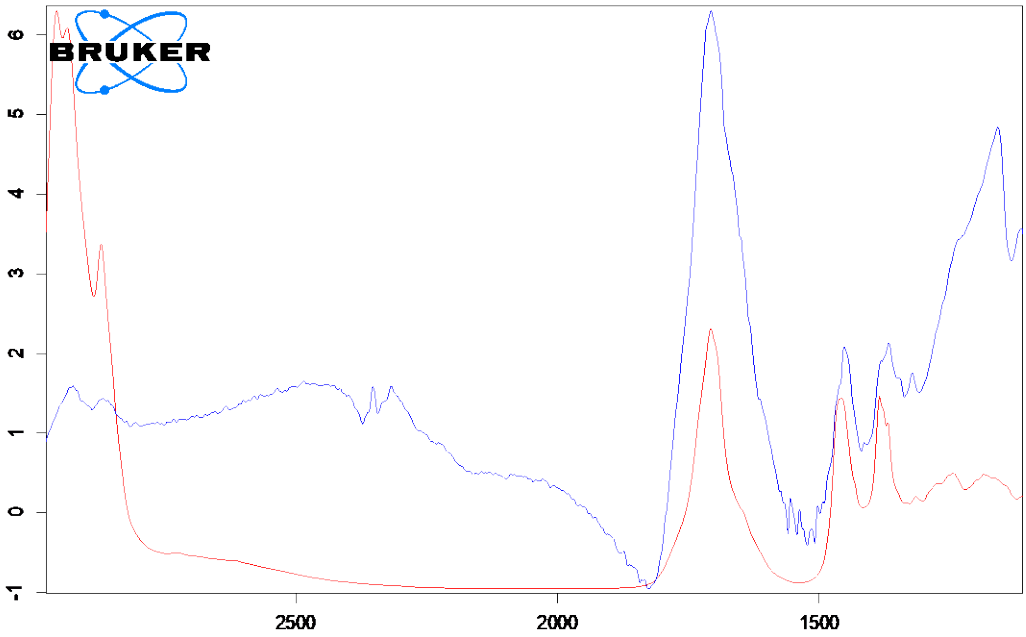


Fig. 49. Kramers-Kronig transformation of reflectance-FTIR spectra of WL84 varnish (blue line) and dammar reference from the IRUG database (red line). The distinctive peaks at the lower end of the x-axis are very similar in both spectra.

Fig. 50. UV image of WL84. Under UV illumination, the varnish present on the surface is strongly fluorescent but has a dull, milky appearance, and the flesh tones of the figure are bright. Abrasions on the surface are more apparent as is the unevenness of the varnish. Dark areas of unpainted paper are also seen. Photo: Hossein Sehatlou, GMA.

4.4. Cardboard Analysis

Three different tests were performed in the cardboard investigation; fiber identification, a lignin test, and an acidity test. All tests required a physical sample of the cardboard. Very small samples were taken along the edges of the cardboard, where fibers were already loose.

4.4.1. Fiber Identification

The fiber identification revealed several different types of fibers in the cardboard sample. The general appearance of the fibers is that they look very worn and macerated (Fig. 51). Most fibers are short and thick, with choppy ends (Fig. 52). This is indicative of woodpulp, either mechanical or chemical, which is probably highly-beaten (Ilvessalo-Pfäffli 1995). In general, mechanical woodpulp has a higher lignin content than chemical woodpulp and it often has signs of mechanical damage (McBride 2002). Further proof of wood fibers can be seen in the fiber in Fig. 53, which has characterizing pits in a single row. The appearance of the pits are indicative of fibers from a softwood, maybe pine (Ilvessalo-Pfäffli 1995).

The fiber in Fig. 54 might be a grass fiber such as esparto, identifiable by the vascular bundles along the edges (Ilvessalo-Pfäffli 1995). The edges of the fibers are also similar to the scales of wool fibers, but they are rarely found in paper. A grass fiber like esparto is more likely, as they have sometimes been added to chemical woodpulp in order to increase strength (McBride 2002). It is also possible that the fiber originates from some kind of contamination.

The ribbon-like twists of the fiber in Fig. 55 suggest cotton. Cotton fibers also have a tapering tip where the fiber was parted from the seed, which can be seen in the image. The fiber in Fig. 56 is also twisted and looks like a collapsed tube (McBride 2002). Other fibers appear to have joints, or ‘knees’, which is usually indicative of bast fibers (Fig. 57). Bast fibers can be present from textile waste (Ilvessalo-Pfäffli 1995).

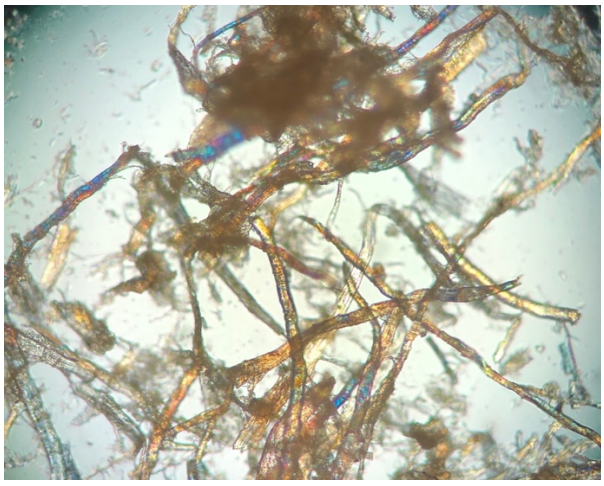


Fig. 51. Macro image (magnification 20x) of fibers in cardboard sample. The fibers look worn and choppy.

Fig. 52. Macro image (magnification 20x) of fiber with choppy, macerated end. Most likely woodpulp fiber.

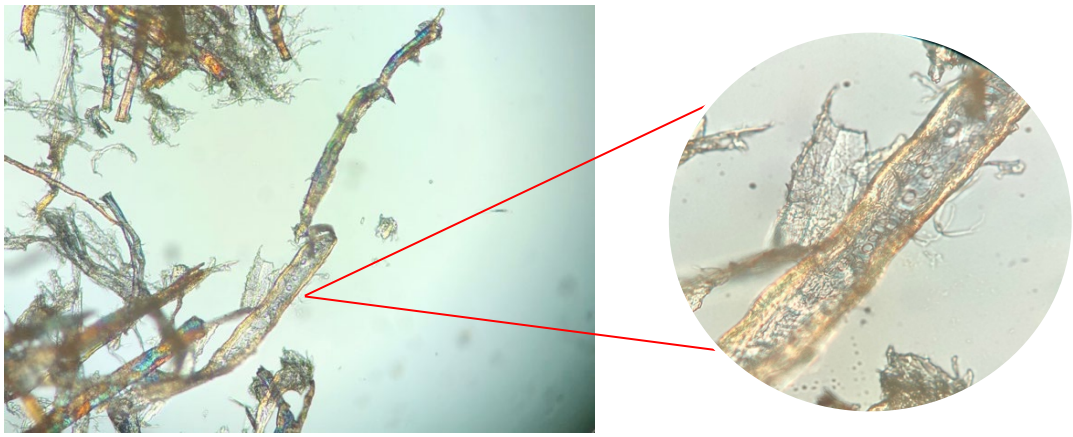


Fig. 53. Macro image (magnification 20x) of fiber with pits, shown in close up image (magnification 63x), indicative of wood fiber.

Fig. 54. Macro image (magnification 63x) of fiber with scales along the edges. Possibly grass or wool fiber, or some kind of contamination.

Fig. 55. Macro image (magnification 63x) of fiber with characteristic ribbon-like twists of cotton. A tapering tip can also be seen at the end of the fiber (marked with red arrow).

Fig. 56. Macro image (magnification 63x) of fiber that is twisted and has the appearance of a collapsed tube, indicative of cotton.

Fig. 57. Macro image (magnification 63x) of fiber with 'knees' or 'joints' (marked with red arrow), indicative of bast fibers.

4.4.2. Lignin Test

Based on the fiber identification, there should be a relatively high lignin content in the cardboard. The results of the lignin test with Phloroglucinol did show a magenta color but only on a small part of the sample (Fig. 58). The test was repeated several times on different samples, all showing the same results.

Fig. 58. Macro image (magnification 3.5x) of cardboard sample after Phloroglucinol spot test. Magenta areas are marked with red arrows.

4.4.3. Acidity Test

The control paper showed a strong purple color after testing, indicating neutrality or alkalinity (Fig. 59a-b). The cardboard sample turned yellow, indicating acidity (Fig. 60a-b).

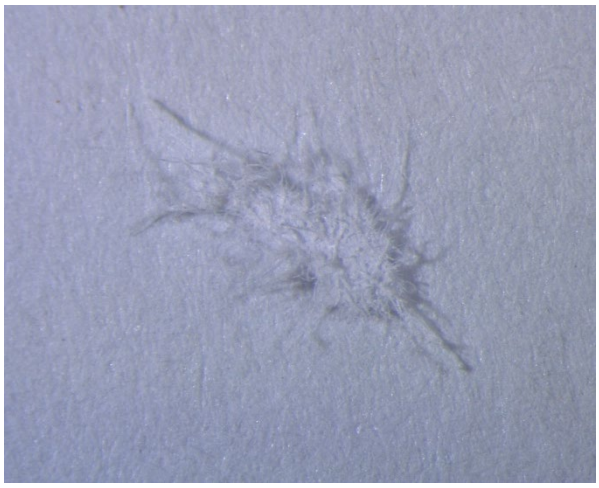


Fig. 59a. Control paper before acidity test.

Fig. 59b. Control paper after acidity test. A strong purple color has occurred, indicating neutrality or alkalinity.

Fig. 60a. Cardboard sample before acidity test.

Fig. 60b. Cardboard sample after acidity test. A yellow color has developed, indicating acidity.

5. Discussion

The investigation of WL84 has shown that it is a complex object. The painting has many degradation issues, such as pigment loss, staining, pulverization of the cardboard, and possible fading. Macro images revealed that Bonnard applied the paints in quick brush strokes, both in thin and pastose layers (Fig. 18). This way of applying the paint is definitely an influence from the Impressionist painting style. As mentioned in *2.1.1. Art Historical Context*, Impressionist painting often gave the impression of being "casual and hasty" (Herbert 1988). This is also the impression in WL84; the paint appears to be applied in a hasty, imprecise manner. Bonnard used sharp objects, such as a palette knife or the end tip of a brush, to make indentations in the paint layer (Fig. 19), possibly to accentuate certain areas. In some areas, the paint appears to be mixed before being applied and in other, such as the mouth, paints of several colors can be seen (Fig. 43). The latter technique resembles the Neo-Impressionist approach of applying colors separately in order to achieve optical mixture (Amory 2000a). Bonnard left many areas unpainted, or with a very thin layer which has since been faded or suffered pigment loss. The brown staining seems to be situated mostly in the unpainted areas of the painting (Fig. 27 and Fig. 28). Based on the 1923 photo of the painting (Fig. 30a), it appears that the painting was already suffering from pigment loss but not from staining. The cause for pigment loss is likely connected to the use of cardboard as a support; the apparent ungrounded cardboard causing a high absorption of the oil medium, resulting in poorly bound paint. It is possible that there is some form of underdrawing or sketch based on the gray lines seen in Fig. 16a-b, but further analyses are required in order to determine this.

The pigments identified in the investigation are zinc white, cadmium yellow, vermillion, and cobalt chromite blue, which were all common in the late 19th and early 20th centuries. The pigment identification was divided by color groups for systematic reasons, but the paints in WL84 are very mixed. There are almost no areas which are pure or consisting of one, clear color; most areas appear to be a mix of pigments. The black paint and the red paints in the purple areas are probably based on organic pigments. Based on the XRF results, it is clear that Bonnard used zinc white not only as the primary white pigment, but also as an additive to other pigments. The yellow areas have most likely faded severely, based on the appearance of the dull color and on the research on cadmium yellow (Comelli et al. 2019; Mass et al. 2012). The background is described as 'green' in old records at GMA, at the time of acquisition in the late 1930s. The area around the signature is slightly greenish (Fig. 31), but other than that the background is mostly gray, blue, and beige with yellowish areas. When the painting first was acquired by GMA, the yellow paint was most likely more vivid, which together with the blue would have appeared green.

The varnish on WL84 is identified as dammar, a varnish that has been widely used both by artists and conservators. The identification is useful for future decision making regarding possible removal of the varnish. However, the identification does not add clarity to the question of when the painting was varnished, and by whom. Dammar was indeed used by the museum conservators at GMA in the past so it is possible that WL84 was varnished after being acquired by the museum. However, it was also used by artists and it was one of the more popular varnishes in Bonnard's time. There are several reasons to suspect that the varnish on WL84 is not original. The most compelling reason is that it seems unlikely that Bonnard wanted a glossy surface on the painting, considering the aesthetic of matt painting on cardboard at the time. It also seems unlikely that Bonnard would have applied it so unevenly, creating a surface that varied in glossiness (Fig. 33). Furthermore, macro images of the surface showed that the varnish was present in the areas of pigment loss (Fig. 22), indicating that the varnish was applied after pigment loss had occurred. It is likely that someone observed pigment loss and craquelure and, in an effort to prevent further loss, applied a layer of varnish to the surface. This could have been done by a conservator, but there are a few reasons why this seems questionable. First, as has already been discussed many times, the varnish seems to be applied in quick and unprecise manner, contrary to conservation practices. Second, there has been no attempt at integrating the losses before varnishing.

There is another compelling reason for the varnish not having been applied at GMA, and that is the disappearance of the signed date. The UV images showed that this area did not emit any fluorescence (Fig. 32), suggesting that the area is unvarnished or painted over. It is more likely that there is a layer of paint on top of the varnish in this particular area. It would have been highly unethical and unreasonable for conservators or other museum professionals to apply paint on top of the varnish in order to conceal the date. One possible explanation is that it was Bonnard himself who painted over the date. This would have to have happened after 1923, as the date can be seen in the photo from that year (Fig. 30a). The painting's provenance suggests that it remained in Paris until 1927, when it was shipped to Sweden. Bonnard could easily have had access to the painting, for example at the Galerie Druet in 1924. As he was known to do, he could have made a few minor additions or changes to the painting, and then painted over the date. The fact that the paint on that area looks similar to the surrounding paint, also speaks in favor of Bonnard being the one who painted over it.

Although discolored and uneven, it is likely that the presence of the varnish on WL84 has prevented further pigment loss. However, a possible removal of the varnish should be evaluated. Old varnishes are usually removed with polar solvents, which might cause swelling of the paint, so it is a course of action with definite risks (Dietemann et al. 2009). The discussion of possible removal would benefit from a dialogue between painting conservators and paper conservators. The same applies to housing and storage of the painting. Studies have shown that oxidation of the varnish takes place even in darkness, although somewhat slower than in light (Dietemann et al. 2009). Thus, storing the painting in a dark place might not halt the degradation processes, and the best solution would be to remove the varnish. Oxidation of the varnish is stronger in the light, but yellowing is often less pronounced in varnishes that have been aged in light rather than dark. This does not mean that the varnish is less degraded, but light causes bleaching, which lessens the appearance of yellowing (Dietemann et al. 2009). It is also likely that exposure to both light and humidity have contributed to pigment alteration noted in the cadmium containing paint. WL84 has been on permanent display, probably since its acquisition, with light levels intended for paintings on canvas.

The presence and both varnish and oil medium also affects the cardboard. The results of the study showed that the cardboard consists of a mix of fibers and is acidic. The presence of oil paints has likely had a negative effect on the pH of the cardboard, as studies have shown that oil medium has a tendency to lower the pH in paper. As a result, degradation of the cellulose is accelerated (Banou et al. 2016). As a vicious cycle of degradation, the acidity in the paper, caused partly by the oil, will in turn accelerate the hydrolysis of the oil (Banou & Singer 2016). Furthermore, the presence of varnish on the exposed cardboard, where there is no paint, can cause further delamination of the cardboard layers due to distortion. Increased humidity can cause further hydrolysis and degradation of both the oil medium and the cardboard, so this should affect how the painting is stored (Banou & Singer 2016). The fact that the support of WL84 is cardboard should strongly affect decision making regarding housing and display. For example, glazing is absolutely necessary in order to protect the painting. Even the Impressionists who painted on absorbent grounds in order to achieve a matt surface exhibited their paintings glazed, likely for protective reasons (Swicklik 1993).

The pigment loss, staining, discolored and uneven varnish, and change in hues are all factors which are important to the appearance of the painting. Bonnard is known as one of the greatest colorists in art history. He took pride in the quality of his paintings and wanted the people of the future to enjoy and appreciate his work, as is evident in his remarks about wanting to present himself to young painters of the future with the "wings of a butterfly" (Bonnard & Groom 2003). It is impossible to know what Bonnard might have thought about the appearance of WL84 today, but it is clear that the painting's appearance has changed over the course of time. Change and degradation in tangible cultural heritage objects is inevitable. It is impossible for conservators to maintain the original state of an object for all time. Artists, as well as the public, must accept that art works will change in appearance, and that these changes may be accelerated after exposure to radiation (light) and incorrect humidity. However, conservators and other museum professionals must not disregard the way an object was originally intended. Artist intention is a complex concept for conservators, especially when the artist is no longer alive. There are two main approaches to understanding an object's original intention if the artist is not

alive. One is the scientific approach, where technical and scientific investigation is the basis for identifying authenticity. The other is an aesthetic approach, which uses social science as a means of understanding the object. Ideally, both approaches are used in a combined interdisciplinary investigation (Wharton 2015).

5.1. Conclusion

This study has employed both the technical and aesthetic approaches in order to understand the materials and deterioration processes of one specific object. The results of these approaches have shown that the painting has undergone significant change. The original intention of WL84 was not the purpose of the study but it is important to at least problematize around Bonnard's intention, in light of the knowledge that the painting has changed. If the colors of a painting are so faded that it looks completely different than when it was painted, should the object be exhibited at all? If exhibited, should it be made clear to the public that the object has undergone severe degradation? For paintings such as WL84, is the artist's original intention important, and should it matter if the artist would be pleased with the current appearance of the painting? These are questions which should be considered in future treatment and exhibition of WL84.

This study has been able to identify many of the materials used in WL84, as well as the composition of the cardboard. The technique, structure, and condition of the painting have been investigated and discussed. By using an inter-disciplinary approach, the results of the technical investigation have been able to be interpreted and discussed in a greater context. Oil paintings on cardboard face many risks of deterioration due to the complexity of the combined materials, but they are an important part of our cultural heritage. Cardboard is not just some material used for its low cost or easy accessibility, it has been used actively for its absorbing qualities. However difficult conservation issues related to oil paintings on cardboard may be, these qualities should be considered.

One of the notable results from this study is how difficult it is to find information about the materials Bonnard used. Considering his place in art history, this is quite peculiar. It is the author's hope that this study can be used as a stepping stone for further research, both on Bonnard and on the complex issue of oil paintings on cardboard.

5.2. Further Research

There are still many questions about the painting. The most pressing ones are:

1. What has caused the severe staining of the cardboard?
2. When and how has pigment loss occurred?
3. What happened to the signed date?

These questions are important for the painting and should definitely be explored in the future. Furthermore, the questions highlight the importance of conducting material-based research, as an understanding of the components of a painting is integral. There are many ways this study can be expanded. The exact pH of the cardboard can be measured in order to find out just how acidic it is, and how that is affecting the paint layers. Further pigment identification based on microsamples can be conducted in order to identify the organic pigments, and to strengthen the identification of the inorganic pigments. The lightfastness of the pigments can be assessed by conducting microfading. Potential housing and monitoring solutions should also be discussed. The lignin test can also be repeated, perhaps with a different microchemical test. Other interesting areas to explore would be to find out more about the gray lines and the dark lines only visible in UV.

The next step at GMA is to investigate another oil painting on cardboard by Bonnard which also belongs to GMA, and to compare the two paintings. Dialogue and collaboration with other museums with cardboard paintings by Bonnard is desirable, and could be of great help in contributing to the material research on Bonnard.

6. Summary

Pierre Bonnard (1867 - 1947) was a French artist who is remembered as being one of the great colorists of his time. An oil painting on cardboard by Bonnard is investigated in this Master thesis in paper conservation. The painting belongs to the Gothenburg Museum of Art (GMA), and has the inventory number WL84. It is dated 1903 and it depicts a nude, dark-haired woman, presumably Bonnard's wife Marthe de Méligny. The painting's palette consists of many earth tones but has some areas of more vibrant colors, such as pink areas in the face and body, yellow areas in the background, and blue areas on the body and in the background. There is a layer of uneven, glossy varnish on the surface. The painting shows many signs of degradation, in the form of pigment loss, staining, and discolored varnish.

In this inter-disciplinary technical study, the materials and condition of WL84 were investigated. The study aimed to identify the painting's specific pigments and varnish, the composition of the cardboard, and to examine the condition of the support and paint layers. The goal was also to assess how the choice of materials has affected the condition of the painting. The methodology of the thesis consists of a literature review and technical investigations with the following analysis methods: ultraviolet (UV) and infrared (IR) imaging, macro imaging and microscopy, microchemical tests, X-ray fluorescence (XRF) spectroscopy, and Fourier-Transform Infrared (FTIR) spectroscopy.

The literature review presented an overview of Bonnard's life and artistry and of the use of cardboard as a support for oil painting. Some of the changing practices in oil painting during the end of the 19th century are discussed; how many artists strived for a more matt aesthetic, using cardboard and other more absorbent grounds as supports and foregoing varnishing. The review also presents the provenance and exhibition history of WL84. The literature review revealed that, while research on Bonnard in an art historical context is abundant, the research on his use of materials is scarce.

The technical investigation of the technique, structure, and condition of the painting showed that the paint is applied in quick brush strokes with both thin and more pastose paint. The cardboard is exposed in many areas, and there are many brown stains, particularly in the face and the left knee and leg. There is flaking of the paint layer. The cardboard shows signs of some flaking and delamination, but is mostly intact. An old black and white photograph of the painting from 1923 revealed that the appearance of the painting has changed significantly. There are no signs of staining in the photo, and the areas of exposed cardboard appear much brighter. The black and white photo does not reveal any information about whether the colors have faded, but there is reason to believe that at least the yellow areas have changed. The yellow areas in the background appear very dull, and old records describe the background as green. The photo also revealed that the date '1903' was once present underneath Bonnard's signature, in the top left corner. The date is not visible in the current condition of WL84, and UV images revealed that the area is either unvarnished, or that there is a layer of paint on top of the varnish.

The pigment investigation identified four different pigments; zinc white, cadmium yellow, vermillion, and cobalt chromite blue. The investigation of the varnish identified a dammar varnish, which most likely was not applied by Bonnard himself. The cardboard investigation revealed that the cardboard is acidic and consists of several different fibers; wood, cotton, bast, and grass or wool fibers. There is some degree of lignin in the cardboard. The combination of oil medium on cardboard has most likely affected the condition of the painting negatively. The presence of oil in the cardboard fibers cause brittleness and weakening of the cellulose. The acidity of the cardboard is most likely worsened by the presence of oil. Furthermore, the acidity in the cardboard accelerates the hydrolysis of the oil.

The results of this study can contribute to the research on Bonnard's use of materials and to the complex issue of oil paintings on cardboard. The study will also be used for further investigation and comparison of other oil paintings on cardboard by Bonnard.

7. Sammanfattning

Nude (Après le bain): En tvärvetenskaplig teknisk undersökning av en oljemålning på kartong av Pierre Bonnard

Pierre Bonnard (1867 - 1947) var en fransk konstnär som är ihågkommen som en av de främsta koloristerna av sin tid. I denna masteruppsats i papperskonservering undersöks en oljemålning på karting, målad av Bonnard. Målningen tillhör Göteborgs Konstmuseum (GKM) och har inventeringsnumret WL84. Målningen, från 1903, föreställer en naken mörkhårig kvinna som antagligen är Bonnards fru, Marthe de Méligny. Paletten består av mestadels jordtoner men det finns ett antal mer färggranna områden, såsom rosa toner i ansiktet och på kroppen, gula områden i bakgrunden, och blå områden på kroppen och i bakgrunden. Ytan är täckt av ett ojämnt lager av glansig fernissa. Målningen uppvisar många tecken på nedbrytning och skada, såsom pigmentbortfall, fläckar och missfärgad fernissa.

I denna tvärvetenskapliga tekniska studien undersöks målningens material och tillstånd. Studiens mål var att identifiera pigment, fernissan, kartongens sammansättning, och att undersöka tillståndet av kartongen och färglagren. Studien ämnade också att diskutera hur valen av material har påverkat målningens tillstånd. Uppsatsen metodik består av en litteraturstudie och tekniska undersökningar med följande analysmetoder: ultraviolett (UV) och infraröd (IR) bildbehandling, makrofotografi och mikroskopi, mikrokemiska tester, röntgenfluoresens spektroskopi (XRF) och Fourier-Transform Infraröd (FTIR) spektroskopi.

Litteraturstudien presenterade en överblick av Bonnard liv och konstnärskap och användandet av kartong som underlag för oljemåleri. Några av de sätt som oljemåleriet förändrades under slutet av 1800-talet diskuteras också, till exempel hur många konstnärer strävade efter en mer matt estetik genom att använda kartong och andra absorberande underlag, och genom att undvika användning av fernissor. Litteraturstudien presenterar även proveniensen och utställningshistoriken för WL84. Ett resultat av litteraturstudien är att det inte finns mycket forskning om Bonnards materialanvändning, även om forskning om honom i en konsthistorisk kontext är omfattande.

Den tekniska undersökningen av målningens teknik, struktur och tillstånd visade att färgen är applicerad i både tunna och mer pastosa områden med snabba penseldrag. Kartongen är ofta exponerad och har många mörka bruna fläckar, speciellt i ansiktet och det vänstra knät och benet. Färglagren lider av viss bortflagning. Kartongen är mestadels intakt men uppvisar tecken på delaminering. Ett svartvitt fotografi från 1923 avslöjar att målningen har förändrats drastiskt under åren. I fotot syns inga tecken på fläckar, och områdena där kartongen är exponerad ser ljusare ut. Fotot bidrar inte med information om huruvida färgerna har bleknat, men det finns anledning att misstänka att åtminstone den gula färgen har förändrats. De gula områdena har en dämpad ton, och i gamla dokument om tavlan beskrivs bakgrunden som grön. I fotot från 1923 är årtalet ’1903’ synligt under Bonnards signatur i övre vänstra hörnet. Årtalet är inte synligt i målningens nuvarande tillstånd, och UV-bilder avslöjar att området inte har någon fernissa, eller att fernissan har ett färglager på toppen.

Pigmentundersökningen identifierade fyra olika pigment: zinkvitt, kadmiumgult, vermillion och kobalt kromblått. Undersökningen av fernissan identifierade dammarfernissa, som troligtvis inte har blivit applicerat av Bonnard. Undersökningen av kartongen visade att den är sur och består av många olika fibrer: trä, bomull, bast och gräs eller ullfiber. Det finns även tecken på lignin i kartongen. Kombinationen av olja på kartong har troligtvis påverkat målningens tillstånd negativt. Oljan orsakar sprödhet och försvagning av pappersfibrerna, och surheten i kartongen blir troligtvis värre av oljan. Dessutom orsakar surheten en acceleration av oljans hydrolys.

Resultaten av denna studie kan bidra till forskningen om Bonnards materialanvändning och till det komplexa ämnet som är oljemålning på kartong. Studien kommer också att användas för vidare forskning och jämförelse med andra oljemålningar på kartong av Bonnard.

Tables and Figures

Tables

Figures

All photographs taken by Victoria Skalleberg if not stated otherwise.

Figures in Appendix

Reference list

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Appendix I

Fig. I. Spot locations for reflectance-FTIR readings.