Material and technique in portraits by Jens Juel and their correlation to degradation patterns

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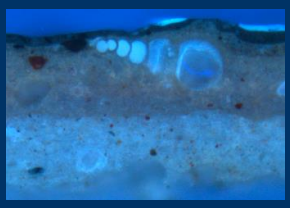

PhD Thesis

Tine Louise Slotsgaard

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Royal Danish Academy
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Conservation

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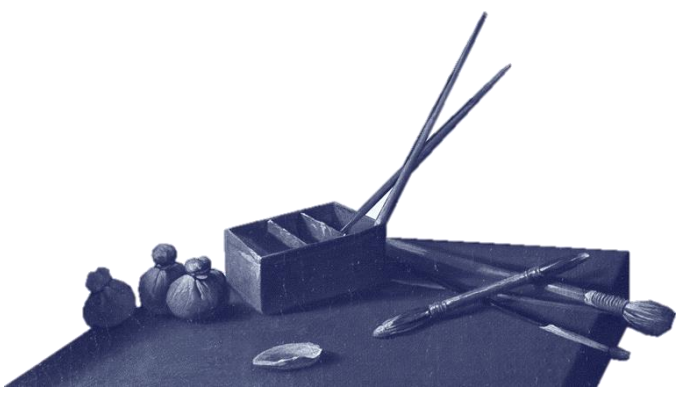

Thesis for the degree of Doctor of Philosophy (PhD) in Conservation-Restoration
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Front cover illustrations:
Detail of Jens Juel, *Meditation, Caricature of Clemens, Juel and Charles Bonnet*, National Gallery of Denmark (SMK) (KKSgb4435), ink on paper, 132 x 166 mm.
Detail of Jens Juel, *Madame de Prangins in Her Park at Lac Leman,* 1778-79. National Gallery of Denmark (SMK) KMS4810, oil on canvas, 86.5 x 72 cm.
Cross-section (KMS4810_621a) from Jens Juel, *Madame de Prangins in Her Park at Lac Leman,* 1778-79
Detail of Jens Juel, *Jens Bruun Neergaard of Svenstrup*, 1788. Svenstrup Foundation, oil on canvas, 70 x 54.8 cm.
Cross-section (SV1-598c) from Jens Juel, *Jens Bruun Neergaard of Svenstrup*, 1788.

Preface and Acknowledgements

This PhD thesis assembles the results from a three-year PhD project conducted between November 2017 and December 2020 at the Royal Danish Academy – Architecture, Design and Conservation. In the Danish educational system, a PhD is limited to three years of work that include PhD courses (30 ECTS), change of environment, field studies, thesis work and thesis-related teaching or dissemination tasks (840 hours) at the Royal Danish Academy or collaborating institutions. The overall extent of the thesis must not exceed the equivalent of 250 standard pages of 2,400 characters each (with spaces, but without bibliography and appendices).

This PhD thesis takes its form as a monograph, prepared personally by the PhD student, and was carried out under supervision of Associate Professor Beate Knuth Federspiel and co-supervisor Associate Professor Cecil Krarup Andersen, the Royal Danish Academy – Institute of Conservation.

The project was funded by the Independent Research Fund Denmark (DFF-7023-00056B) under an Open Access research policy and carried out in cooperation with several institutions: The National Gallery of Denmark (SMK), The National Museum of Denmark, CATS – Centre for Art Technological Studies and Conservation and the National Gallery of Art in Washington D.C., USA.

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Much of my research was carried out at the National Gallery of Denmark (SMK) and CATS – Centre for Art Technological Studies and Conservation. I am very grateful for the opportunity to

include portraits by Juel from the collection in my thesis work. Thank you to all the staff for making me feel most welcome and being kind and helpful throughout the entire time I was there; it has been a great pleasure. I wish to thank David Buti and Gianluca Pastorelli for their great effort in conducting scientific analysis and interpretation during examination of the paintings, and Astrid Grinder-Hansen and Sofie Wikkelsø Jensen for their many hours spent preparing cross-sections; to Loa Ludvigsen for conducting IR, X-ray and weave-mapping analysis and to Jacob Skou-Hansen for being helpful with high-resolution images. I would like to express gratitude and appreciation to all who offered their guidance and expertise, especially: Troels Filtenborg, Anne Haack Christensen, Karen-Marie Henriksen, Pauline Lehmann Banke, Karen Esser, Cæcilie Vieth Vad, Angela Jager, Anne Duur, Kim Brasen and Pil Rasmussen as well as Jesper Svenningsen – for friendship and advice both in the stipend application process and during the project – and, furthermore, former head of CATS Prof. em. Dr. Jørgen Wadum, now director of WATS – Wadum Art Technological Studies, for his initial openness to the project, and comments and advice in connection to my evaluation seminar towards the end of the project.

A part of the examination of paintings by Juel was conducted at the National Museum of Denmark's Conservation Department in Brede. I wish to express special thanks to Mikala Bagge and Lis Sejr Eriksen for contacting me about the portraits by Juel that were to undergo treatment. Further, to Mikala Bagge for her helpfulness and sharing her great practical experience; to Mads Christensen for conducting FTIR analysis; Birgitte Larsen, Bodil Holstein and Kim N. Hou Alberdi for their knowledge on carpentry; Signe Nygaard for performing X-radiography; and photographers Jenny Sundby, Arnold Mikkelsen and Roberto Fortuna for assisting with information and photographic equipment. Additionally, I wish to thank Niels Bonde and Claudia Baittinger from the department of Environmental Archaeology and Materials Science for undertaking wood-species identification of the strainers.

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An eight-week fellowship was undertaken at The National Gallery of Art, Washington D.C. I wish to thank the institution for hosting me and express sincere thanks to Head of the Scientific Research Department Barbara Berrie and Conservation Scientist Christopher Maines for making this experience possible. I especially wish to thank Chris for his immense contribution and our work together in preparing and carrying out GC/MS analysis and interpretation. I much enjoyed this time and our friendship. Thank you Barbara for your help with examining canvas samples and for your support and enthusiasm for my project. Additionally, I would like to thank Joan Walker, Lisha Deming Glinsman, Melanie Gifford, Julia Burke and all the additional staff in the Scientific Research Department and the division of conservation; you all contributed to a most welcoming and fruitful experience with your high level of professionalism and dedication to our field.

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Last, but not least, thank you Anders for your enthusiasm, constant willingness to provide feedback, help and endless support. Having you by my side has been invaluable.

Abstract

Jens Juel (1745-1802) was the most famous portrait painter and the most productive painter of his era in Denmark. His production spans forty years and he left behind more than 600 portraits on canvas. This thesis investigates twenty-two portraits on canvas from throughout Juel's career, focusing on whether Juel's materials and techniques changed with regard to time, location and availability of materials – and how these correlate with degradation patterns, especially craquelure, which display a different morphology in the paintings he produced abroad than paintings produced in Denmark.

The selected paintings are examined focusing on original strainers, canvas characteristics, absence or presence of a sizing layer, colour and composition of the ground layers, use of pigments and build-up of the paint layers as well as the application of varnish. Juel used mainly traditional materials and his paint application shows a very assertive and deliberate approach with few changes and a rapid technique resulting in only one to two paint layers in a non-experimental manner. The results of material analyses in combination with documentary evidence provide some indication of the circumstances of Juel's choices, the available materials and the market for art and artistic practice in the pre-industrial era. Many materials commonly available in Europe at the time were also available in Denmark; however, the absence of some materials, such as ultramarine, as well as the use of different ground layers used in the eight years he spent abroad during the 1770s compared to those used while in Denmark, suggests that the extent of access to some materials varied. Except for the occasional use of white grounds, which emerged in his paintings during this period, the years abroad do not seem to have had significant influences on his technique in the years following his return to Denmark; rather he seems to have returned to a similar approach to his early years. The availability of materials or items must have been contingent on necessity and demand, including the access to pre-primed canvasses, and it is unclear whether this was yet an established line of work outside the studio. Canvasses were usually cut from larger pre-primed canvasses, and two sets of matches between the canvas and preparatory layers of paintings dated art-historically as being several years apart, suggest the dates for some of the paintings should be adjusted.

The identified differences in the ground layers, based on the presence or absence of calcium carbonate versus lead white, appear to be a major factor in the development of one type of craquelure over another. This difference has a significant influence on the mechanical and chemical properties within the structure of the painting, and therefore influences the way and degree to which cracking occurs. The findings of this thesis may provide a point of departure towards expanding the understanding and explanation of the formation of cracks in paintings. This relates not only to Juel's paintings, but also to the preservation of paintings in general, contributing to the understanding of paintings' degradation, and enabling a more targeted approach to both preventive and active conservation.

Resumé (Danish)

Jens Juel (1745-1802) var den mest berømte portrætmaler og den mest produktive kunstnere i sin tid i Danmark. Hans karriere spænder over fyrre år, og han efterlod sig mere end 600 portrætter malet på lærred. Denne afhandling undersøger toogtyve portrætter på lærred udført på tværs af Juels karriere med fokus på, om Juels materialer og teknik ændrede sig i forhold til tid, lokalitet og tilgængelighed af materialer – og hvordan disse hænger sammen med nedbrydningsfænomener, særligt revnedannelser, som viser forskellige mønstre i malerier udført i udlandet og i malerier udført i Danmark.

De udvalgte malerier er undersøgt med fokus på originale blændrammer, lærredskarakteristik, tilstedeværelse eller fravær af forlimning, grunderingens farve og sammensætning, brug af pigmenter og lagvis opbygning af farvelagene samt anvendelsen af fernis. Juel anvendte primært traditionelle materialer, og hans maleteknik viser en selvsikker og velovervejet fremgangsmåde med få ændringer, og en hurtigt arbejdende hånd med kun et til to farvelag i opbygningen, og uden væsentlige eksperimenter. Resultaterne af materialeanalyser, sammenholdt med skriftlige kilder, giver en indikation af Juels tekniske valg, tilgængelighed af materialer og markedet for kunst og kunstnerisk praksis i den førindustrielle tid. Mange af de materialer som var tilgængelige i Europa på dette tidspunkt, var også tilgængelige i Danmark; om end fraværet af bestemte materialer, såsom ultramarin, indikerer, såvel som at Juel har anvendt en anden type grundering i malerierne som han udførte i de otte år i 1770erne han tilbragte i udlandet, end han anvendte i Danmark, at tilgængeligheden af visse materialer varierede. Bortset fra, at Juel begynder at anvende lyse grunderinger, hvilke fremkom i hans teknik imens han var i udlandet, synes udlandsårene ikke at have haft stor indflydelse på hans praksis i de efterfølgende år i Danmark; snarere synes han at have anvendt tilsvarende teknik og materialer som i hans tidligere år. Tilgængeligheden af materialer og varer må have været afhængige af udbud og efterspørgsel, hvilket også indbefatter adgangen til at købe præ-grunderede lærreder fra en leverandør, for så vidt, at det var blevet en etableret praksis som foregik uden for kunstneres atelier. Lærrederne blev som regel udskåret fra større præ-grunderede lærreder og to sæt malerier, matchende mellem lærred og grundering, som er kunsthistorisk daterede blev fundet i denne undersøgelse. Dette stiller spørgsmål til den nuværende datering og hvorvidt nogle dateringer bør afstemmes.

De identificerede forskelle i grunderingslagene, som baserer sig på fravær eller tilstedeværelse af blyhvidt og kridt, synes, at være en af de primære faktorer for de to forskellige revnedannelsesmønstres opståen. Denne forskel har en væsentlig indflydelse på de mekanisk og kemiske egenskaber i maleriets struktur, og dermed også indflydelse på formen og omfanget af revners opståen. Disse fund kan være med til at bane vejen for en udvidet forståelse og forklaring på udbredelsen af revner i malerier. Ikke kun i Juels malerier, men også mod en generel forståelse for, hvordan nedbrydning foregår i malerier og for at skabe en mere målrettet bevaringsstrategi, både i præventiv og aktiv konservering og restaurering.

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1 Introduction

> If only we could tell, what good mixtures were in the tin container next to the colour bladders on his table! The secrets to the now-lost techniques he knew by heart.[1]
>
> – Karl Madsen, 1909

The painter and art historian Karl Madsen made the above comment about Juel and his self-portrait from 1766, where the young painter is seated painting in front of an easel with several painter' materials on the table next to him (Fig. 1.1). Jens Juel (1745-1802) was one of the most famous painters of his era; he is regarded one of the most important portrait painters in the history of Danish art and culture and one of the first Danish painters to gain an international reputation in his own lifetime (Weinwich 1811; Høyen 1828). Juel produced close to a thousand portrait and landscape paintings, drawings, sketches and pastels. Members of the Danish royal family, the aristocracy and the bourgeoisie all wanted their portrait painted by him, and he was known for making his models look their best. Juel depicted an era and his portraits represent decades of the most central people and historical figures of his time. His portraits are characterised by elegance and carefully rendered details. He was skilled at capturing the latest trends, and his art reflects the transition from the lofty portrayals of the Rococo to more Realist depictions. Furthermore, his portraits reflect a Danish rise in identity, changes in societal structures, developments in fashion, culture and commerce, and the establishment of Danish art. It was the time of the Enlightenment and, for the upper class, a rising self-promotion, wealth, luxury and consumer goods, initiated the foundation of modern life and more than other eras since, this time resembled the era we live in nowadays (Lange 1873; Feldbæk 1991; Kryger 1991; Venborg Pedersen 2013). This makes Juel's portraits and the topics they reflect continuously relevant to studies of history and culture today and in the future – and thus the preservation of Juel's paintings for future generations is of great importance.

A thorough knowledge and understanding of the use of materials and techniques are essential to assess the best possible conservation, storage and exhibition conditions for the long-term preservation of Juel's paintings in the future. What we see when looking at a painting surface is the result of a complex, multi-layered structure of materials; these structures continuously interact in the ageing and degradation processes within the artwork. As a paintings conservator-restorer my motivation and approach is to examine the paintings and interpret the physical evidence they provide to understand the intentions of the artist, the structure of the artworks, the use of materials and techniques and their effect on the ageing and deterioration of the paintings to contribute to the best preservation strategy for the paintings in the future.

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[1] "Gid vi vidste, hvad det var for gode Blandinger, der fandtes i Blikbeholderen ved siden af Farveblærene paa hans Bord! Teknikkens nu tabte Hemmeligheder kendte han til Bunds."
Unless otherwise noted, all translations into English throughout the thesis are made by the author, Tine Louise Slotsgaard.

There has always been a mystery surrounding Juel's painting technique and his use of materials. Juel was praised and admired even in his own time. Art historians commend him for his talent and versatility, for his brushwork and colour-use, although the portraits from the later period of his career at times have been critiqued for having an expression of repetition or a rushed and over-assertive paint handling, likely due to a large number of commissions (Høyen 1828; Madsen 1909). Until recently, little was known about Juel's painting technique, use of materials or studio practice (Slotsgaard 2013; 2015). Not much documentary evidence has survived. As is testified by his contemporaries, Juel did not write much and according to tradition Juel's wife burned all surviving papers after his death (Göthe 1900:60; Swane 1944; Poulsen 1991:18). Several students trying to learn from him expressed their frustration at wanting to learn from the professor who was not very keen to provide information (Weilbach 1882; Hansen 1907; Glarbo 1929-30; Christensen 1996a:65). Much of what is known was documented by Juel's contemporaries and this has helped establish his biographical outline and the timeline of a large number of unsigned paintings.

Fig. 1.1 Jens Juel. *Self-Portrait*, 1766. The Royal Danish Academy of Fine Arts, Copenhagen, oil on canvas, 34 x 43 cm.

While attention has been given to the art-historical and biographical aspects of Juel's life and production, very little attention has been given to the technical and practical aspects of his art (Poulsen 1991; Christensen 1996; Monrad 1996). Art historians have sporadically and to a limited extent made proposals regarding the build-up of layers, use of pigments, colour mixtures, visual influences, authenticity and state of preservation of Juel's paintings, based on the general knowledge of the materials available in Juel's era (Madsen 1909; Swane 1944; Poulsen 1991; Christensen 1996; Monrad 1996). However, none of these relies on any scientific analyses and they are primarily based on qualified subjective observations of the surface. Thus, the comment made by Karl Madsen, rightly summarises the conundrum, which has always existed with regard to the painting technique and materials employed by Juel: "If only we could tell …"

The scarce biographical documentation that exists requires the support of the paintings as physical evidence to provide further information. By means of modern methods of analysis adopted by the field of conservation and a technical-art-historical approach where scientific research is compared to documentary sources, the ability to obtain information about the techniques and materials employed by artists has advanced over the past century (Ciliberto & Spoto 2000; Pinna et al 2009; Hermens 2012; Stoner 2015; Burnstock 2017). Thus, our aim to tell "what mixtures" artists employed has become much more achievable since Karl Madsen posed his question more than a century ago, making this task one of the main intentions of this thesis.

1.1 Problem Statement and Research Questions

In Juel's era, painters were trained in private studios and most acquired their own materials and prepared them in the studio or workshop. Therefore, it is unclear exactly what was taught, what materials were used and which actions took place in the individual studio. Troels Filtenborg, Conservator at the National Gallery of Art (SMK), has made an important publication on the painting technique of Juel's contemporary colleague, the history painter Nicolai Abildgaard (1743-1809), which will act as a comparison for the findings on Juel's technique and materials (Filtenborg 2014). However, we still have limited insight into the availability of materials for painters in Copenhagen at this time, the commercial preparation of paintings or the emerging market for art and artistic practice in Denmark in the period leading up to the Danish Golden Age (Bregnhøi 2010; Slotsgaard 2013; Filtenborg 2014; Bregnhøi & Raabymagle 2019).

Juel's career spans four decades and an initial study into the techniques and materials used by Juel indicated that a change in technique, especially in the use of ground layers, took place between the early and later periods of his career (Slotsgaard 2013; 2015). In between these periods, Juel spend eight years abroad during the 1770s, visiting and working in the most important artistic centres in Europe. One theory is that Juel was inspired to use new techniques or materials during his years abroad. This is one of the hypotheses, which ignited the curiosity for this thesis: to learn more about the use of materials and sources of inspiration for Juel and other Danish painters in the late eighteenth century. Differences in the structures of the paintings may depend on whether the canvasses were prepared in the studio or purchased pre-primed from a supplier.

There is an overall understanding of the existing painting materials in Europe during this era; however, new information progressively emerges with technical analyses of artworks and research into the documentary sources. The materials used and their combinations sometimes vary depending on geographical and local traditions as well as accessibility of the materials (Laurie 1926; Mayer 1930; Villers 1981; Harley 1982; Hermens 1998; Stoner & Rushfield 2012; Filtenborg 2014; Stols-Witlox 2017; Simon 2019, Haack Christensen et al (eds.) 2020). These

often-unknown combinations of materials continuously influence the ageing and deterioration of the paintings.

While the materials and techniques of an artist are often investigated due to problematic issues in the state of preservation, Juel's paintings generally are in a well-preserved state with few losses suggesting that the structures of the paintings are in relatively good condition. Thus, it may be more relevant to ask what choices in materials and technique made it possible for Juel to uphold a production that was equally fast and of good quality, both in terms of visual representation and state of preservation.

As is common for aged paintings, all of Juel's paintings display cracks and craquelure. The paintings executed while he was travelling and working around Europe display a different type of craquelure from those produced in Denmark. The character of a craquelure pattern is related to the materials and methods employed by the artist (Bucklow 1997, Keck 1969). This supports the assumption that Juel used different materials or techniques while travelling from those he used while in Denmark and, further, might provide important insight into what materials or properties are responsible for such differences in craquelure patterns in general and their influence on degradation.

The overall hypothesis is that there is a correlation between the degradation patterns and the use of materials at different times and locations during Juel's career, and that, rather than making use of secret formulations and techniques as suggested by contemporaries and art historians, Juel simply was a master of his craft. This study will test the assumption that he used the same materials as were available for other painters and in a traditional, non-experimental manner, with good technical skills and an assertive hand.

Based on the examination of twenty-two paintings from throughout Juel's career, this thesis aims to address two main questions, which can be summarised from the above:

- How do materials and techniques change with regard to time, location and availability of materials throughout Juel's career?
- How do differences in the use of materials and techniques correlate to degradation patterns, especially craquelure?

1.2 Purpose

A significant condition for the preservation of our cultural heritage is a comprehensive understanding of the complexity of materials that constitute the objects as well as insight into the artists' intentions and work processes during the creation of the artworks. This helps to understand the degradation processes within the constituent materials and to predict the reaction to their ambient environment and to various conservation treatments and materials applied by

conservators over time. The knowledge obtained in this thesis can ultimately provide a basis for an enhanced preservation strategy for paintings on canvas by Juel and his contemporaries.

Juel left behind more than 600 paintings on canvas from throughout his forty-year career. Thus, being the most productive painter of his era in Denmark, a study of his paintings provides not only specific information about his work, but makes him a suitable representative for the general use and availability of materials, as well as the technical and practical aspects of painting in Denmark in the last half of the eighteenth century. Understanding the materials of Juel's paintings allows us to differentiate between the painting techniques used over time and at different locations, as well as gaining an understanding of how information was shared between painters.

An account of the material and technical changes throughout Juel's career may also form the foundation for further research that could aid in matters regarding authenticity and dating, as well as generating additional biographical information. Lastly, as Juel was likely to have influenced the generation of painters following in the Danish Golden Age, technical analyses of his paintings may provide an insight into this broader aspect as well.

The material laid out in the thesis can contribute to comparison for further analyses of Juel's paintings and his contemporaries, both in Denmark and abroad, in order to understand the developments and differences in materials and techniques across borders and the impact on the preservation state of paintings in general.

1.3 Theoretical and Methodological Framework

The research conducted in this thesis is founded on the understanding of paintings as material expressions of history and practice, depending on technical execution and the application of materials. The purpose of the examination of artworks is to extract information regarding relevant trends and patterns in the use of materials and techniques employed during their creation. This approach takes place within the framework of the fields of conservation – concerned with the preservation and conservation-restoration of cultural heritage – and technical art history; the latter is a rather newly termed discipline, which emphasises the knowledge of techniques, materials and studio practice of an artist by the interdisciplinary collaboration between conservation, conservation science and art history (ICOM-CC 1984; Muñoz Viñaz 2005; Ainsworth 2005; Considine 2005; Hermens 2012; Marvelde 2015; Stoner 2015; Cardinali 2017).

Insight and knowledge regarding the techniques, materials and studio practice of an artist are of great importance to the proper conservation and restoration of artworks; firstly, to understand the degradation processes taking place within an artwork, and secondly, to better understand and respect the artist's intent and maintain the integrity of the artwork. Technical studies may also provide information relating to dating and provenance of an artwork, which can be important to both conservators and art historians. Scientific methods from chemistry and physics providing

quantitative data are utilised to characterise the materials and methods used for painting as well as to identify issues in their condition or state of preservation (Ciliberto & Spoto 2000; Hermens 2012; Stoner 2015; Burnstock 2017). The state of preservation of a painting is a result of drying and natural ageing processes in the material of the layers, beginning the moment they are applied by the artist and progressing slowly over time. These processes are inherent to the painting and depend on the materials chosen by the artist. Variations in the quality of the different materials applied, their characteristics, mixtures or combinations, the layer build-up and thickness, the type of binding media, pigments, fillers, additives and particle size are all factors influencing the chemical environment and reactions within the composition (Toussaint 1974; Keck 1969; Zosel 1980; Mecklenburg 1982; Bucklow 1997; Van Loon et al 2012). The stability and interaction between layers is ultimately a result of the technical knowledge and skills of the artist and the choices made in the creative process with regard to materials and their application. These both affect the aesthetic qualities and the durability of the paintings. Furthermore, external factors such as their physical environment influence the reactions within the composition of the painting. Light, temperature, relative humidity, air pollution, vibrations and mechanical damages play a major role in the acceleration of ageing and deterioration processes (Van Loon et al 2012). Although conservators work with the best intentions to prolong paintings' and other objects' lives, historically treatments by conservators and materials applied to paintings may in some instances have caused harm to the painting structure, immediately or over time (Percival-Prescott 1974; Bomforth & Stanifort 1981; Stoner & Rushfield 2012). Preservative measures such as controlled environmental conditions during storage, exhibition and transportation aim to slow down the ageing processes to minimise the need for physical intervention. However, when intervention can no longer be avoided, material knowledge facilitates the evaluation of the physical condition such as deterioration and past treatment, and may be helpful in conservation decisions and in tailoring the treatment applied to the artwork.

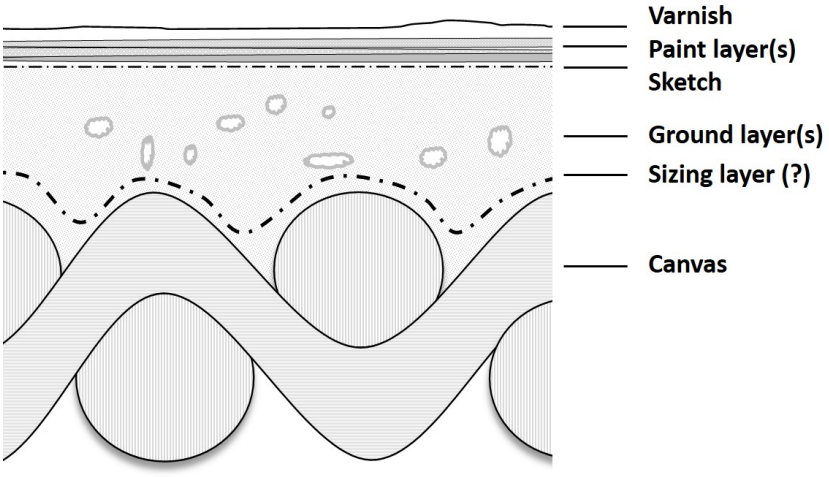


Fig. 1.2 Stylised schematic layer build-up of a traditional oil painting on canvas (ill. by Tine Slotsgaard[2]).

[2] Unless otherwise noted, illustrations throughout the thesis are created by the author, Tine Louise Slotsgaard.

A traditional oil painting on canvas consists of a number of different layers, which usually include preparatory layers applied to the canvas support before the paint layers are applied (Stols-Witlox 2017). These layers usually consist of one or two ground layers and, at times, intermediate isolation layers or a sizing layer before the ground layers. The term *preparatory layers* refers to layers between the support and paint layers, which are recognised by being applied to the entire surface to be painted. Thus, they can be distinguished from the sketch or underpainting, as these are local applications and considered a part of the painting stage as they relate to the design or image. The number of paint layers depends on the technique of the artist and can consist of a single layer, few or multiple layers. Finally, a layer of varnish is applied, with the effect of saturating the colours and protecting the surface. At some time in the preparation process, the canvas is stretched and mounted onto an auxiliary support. Artists at different times and locations selected different materials and techniques and thus variations and modifications exist between the use of layers and the layer build-up. Figure 1.2 shows a schematic build-up of a traditional oil painting on canvas.

Painters' skills and technical knowledge can be studied in various ways, including visual observations and advanced technical analyses of the techniques and materials applied in an object. With scientific methods, it is possible to go beyond the scope of what a person can perceive by looking at the object. To obtain knowledge of the materials constituting the different layers of a painting, technical analyses can provide information concerning the original material as well as detecting and identifying alterations made to the artwork over time, to separate original materials from later applications or interventions, such as retouching. This is essential for the most correct interpretation and identification of original materials and intent. To interpret and understand the results of the analyses it is necessary to lean on art-technological source material, to relate the materials to the era and common use to understand the connection between the artists' choices, socio-economic influences, geographical location and differences in trade and availability. The original voices of the artists, found in journals, correspondence, treatises, recipe books and other contemporary writings on techniques, are central for a proper interpretation of technical data. Around the middle of the nineteenth century, an interest in documentary-source research arose, particularly with technical scholars such as Mary Philadelphia Merrifield (1804/1805–1889) and Charles Lock Eastlake (1793–1865), whose transcriptions and translations of historical recipe sources attest to their motivation to understand developments in early painting techniques (Nadolny 2005). Soon more transcripts by other scholars followed, and since then many historical sources have become available in facsimile editions or transcriptions. Such sources provide crucial support to the technical analyses, as they act as an important comparison and aid in interpretation and understanding of the materials used by artists over the centuries. Additionally, reconstructions from these sources are used to obtain insight into the practical aspects of the craft and its interpretation (Carlyle & Witlox 2005; 2007; Carlyle 2006). The combination of these methodological approaches contributes significantly to our understanding of artworks and their execution; thus, art history, documentary sources, conservation and material science support each other (Hermens 2012).

The first scientific analyses in the study of historical paint were introduced as early as around 1780 (Nadolny 2003). However, mainly since the early twentieth century, the use of analytical methods in studies concerning artworks have contributed to increased knowledge with regard to historical painting techniques and artists' use of materials. In 1888 a scientific laboratory was founded at the Staatliche Museen, Berlin, and during the 1920s and 1930s technical or scientific departments were established in institutions such as the British Museum (1920), Fogg Museum at Harvard's Centre for Conservation and Technical Studies (1928), the Courtauld Institute of Art (1932), the National Gallery, London (1934), and the Doerner Institute in Munich (1937) (Thomson et al 1977; Faries 2003; Bewer 2010; Stoner 2017; Burnstock 2017). Initial methods included X-radiography and were intended to detect forgeries and identify masterpieces (Eastaugh 2009; Nadolny 2012; Hermens 2012; Stoner 2015; Burnstock 2017). Technical journals emerged as early as the 1880s, with *Die Technische Mitteilungen für Malerei* in Munich, followed by *Technical studies in the Field of Fine Arts 1932-42*, in England, and the first international conference regarding scientific examination of artworks was held in Rome in 1930 (Nadolny 2012; Kinseher 2014; Stoner 2017; Cardinali 2017). The development of conservation science as a discipline is exemplified by the establishment of *Studies in Conservation* in 1952 and the later *National Gallery Technical Bulletin,* published from 1977 (Thomson et al 1977; Burnstock 2017). Especially during the past fifty years, the focus on technical and scientific research of paintings has increased (Burnstock 2017).

The interaction between art history and technical analyses has led to the development of various scientific analytical techniques, as well as the integration of existing scientific or industrial techniques into the field of technical art history and conservation. Increasingly, scientific analysis is considered an integral part of conservation and the care of paintings. In many art museums today, technical art history has become a part of the interdisciplinary collaboration between conservators, scientists and art historians, resulting in new knowledge about the materials and techniques of specific periods and certain geographical locations. Over the past decades, there have been substantial advances made in the application of modern scientific techniques to the chemical and structural analyses of works of art. However, there is still room for improvement, as the analysis of artworks is generally a very complex and demanding area (Faries 2003; Considine 2005; Eastaugh 2009; Hermens 2012).

1.4 Research Design

Within the framework of the above theory and methodology founded on an object-based empirical approach and interdisciplinary research methods, this investigation makes use of descriptive research with a hypothetic-deductive approach to identify characteristics, frequencies, trends and correlations.

Based on the assumptions that there are differences in the materials and techniques used throughout Juel's career and that materials used in the paintings result in different reactions

throughout the degradation processes, twenty-two paintings were selected, which would provide a timeline throughout Juel's career to identify common parameters, differences and variables. This built upon a preliminary investigation of eight paintings – four from the early period and four from the later period – which gave an initial insight into Juel's techniques, use of materials and studio practice, and suggested that a change in these aspects might have occurred during his years abroad. The paintings examined for this thesis include paintings both from Juel's early and later years in Denmark, as well as six paintings from the eight years he spent abroad during the 1770s. This range was selected to obtain insight into how Juel's materials, technique and studio practice changed relative to time, location and availability. The selection criteria and a presentation of the selected paintings are given in Chapter 3.

The paintings were examined and various methods of technical analysis employed. The method and research design takes on a systematic approach to the paintings, where each layer of the painting is examined and characterised both individually and as an element of the entire structure. This is undertaken to characterise the original material, to identify alterations and applications of non-original material which may produce false results in analyses, as well as to consider the state of preservation of the paintings. The applied techniques are all technical methods commonly used in analysis of paintings within the field (Thomson et al 1977; Ciliberto & Spote 2000; Faries 2003; Pinna et al 2009; Burnstock 2017). The methods chosen are among those accessible in the scientific laboratories between the Royal Danish Academy – Institute of Conservation, the National Gallery of Denmark and the National Museum of Denmark, while Gas Chromatography/Mass Spectrometry (GC/MS) analysis was made accessible through the National Gallery of Art in Washington D.C., USA. The planning of the research was estimated and based upon the constraints of time and finances for a three-year PhD in Denmark.

Various methods of analysis offer different results and it is those results combined that provide the overall information on the painting technique and materials, and how these were applied in the practical execution of the paintings. Visual analyses, microscopy and different light and radiation sources, such as ultraviolet, infrared and X-rays, are used to obtain as much information on the layers and the state of preservation as possible, as these are all non-invasive methods that do not require sampling or for components to be removed from the paintings. Some non-invasive analytical instruments provide information on the elemental composition, such as X-ray Fluorescent Spectroscopy (XRF), or molecular compounds, such as External Reflectance-Fourier Transform Infrared Spectroscopy (ER-FTIR) and Fibre Optics Reflectance Spectroscopy (FORS), which can be used to identify pigments in the paint and ground layers.

Other methods of analysis require sampling of material from the paintings. As it is always sensitive to remove original material from artworks or other objects of cultural heritage, this act was limited to one or two samples mounted into cross-sections, preferably sampled from the edge of the painting in areas already displaying some damage. Cross-sections provide a valuable

window into the structure and composition of the different layers of a painting. On the mounted cross-sections, Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (SEM-EDX) was used to identify the elemental composition of specific layers, while Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR) mapping and Raman Spectroscopy assisted in the determination of molecular compounds. Besides cross-sections, a sample of the ground material from each painting was removed and analysed by Gas Chromatography/Mass-Spectrometry (GC/MS), which is the most widely used method for identification of binding media in art samples (Colombini et al 2010). Furthermore, a thread from each direction of the canvas was sampled from the very edge of each painting to analyse the fibres and threads. Each individual analytical method, its purpose and application is described in further detail in Chapter 4.

The results of the analysis of the use of materials and techniques are to some extent compared and discussed with relation to known contemporary written sources and publications on artists' materials and technical examinations of paintings of other painters, as these support the interpretation and understanding of observations and scientific results made during the investigation.

1.5 Focus and Delimitations

Juel left behind close to a thousand portrait and landscape paintings, drawings, sketches and pastels. For this thesis, the choice has been to examine portraits on canvas. This was Juel's preferred support and his portraits on canvas number at least 600. This amount constitutes a large number of artworks in total for this era of practice in Denmark.

This study builds upon a previous examination of eight paintings and adds twenty-two paintings to the total number of artworks studied in the pursuit knowledge about Juel's use of materials, techniques and studio practice. While the selection of paintings has focused on covering the timeline of Juel's production to obtain knowledge about changes taking place throughout his career, it has to be made clear that such a number of examined paintings will only allow for an overview and perhaps a fragmented insight into the entirety of Juel's use of materials and techniques throughout his almost forty-year career. However, it is not possible to examine all paintings and the research has to start somewhere. This study may act as a foundation for further studies in the future – both of Juel's techniques, and those of his contemporaries.

In general, sampling was done as a single-point reference. Such limited sampling can at times be misleading, unless great care is taken in the interpretation of optical and chemical evidence, especially if the sample contains homogeneous material (Harris 2010:6,701); however, as the selected paintings are valuable artworks, extensive sampling to obtain certainty would be ill-advised. No treatments or reconstructions were performed during the investigation, so all results are based on visual observations and the interpretation of technical analysis.

A few subjects that could have been touched upon have been left out. For instance, even though most of Juel's paintings remain with their original frames, and it must have been a large production over the decades as the price is often included in the receipts and they were quite valuable (Slotsgaard 2019), any descriptions and considerations of the frames have not been included.[3] Questions with regard to originals and copies of Juel's portraits frequently arise. It is well known that Juel had assistants working with him in the studio who made copies or replicas of portraits. Otherwise, it is not entirely clear which elements of the practical execution may have been performed by Juel's assistants. A direct comparison between different versions depicting the same sitter may reveal different approaches to the paintings between originals (first versions) and repetitions, which could provide evidence of the executing hand. This could help establish authenticity in portraits that exist in several versions or occasionally emerge in auctions from private ownership. A similar study was recently undertaken by Alexandra Gent with regard to portraits by Reynolds and his studio (Gent 2019). However, such research requires a steady foundation of knowledge of the technique used in Juel's paintings from previous studies. These studies are limited; therefore, such consideration is not included in this thesis. The focus has not been placed on attempting to establish visually stylistic or technical sources of inspiration for Juel's paintings from other artists either. Similarly, while some comparison has been extended to the practice and materials employed by other artists of the era as a comparison to the findings in Juel's paintings, it has not been possible, nor the intention, to pursue a full review of the literature and research on contemporary artists. The main focus has been kept to the information that can be extracted from Juel's paintings specifically. Furthermore, as archival studies and obtaining new knowledge from historical records is very time-consuming and often a research project in its own right, this thesis primarily takes such information from already published resources and studies of archival materials.

1.6 Current State of Research

While this study is based primarily on the examination of Juel's paintings, it also builds upon an existing biographical knowledge of Juel and his contemporaries and existing publications on materials and techniques employed by other artists, both in Denmark and abroad.

In later years, there has been an enhanced interest in the eighteenth century within both art history and technical art history; however, even internationally, technical studies on eighteenth-century portrait painters remain scarce, although the number is increasing. English portrait painters such as Sir Joshua Reynolds (1723-1792), Thomas Bardwell (1704-1767) and Sir Henry Raeburn (1756-1823) have been fairly thoroughly investigated, and German portrait painters such as Anton Graff (1736-1913) and Philip Otto Runge (1777-1810), just to mention a few, have also been

[3] Concerning frames, it shall briefly be noted here that the previous suggestion that Juel used a framer named Kriedt (Slotsgaard 2013; 2019) as per a letter from Juel to his wife (Glarbo 1929) is incorrect. The term Rammesnieder (*Ramme*=Frame; *snieder*=cutter/fitter) is misspelled and should be *Remmesnieder* (*Remme*=Straps), which refers to a saddler or coachbuilder not a framer.

subject to technical studies (Kirby-Talley 1986; Brett et al 2011; Gent et al 2014; Kirby-Talley & Groen 1975; Stevenson 1998, Mösl 2013; Möckel & Castro 2013). Further, a number of publications focusing generally on, for instance, Dutch and French painting technique of the era exist (for example: Hendricks 2006; Massing 1998; O'Donoghue et al 1998; Phoenix et al 2009). The book *Conservation of Easel Paintings* published in 2012 (Stoner & Rushfield, eds.) does impressive work in encompassing the current state of knowledge, as regards materials, techniques, conservation history and conservation treatments, with references to documentary sources and technical publications, which include those of the late eighteenth century. Conservator Maartje Stols-Witlox, in her research on ground layers, has done an impressive comprehensive study of the materials and techniques described in historical recipes for ground layers used in north-west European paintings between 1550 and 1900 (2014; 2017); this publication, and the information it contains, has been an important source for comparison during the examination of Juel's paintings for this study. It is not the intention here to make an exhaustive review of the technical research published internationally and used throughout this thesis; however, it is important to emphasise that technical publications, such as those mentioned here, allow for a comparison of theory and practice between various artists, eras and geographical locations. The larger the number of artworks analysed and the more written sources become available, the better the comparison becomes – and thus our understanding of artists' choices, work processes and material knowledge, which can be pieced together with technical observations and the condition of the paintings, deepens.

In the following section of the introduction, more in-depth focus has been given to outlining the existing biographical information on Juel and the current state of art-historical, material and art-technological research on Juel and other painters in Denmark in the eighteenth century.

1.6.1 Biographical and Technical Research on Jens Juel

Despite Juel's popularity in his own time, art-historical research into the painter's life and oeuvre was scarce for a long while. According to the historian Ole Feldbæk (1992), the early art critics of the nineteenth century regarded him simply as a representative of the blooming era and mainly acknowledged his endeavours as a predecessor for the then-more-appreciated painters of the Danish Golden Age, which followed in the early nineteenth century. Fortunately, this attitude changed around 1900, when Juel truly gained art-historical acknowledgement for his eminent skills (Madsen 1909).

Besides a brief mention in N.H. Weinwich's artist encyclopaedia from 1811, the early Danish art historian N.L. Høyen made the first proper biographical description in 1828. This is believed to have been based mainly on oral histories from Juel's contemporaries (Glarbo 1929-30; Poulsen & Monrad 1982). Along with other contemporary sources, Høyen's description laid the foundation for the biography in the first publication of *Weilbachs Kunstnerlexicon* in 1877 to 1878. In 1891, A. Lowzow published a memorial, and the archivist Henny Glarbo published an

article in *Kunstmuseets Aarskrift* in 1926 to 1928, which both contributed to new biographical information on Juel, his birthplace and parents (1929-30). A previous article by Glarbo from 1925, on Danish artists in Geneva, contributed important information on this period of Juel's career, and the art historian Christian Elling supplied information on Juel's breakthrough and first years in Copenhagen (1941). From the 1870s onwards, several small publications in the context of anniversaries, exhibitions, new acquisitions, emerging paintings and biographies were produced; however, none of these contributed much new biographical information (see for instance Lange 1873; Hannover 1902; Røder 1904; Madsen 1909; Swane 1944).

The art historian Ellen Poulsen (1911-1995) made the most important contribution in collecting new information on Juel's life and career. Since 1936, and for more than fifty years, she performed a systematic search and registration of Juel's paintings in Denmark, as well as abroad (Møller 1982). The early critics had been unaware of some of these paintings, which rate among Juel's best artworks (Christensen 1996a:26). Finally, in 1991, Poulsen's catalogue raisonné of Juel's paintings and pastels was completed and published. The catalogue has some errors and is not entirely complete, but as Poulsen, herself expressed in the preface: "To prepare a complete and final catalogue of Juel's oeuvre is not possible – additional paintings continue to emerge, and many others are still missing. Now, however, after half a century's compilation of material, the endeavour is brought to its conclusion – whatever its flaws and imperfections." (1991:7). All paintings and pastels that were known in 1991 are recorded in the catalogue and indexed chronologically. The anchor-points are the works signed and dated by Juel himself. The undated works unfortunately represent a bulk in his production and are tentatively placed within decades. The dating is based partly on the artistic development in Juel's style, and partly on biographical factors of the sitters. Clothing and hairstyles of those portrayed give a strong indication of the decade, based on fashion history. Poulsen's catalogue raisonné is an important source of information when working with Juel's paintings.

The biographical section of the catalogue is mainly a rewrite of Poulsen's book on Juel from 1961. A catalogue of Juel's drawings from The Royal Collection of Graphic Art (at SMK) from 1975 was also published by Poulsen. The art historian Torben Holck Kolding contributed with a sections on eighteenth-century art in *Dansk Kunsthistorie* (1972a; 1972b), which included information on Juel's work. The art historians Kasper Monrad (1982 (Poulsen &); 1989; 1993; 1996) and Charlotte Christensen (1996) have both published works on Juel. Christensen edited the extensive catalogue for the last large exhibition of portraits by Juel at the Museum of National History at Frederiksborg Castle in 1996.

More recent studies and inclusions in exhibitions have focused on Juel's practice in landscapes. Although landscape paintings made up about ten percent of his production in his later years, this practice was downplayed by early art historians who considered them to have been completed in "moments of leisure and for pleasure" (Weinwich 1811). In more recent years, however, Juel has gained recognition as one of the forefathers of Danish landscape painting (Kold 1989; Hvidberg-Hansen et al 2011; Oelsner 2012; Løventoft-Jessen 2013).

A re-evaluation of Juel's work in art history is long due and currently two new art-historical contributions are in the making: one by art historian Birgitte Zacho that focuses on Juel as enlightened artist and how his works relate to enlightened thinking in Denmark and Europe at the time (forthcoming), and another by art historians Anna Schram Vejlby and Thyge Christian Fønss-Lundberg, which focuses on Juel as a European master. It relates his work to the stylistic and spiritual trends occurring in Europe during the late eighteenth century and to his European contemporaries, such as Pompeo Batoni, Johann Zoffany, Anton Graff, Alexander Roslin, Jean-Etienne Liotard, Anton von Maron, Jean-Baptiste Chardin and Benjamin West (forthcoming/2021).

While art historians and the publications mentioned above at times make comments regarding Juel's technique, use of materials, studio practice and state of preservation, no focused studies on these subjects were performed before 2013. The first technical study on Juel's painting technique was conducted during my master thesis completed in 2013. Subsequently, the results were presented at the international conference *Studying 18th-Century Paintings and Works of Art on Paper* in 2014 and published in the conference proceedings (Slotsgaard 2015). The investigation showed evidence of a change in painting technique between the early period and the later period of Juel's career and acts as preliminary research for the current thesis. A paper from 2019 with the title 'Jens Juel and the Business of Portrait Painting' examines the circumstances that may have contributed to Juel's success and whether the increasing demand for portraits influenced their production, concerning technique and materials, while extending comparison to portrait painters from nearby countries, especially Sir Joshua Reynolds and Anton Graff (Slotsgaard 2019).

Besides the studies made by the current author, paintings conservator from Norway, Lise Sæter, in her master thesis, did a thorough investigation of a portrait by Juel depicting Maren Rosenkrantz neé Juel (no relation to the artist) (c. 1790), listed as entry no. 523 in Poulsen's catalogue raisonné. Three or four versions of the portrait exist, including one at the National Museum of Norway. It is not entirely clear which version is the original first version, and thus references to these results are limited in the current thesis (Sæter 2016).

1.6.2 Technical Art History

Not many publications on individual eighteenth-century Danish painters exist. Besides the publications on Juel mentioned above, there are some larger art-historical publications on Juel's colleague the history painter Nicolai Abildgaard (Christensen 1999; Kragelund 1999; Lederballe 2009; Bregnhøi & Raabymagle 2019), and Charlotte Christensen has made a large contribution to the life and work of Juel's predecessor the Swedish-born portrait painter Carl Gustaf Pilo (1711-1793) (2016).

Paintings conservator Troels Filtenborg (2014; 2015) has published a significant technical study on Abildgaard, which he relates to general technical and practical aspects of eighteenth-century

European painting technique. While some artists in their practice show evidence of an evolution of technique or use of materials related to changes in style or subject or shifting availability of materials, this does not seem to be the case for Abildgaard. The study concluded that Abildgaard does not seem to convey to one single set of standards for his production of paintings throughout his career and that many structural features show varying technical solutions applied in the creative process with no apparent relation to the chronology of his production. Even his serial productions take a somewhat arbitrary approach, with a variety of interchanging methods, although separate components are characteristic of eighteenth-century painting. Certain elements, however, are due to circumstances of time and place, such as the nature and availability of specific materials. The publication does not provide information on the state of preservation of the paintings. However, Filtenborg has stated that no systematic issues inherent in the paintings appear in those examined, and damages are primarily related to external factors to which the individual paintings have been exposed (personal communication November 2020). This publication is not only essential as a contribution to the limited information on painting technique in eighteenth-century Denmark, as Juel and Abildgaard were contemporaries and followed largely parallel careers, but it also acts as an important comparison to Juel's use of materials and techniques, as well as sources of inspiration and art-market conditions in Denmark. Conservator Line Bregnhøi and art historian Hanne Raabymagle recently contributed with a publication focusing on Abildgaard's undertakings as an architect and artist of decorative interiors (2019).

Further, Loa Ludvigsen et al have published an article on the techniques of early eighteenth-century court painters Hendrik Krock (1671-1738) and Benoît le Coffre (1671-1722) (2015). Besides this, no structured technical studies have been performed on Danish painters active in the eighteenth century. Conservator Anne Haack Christensen's research on the accounts of the Colour Chamber during the reign of Christian IV in the early seventeenth century provides important insight in the trade, availability and usage of (coarse) painters' materials at this time (2017; 2019). Similarly, conservator Line Bregnhøi's publication from 2010 focuses generally on usage of materials as well as decorative techniques for the painters' crafts in Denmark in the period between 1790 and 1900. These publications focus on the periods immediately before and after Juel's era and add to the general knowledge on the condition of painters' crafts and available materials at these times. As the periods covered by the above-mentioned publications show, there are still large gaps in knowledge of these aspects, especially concerning the late-seventeenth and eighteenth centuries in Denmark.

1.7 Structure of Thesis

The structure of this thesis takes its form as a monograph and consists of twelve main chapters. The current chapter, Chapter 1, introduces the research project with problem statements, hypotheses, research questions and purpose, the theoretical and methodological framework, research design, delimitations and the current state of research regarding the biographical and technical research on Juel and his era.

Chapter 2 provides an insight into the historical background for the thesis, including a brief introduction to the societal circumstances of late eighteenth-century Denmark, the position of art and commerce, the establishment of the art academy and the position of Danish artists and the portrait painter. Juel's life and career are outlined and certain elements regarding his training, sources of influence, his career and production, position in society, studio practice and use of assistants are elaborated upon.

Chapter 3 introduces the empirical elements of the project consisting of twenty-two portraits on canvas and the criteria for their selection.

Chapter 4 presents the research-design and describes all the primary methods of examination and analysis to investigate the materials and techniques used in the selected paintings and to evaluate the paintings' state of preservation. Each method is described including its purpose, limitations and the practical approach by which it has been carried out.

Chapter 5 presents and describes the general trends and exceptions in the state of preservation and degradation patterns in the examined paintings by Juel. These concern the extent of losses of ground and paint layers, lining treatments, crack patterns and surface phenomena, including a brief overview of the theory of their common causes. Generally, the paintings are in good condition with the most common features being the crack patterns that generally display two different morphologies, which can be correlated to geographical location and material used in the ground layers.

Chapters 6 to 10 focus on each layer of the traditional structure of a painting respectively. Each chapter initiates with a brief introduction to the layer regarding theoretical and practical aspects of the traditional use of the layer or its materials as well as its potential properties within the structure of the painting. Each chapter provides results and discussion on the visual observations and technical analyses for the layer. These chapters give an overview of the materials, techniques and studio practice throughout Juel's career, if any changes occurred with regard to time, geographical location and availability of materials, as well as an evaluation of how each layer may contribute to degradation patterns and the different morphologies of the craquelure.

Chapter 6 examines the original strainers in Juel's paintings, their construction, manufacture and current structural stability. It evaluates where Juel may have acquired them, as well as the availability of expandable stretchers in Denmark.

Chapter 7 characterises the canvasses used as support for Juel's paintings to obtain a better understanding of variations in market conditions, such as format and canvas roll width, and the artist's choices in fabric support. Investigation is also carried out into how the canvasses were prepared for painting, whether some of the paintings originate from the same canvas roll and how this may have an effect on the art-historical dating of the portraits.

Chapter 8 investigates the use of sizing in Juel's paintings. Juel's era of practice took place in a time of transition between a traditional use of sizing and a seemingly later tendency to omit the layer. It could appear that in the majority of Juel's paintings produced in Denmark the sizing layer was omitted.

Chapter 9 investigates Juel's use of ground layers throughout his career. Firstly, this is considered concerning variation in use of ground colour and structure and how these may reflect a certain time, practical influence or pattern in practice. Secondly, the results of analyses of the composition of pigments and fillers, as well as the binding media, are presented and discussed. It could appear that particularly the difference between pigments and fillers used in ground layers in paintings produced in or outside of Denmark may explain the different crack patterns between locations. Finally, based on the observations and results of analyses of the ground layer composition and application, it is assessed whether the canvasses may have been prepared in Juel's studio or purchased pre-primed from a supplier.

Chapter 10 characterises the design layers in Juel's paintings by investigating the structure of the composition and the build-up of paint layers, from initial sketch to finished portrait. Juel's palette and use of pigments are investigated to see whether use of pigments changed over time or depending on location and to establish whether there is compensation of different pigments or layers depending on ground colour. Furthermore, the use and application of varnishes is briefly discussed.

Chapter 11 contains the main discussion, which reflects on the results of analyses and discussions made throughout Chapters 6 to 10 by establishing synergy between the layers and how this relates to the overall hypotheses and research questions for the thesis. This is considered with regard to Juel's own use of materials and practice, as well as in relation to how such information can enhance our understanding of the general practice, availability of materials and emerging art market in Denmark in the late eighteenth century. Furthermore, it is applied to an enhanced understanding of the entire structure of the painting, how the layers influence each other and their combined role in the preservation or degradation of the paintings. The chapter also includes reflections on conservation treatment of the paintings – both past and future – with some general advice and concerns.

Chapter 12 summarises the conclusions of the research conducted in the thesis with consideration to its contribution to knowledge and some avenues for further research.

2 Jens Juel and His Era

The last half of the eighteenth century, when Juel lived and worked, was an era of transition with many emerging trends, societal circumstances and evolutions relating to the Enlightenment, many of which would become dominant in the nineteenth century. In Denmark, the absolute monarchy still had supreme authority and the nobility retained great power. Due to financial growth, the expanding bourgeoisie gradually gained more influence. The changes in cultural society, which took place from the Middle Ages, probably resulted in the greatest change in everyday life of ordinary people during the eighteenth century (Poulsen & Monrad 1982; Venborg Pedersen 2013). The establishment of Danish art during this era is evident by the foundation of the Royal Danish Art Academy in 1754, the first public art exhibitions and emergence of art critics. The main purpose of the academy was to produce and educate a collection of artists and artisans to accommodate the diverse artistic activity required by the king and to ensure the country could provide the appropriate talent (Colding 1972a:11-15; Monrad 1989; Salling & Smidt 2004:23-31). This placed a gifted portrait painter such as Juel in a central position. Not only was Juel highly talented, but he also had a good understanding of business and, according to contemporaries, an endearing personality (Ramdohr 1792:161; Colding 1972b:160; Slotsgaard 2019). He adapted quickly to societal changes and trends and seemed willing to meet market demands and client requests. Through his connections in society and some self-promotion, Juel became a public figure who achieved a popularity and fame unprecedented for a Danish artist (Slotsgaard 2019).

This chapter is intended to provide insight into the historical background regarding Juel's era and production as context for the investigation and examination of his paintings. It initiates with a brief introduction to the societal circumstances in late eighteenth-century Denmark, the position of art and commerce, the establishment of the art academy and the position of Danish artists and the portrait painter. Juel's life and career are briefly described, first as a biographical outline, while the following sections elaborate on his training, sources of influence, his career, his production and position in society; further, some insights into his studio practice and use of assistants are discussed. Understanding of these subjects regarding the circumstances and conditions of practice in the span of Juel's life support the examination of his paintings and discussions made throughout this thesis.

2.1 Art and Commerce in Late Eighteenth-Century Denmark

In the last half of the eighteenth century, the Danish kingdom was a typical, medium-sized European state with a linguistically and culturally mixed population (Juul 2013). Denmark was experiencing a golden age of commerce, which was partly due to the country remaining neutral to wars of the era and, like many other European countries, making great earnings in international trade of colonial goods and export of agricultural products (Olsen 1962:216). The industrial

revolution, initiated in England in the mid-eighteenth century, gradually spread to the rest of Western Europe. However, it would be at least a century before industrialisation had its proper break-through in Denmark (Olsen 1962). Generally, tendencies emerging in the large cities such as Paris and London also spread to Denmark, although often with some delay; compared to Central Europe, Denmark was peripheral (Feldbæk 2012). Trends were shared and spread by letters, newspapers, books, treatises, travellers and nationals returning from the Grand Tour.

Copenhagen was by far the largest city in Denmark and the centre of commerce, fashion and culture.[4] Many common goods available in the rest of Europe were also available here. What was not readily available was ordered specifically from other countries. This is, for instance, evident through advertisements and entries in *Adresseavisen*, the oldest newspaper in Copenhagen (from c. 1759) (Mediastream; Venborg Pedersen 2013:59-60). Generally, European society was experiencing rapid commercial growth, and with an expanding bourgeoisie with money to spend on luxury goods, a new type of consumerism emerged (North 2008; Venborg Pedersen 2013). For centuries, aristocratic luxury had been connected to wealth, status and power, whereas the new bourgeois luxury was embedded in trade, utilitarianism, consumerism, taste and comfort. Due to a golden age of trade in Denmark, the bourgeoisie was expanding and seeking to emulate the court, aristocratic concepts and fashions, and to challenge the nobility (Venborg Pedersen 2013). There was an until-then-unheard-of change in the sophistication of habits, practices and traditions, and the use of people's homes expanded in the spheres of both private and public life; homes became filled with objects and luxury items, including furniture and paintings (Ramdohr 1792:339; Elling 1958; North 2008; Venborg Pedersen 2013). Dutch and Flemish paintings were especially popular with the new collectors (Svenningsen 2015:103) and with relation to an increased self-awareness, portraits provided sitters with a means of asserting social status. Portraiture, especially, gained new audiences and became a dominant artistic genre. This subverted the traditional academic hierarchy, which placed history painting higher than portraiture, genre, landscape and still-life paintings (Lippencott 1995; Murray 2004; Salling & Smidt 2004:43). There is evidence of the establishment of prolific and successful portrait painters in Europe, who gained both fame and the prestigious social status of public figures. Prime examples of this type of portrait painter are Sir Joshua Reynolds (1723-1792) in England, Anton Graff (1736-1813) in Germany and Jens Juel (1745-1802) in Denmark (Slotsgaard 2019). They all had careers closely connected to the newly established art academies in their countries and simultaneously ran busy private studios with assistants and students.

[4] The census of 1769 lists 92,500 inhabitants, while it rose to 101,000 at the census in 1801. The second largest city in Denmark was Odense, with only 5,200 inhabitants in 1769 and 5,800 inhabitants in 1801 (Dybdahl og Dübeck 1983:12). As comparison, London was the largest city in Western Europe with short of a million inhabitants, while Paris, the second-largest city in Europe, had a population of about 600,000 during this era (Emsley 2018).

2.2 The Artists and the Art Academy

The Royal Danish Academy of Fine Arts in Copenhagen was officially founded in 1754. Its establishment was a result of a development in Europe throughout the past centuries, from the establishment of the early academies in Italy to the foundation of the French art academy in 1648. Over the following century, academies were founded throughout Europe, inspired by the French academy (Pevsner 1940; Goldstein 1996). The establishment of the art academy in Copenhagen was a result of absolutist ideas and the aim of providing enough artistic talent for the king and country that had previously largely depended on foreign artists (Colding 1972a:11-15; Meldahl & Johansen 1904:8-60; Salling & Smidt 2004:23-31). The artists were subject to strict rules and conventions. Competitions, stipends, honorary titles and privileges kept them in a certain tradition under monarchical decree. The fact that the Danish art academy granted travel stipends provides an impression of their conscious effort to educate the different types of artist which were in need in society and, at the same time, avoid overproduction of representatives of certain genres. The ideal distribution, however, did not match reality and at times proved troublesome to sustain (Salling & Smidt 2004: 42-43). The country was not able to provide the necessary talent at all times and, in contrast, at other times the demand for artistic services was limited and caused an immense struggle, even for the academically educated and most gifted artists. Four artists, each specialised in a different genre, particularly stand out in the last half of the eighteenth century: Nicolai Abildgaard as a history painter, Cornelius Høyer (1741-1804) as a miniature painter, J.C. Clemens (1748-1831) as an engraver and Jens Juel as a portrait painter (Poulsen 1991:11). Juel served both the royal family, the nobility and the bourgeoisie. While Juel's studio was busy, other artists of the time were still highly dependent on a decreasing number of court commissions (Colding 1972b; Kryger 1991; Christensen 1996:18). This is, for instance, expressed in a letter from 1800 sent by Abildgaard to the Swedish sculptor Johan Tobias Sergel (1740-1814) in Stockholm: "Jens Juel who is the Director, continually paints portraits; he is the only one who has anything to do"[5] (cited in Poulsen 1991:23), to which the sculptor replied: "It doesn't surprise me that Juel is fully engaged; it is the same here, portrait painters are more like manufacturers than artists"[6] (Göthe 1900:48). Erik Pauelsen (1749-1790), who could not decide whether he wanted to be a history painter or a portraitist, was outshone by both Abildgaard and Juel, and ultimately committed suicide (Colding 1972b).

The education at the art academy was based primarily on theory and drawing, under which system copying from the old masters was fundamental and dominant. The aspiring painter was expected to undertake an apprenticeship in a master's studio to learn the practice of painting, as well as classes in the private studios of the professors of the art academy. As per tradition, the technical skills and practice of painting were passed down through oral transmission from master to

[5] "Juel, som er Directeur, maler uophørlig Portrætter, han er den eneste der har noget at giøre"
[6] "Je ne suis pas etonné que Juel a toujours a faire, ici c'est de méme, les peintres des portraits sont plus fabricants qu'artists"

apprentice in the individual studios. It was not the role of the academy to replace the studio practice, as the academy did not provide any teaching in the actual practice of paintings (Pevsner 1940:90,168; Goldstein 1996:115). Not until 1812 was a proper painting school established at the academy in Copenhagen (Salling & Smidt 2004:51-54).

2.3 Jens Juel – Biographical Outline

Juel was born in 1745 on the island of Funen in Denmark. He was the son of Elisabeth Vilhelmine Juel and tutor Jørgen Jørgensen. For many years, the story that Juel was the illegitimate son of higher-ranked gentleman persisted; however, now this myth has been discredited (Lowzow 1891:3; Glarbo 1929-30:207-10; Poulsen 1973:94-96).

At about the age of fifteen, Juel initiated his apprenticeship with the painter (Johann) Michael Gehrmann (1707-1770) in Hamburg. Around 1765 Juel returned to Denmark and became a student at the newly established art academy. Portrait painting became Juel's main subject, although he was required to practise classical history painting to participate in the competition at the art academy for a chance to win the gold medal and a stipend for a Grand Tour. Juel won the gold medal in 1771, however, the associated stipend went to his colleague the history painter Nicolai Abildgaard. The following year, in 1772, Juel embarked on his Grand Tour regardless; private benefactors sponsored him for four years. His travels took him to the most important artistic centres in Europe: Hamburg, Dresden, Vienna, Venice, Bologna, Florence, Rome, Naples, Paris, Geneva and Kassel. Juel managed to extend his trip to eight years by painting portraits on commission, especially in Switzerland, where he remained for three years. Juel returned to Copenhagen in 1780, and soon became official court painter (1780). Then he was elected member of the art academy (1782), professor (1784) and later director of the art academy (1795-97 and 1799-1801), while simultaneously maintaining a busy private studio with assistants and academy students (Poulsen 1961; Poulsen 1991; Christensen 1996; Monrad 1996; Slotsgaard 2013). During the 1780s and especially in the period after 1794, when Christiansborg Palace burned, Juel and his assistant Herman Kofoed functioned as conservators for the Royal Painting Collection (*Den Kongelige Malerisamling*, KMS, later SMK) (Poulsen 1961; Poulsen 1991:24; Scharff 2000).

Juel was originally engaged to a Swiss-Danish girl named Susanne Elisabeth Holm (1760?-1781) (Holm KMS1766, Fig. 3.8), whom he met in Geneva. However, she sadly passed in 1781 on her way to Copenhagen, where they were supposed to have married (Glarbo 1925; Poulsen 1991). Not until ten years later did Juel marry the much younger Rosine Dørschel, with whom he had six children. Their two daughters both married the Golden Age painter C.W. Eckersberg (1783-1853) who was a great admirer of Juel, first Julie (1791-1827) and, after she passed, her sister Sanne (1793-1840) (Glarbo 1929-30; Villadsen 2009:19). Juel died on 27 December 1802, rather suddenly, at the height of his career.

2.4 Juel's Training and Career

Juel's training reflects the traditions of the time. It is not known exactly what practical aspects Juel learned while an apprentice with painter Michael Gehrmann, but according to tradition, and as the division between artist and craftsman was still at an early stage, Juel was likely trained in all the practical aspects of painting (Høyen 1828:1; Weilbach 1877-78:340; Madsen 1909:258; Bregnhøi & Raabyemagle 2019:39). Juel seems to have been trained within north-German and Dutch technique and tradition, as evidenced by the Dutch-inspired paintings remaining from this time (see Section 2.5). Hamburg was the largest art market in Europe in this period and Dutch paintings were in high demand (North 1997:104; 2008:113). It is possible that Juel and Gehrmann supplied paintings to the commercial art market and that Juel's exposure to this market gave him a commercial insight he would later benefit from in his establishment and success as a portrait painter in Denmark (Slotsgaard 2019).

Books of knowledge

The little evidence that survives from Juel's apprentice years in Hamburg shows that he studied the same books and treatises as many other painters in north-west Europe in this era. The earliest preserved drawings from his apprentice years are classical and allegorical representations (Fig. 2.1) as well as two sketches for his first painted self-portrait from 1764 (*Self-Portrait KMS3990*, Fig. 3.1) (Poulsen 1975). Two books have been preserved, one containing copies of sixteen anatomical drawings (1679) by the Italian engraver Carlo Cesio (1623-1686), republished in the book *Die Durch Theorie erfundene Practic …* (1728-31) by Johann Daniel Preissler (1666-1737), who was director at the Nuremberg art academy, and two chapters from the book regarding light and shadow and drapery. The second book is a transcript from a German translation of Charles-Alphonse du Fresnoy's (1611-1668) poetic treatise *De Arte Graphica* from 1668. Preissler's book was the most successful drawing treatise in the German language and was republished in eight editions (Voss 1971:425-26; Röhrl 2000:186). It was popular also at the Danish art academy where it was mentioned first in 1750 and, along with treatises by the French painter Charles Le Brun (1619-1690), was one of the best and most used treatises in teaching (Voss 1971:426; Christensen 1999; Ludvigsen 2008:46-49). Du Fresnoy's treatise was equally one of the most influential French treatises on art in this period (Nadolny 2012:13,24). That Juel was familiar with these books even before attending the art academy attests to their wide popularity and their use in artistic training throughout Europe (Slotsgaard 2013:64).

According to tradition, Juel's master, the painter Michael Gerhmann, was the student of a student (possibly the Hamburg painter Hans Hinrich Rundt, c. 1660-1750 (Weilbach 1877-78:340)) of the Dutch painter Gerard de Lairesse (c. 1640-1711); however, this connection has been found doubtful in more recent research (Madsen 1909; Poulsen 1991; De Gruyter 2018). If so, however, Juel would likely, from an early time, also have been familiar with Lairesse's publication *Het Groot Schilderboeck* from 1707. A German translation of the book is listed in the estate auction

after Juel's death, along with at least 140 other titles of theoretical and practical books in different languages (Fugl 1803). A variety of different treatises on the theoretical or practical aspects of art were published and re-printed multiple times in several languages throughout the seventeenth and eighteenth centuries (Pevsner 1940:90-95; Talley & Groen 1975; Harley 1982; Schieβl 1989:99; Massing 1995; 1998; Carlyle 2001; Brænne 2001; Bregnhøi 2010; Nadolny 2012:13-16). Some were compilations from different books; one such example is the Danish edition *Nye og Fuldstændig Maler og Forgylderbog …* (Anonymous 1794). No author is listed and the front page expresses that it is a compilation of the best and most famous masters' instructions. It evidently contains elements that are incorporated and adopted from other foreign treatises. Many of these publications were known as *books of secrets* as many of the skills within the crafts had been strongly regulated by the guilds or considered personal possessions of the workshops and handed down from master to apprentice (Massing 1995).

Both Juel and Abildgaard held extensive libraries containing the era's relevant treatises and publications. Abildgaard's library consisted of 1,628 literary titles and following his death many of these books were incorporated in the academy library, which up until then contained far fewer books (Meldahl & Johansen 1904:523; Thygesen 1974; Kragelund 1999:56-58). This is a testament to their interest in both theoretical, practical and philosophical aspects of art and society throughout their lives and careers. Generally, throughout his life, Juel seems to have kept up to date with societal developments and fashions. This is seen both in his stylistic developments, character rendering and subject matter and, besides his book collection, he owned many drawings, engravings, plaster figures and a collection of at least 125 paintings (Fugl 1803; Christensen 1996b:252; Slotsgaard 2013; Slotsgaard 2015). Furthermore, Juel was very engaged in society, which is evidenced by his membership in several social clubs and the masonic order (Westengaard 1996; Christensen 1996b).

Breakthrough and self-promotion

When Juel was accepted into the newly founded art academy and moved to Copenhagen in 1765, he was already a skilled painter and had experience of painting portraits. Not long after his arrival, he started receiving commissions for portraits in the social circle of the bourgeois family called Klingberg, with whom he resided. An introduction by this family to other established families in Copenhagen is generally considered one of the reasons for his rapid breakthrough (Elling 1941; Slotsgaard 2019). Juel's popularity escalated quickly and soon reached the attention of the royal family. Juel's self-portrait in the studio from 1766 (Fig. 1.1) may have acted as advertisement and self-promotion, as examples from abroad propose for other painters (Postle 2005; Auricchio 2007; Fehlmann & Verwiebe 2013). It shows a confident and skilled young artist capable of mastering several genres of painting – a manifestation of his skills and ambitions as an artist. Apart from a self-portrait by painter Peter Cramer (1726-1782) from around the same time (Fig. 2.2), it could appear that Juel was the first Danish painter to have depicted himself positioned in front of the easel in this manner (Neiiendam 1994; Slotsgaard 2019). The practice of artists painting self-

portraits while sitting in front of the easel was initiated in the mid-sixteenth century, with one of the earliest depictions being by Catharina van Hemessen in 1548 (Kunstmuseum Basel). The inclusion of artists' tools become a regular feature in the seventeenth century and by the eighteenth century self-portraits showing the artist with their tools of the trade, had become the standard and most common for self-representations (Reynolds et al 2016; Peter 2016). Juel painted about ten self-portraits throughout his life. In the later self-portraits, he displays himself elegantly in the same format as his clients, and his self-portrait from 1791, *The Artist and his Wife Rosine, née Dørschel* (Fig. 2.3), illustrates his dual role of practising artist and established gentleman (Slotsgaard 2019). Some artists tended to present an idealised version of their workspace (Peter 2016:104), but Juel's representation appears fairly simple and not too extravagant. It depicts portraits of his parents on the wall, furniture and several books. The books might suggest that he wished to emphasise that he was not only a painter but also a scholar.

Fig. 2.1 Jens Juel, *Allegori på bygningskunsten*, 1760. National Gallery of Art (SMK) (KKS1976-801), drawing, 201 x 113 mm. The earliest known drawing by Juel.

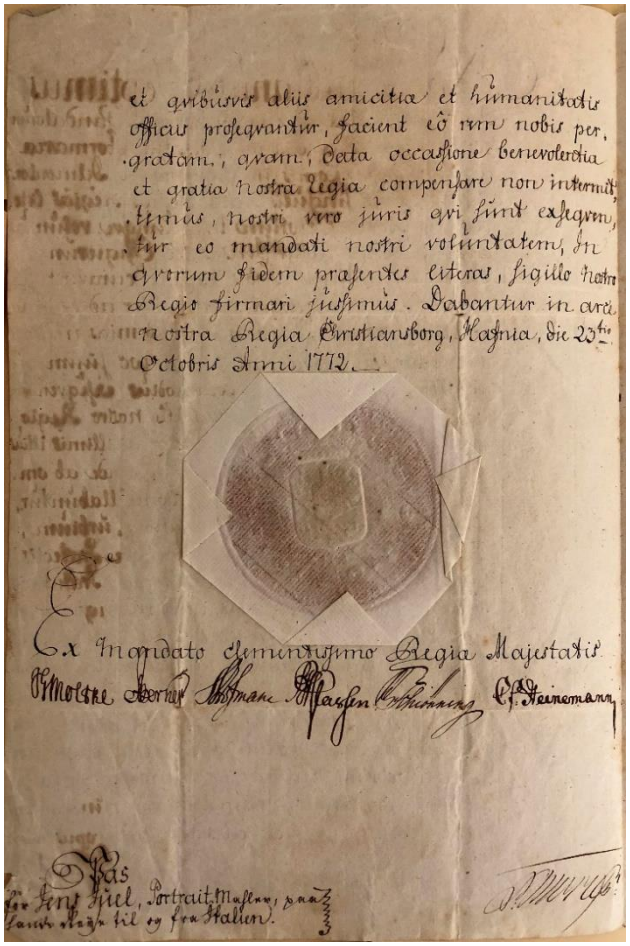
Fig. 2.2 Peter Cramer, *Self-Portrait*, c. 1765. Museum of National History, Frederiksborg Castle (A 968), oil on canvas, dimension unknown.

The grand tour and sources of inspiration

Juel himself was very aware of the importance of a Grand Tour in obtaining a higher learning in painting than he could receive by staying in Denmark. It was likely the official recognition, the competitions and the travel stipend, more than the teaching and education that encouraged Juel to attend the art academy (Monrad 1996). According to tradition, Juel rejected the offer of training

and painting in the studio of the professor and portrait painter Peder Als: “When Professor Als, the most important portrait painter at the time, once kindly offered him his guidance and to come and paint in his studio, Jens Juel replied that he thanked the Professor for his kindness, but he certainly had no time” (Høyen 1828).

In his application for a stipend to the king, Juel argues that to perfect himself in the art of painting he has to travel to foreign lands and especially Italy, where this science excels beyond others (Bobé 1928, letter 1769). Not until three years later was Juel successful in obtaining a stipend. In his thank you letter to Count A.G. Moltke, Juel explains that his trip will take him directly to Italy, though he plans to spend the winter visiting all the prime galleries in Germany to become the best portrait painter that his talent and diligence will allow (Bobé 1928, letter 1772). Juel left Denmark in November 1772 (Fig. 2.3). Although his path through Europe is fairly well-known, little is known about his sources of influence. Juel did not make a direct path to Rome. Letters from Abildgaard, who was in Rome at the same time, report that Juel did not arrive there until the autumn of 1774. In the meantime, Juel stayed in Hamburg and Dresden, where he supposedly studied with Anton Graff, and then travelled through Vienna, Venice, Bologna and Florence, before reaching Rome (Poulsen & Monrad 1982:30; Poulsen 1991). Visual influences on Juel from painters in Rome such as Pompeo Batoni (1708-1787) and Anton Raphael Mengs (1728-1779) have been discussed (Poulsen 1991; Christensen 1996a). It is suggested that Batoni’s portraits of British travellers with landscapes in the background, a type also practised by Sir Thomas Gainsborough (1727-1788) in England, functioned as an inspiration for those Juel would later paint in Switzerland. Two of the portraits included in this thesis – *Baroness Matilda Guiguer de Prangins in her Park at Lake Geneva*, 1778/79 (KMS4810, Fig. 3.9) and *Jean-Armand Tronchin, Ambassador to the French and English*


et quibusvis aliis amicitia et humanitatis officia prosequantur, facient eô rem nobis per gratam, quam, data occasione benevolentia et gratia nostra Regia compensare non intermittimus, nostri vero juris qui sint exigam, In eo mandati nostri voluntatem, In cujus rei fidem praesentes literas, sigillo nostro Regio firmari jussimus. Dabantur in arce nostra Regia Christiansborg, Hafnia, die 25to Octobris Anni 1772.

Ex Mandato clementissimo Regiae Majestatis

Pas for Jens Juel, Portrait-Maler, paa Reise til og fra Italien.

Fig. 2.3 Juel’s travel pass of 1772 (verso), signed by members of the academy and with the seal of the king (SMK archives).

Courts, 1779 (KMS6151, Fig. 3.10) – are such portraits in a landscape setting. The baroness's diary gives insight into Juel's practice while executing her portrait (Monrad 1993).

After Rome, Juel was briefly in Naples in July 1776, and is then supposed to have covered the distance from Rome to Paris on foot along with his friend and colleague Simon Malgo (1745-1793) (Poulsen 1991). There they met up with the engraver J.F. Clemens (Fig. 3.7) and did not stay long before continuing to Geneva. Information on possible influences while in Paris are scarce. Both Poulsen (1991) and Christensen (1996a) suggest that at least Juel would have studied the art of the Swedish portrait painter Alexander Roslin (1718-1793) and the French masters such as Joseph Duplessis (1725-1802) and Louis-Michel van Loo (1707-1771). Less than a handful of paintings by Juel from each Rome and Paris are known, making it hard to establish either stylistic or technical influences.

It does not seem that it was intended originally for Juel to pass through Switzerland, an extension of his trip that ultimately lasted for three years. The miniature painter Henrich Plötz (1747-1830), who was a friend of Clemens, had since the early 1770s stayed with the Swiss naturalist and philosopher Charles Bonnet (1720-1793), and convinced the three artists to come to Geneva from Paris (Høyen 1828; Glarbo 1925). Juel painted Clemens' portrait (Fig. 3.7) in Paris, and Juel and Clemens subsequently brought the portrait with them to Switzerland. According to Høyen: "When Plötz saw the half-length portrait that Juel had painted of Clemens in Paris, he was so taken by it, that he immediately mounted it on a strainer and showed it to several people …"[7] Juel is supposed to have declared that he would not arrange his palette for orders less of 100 *louis d'ors*, after which Plötz is supposed to have collected double that value for commissions (Høyen 1828:4; Weilbach 1877-78; Glarbo 1925). Juel constructed many great portraits in these years including a portrait of Bonnet. After having his portrait painted, Bonnet wrote in a letter: "The artist [Juel] exerts his talent with an astonishing superiority, the soul as well as the body, and what may surprise you, is that he requires only three sittings, none of them exceeding three hours"[8] (20 August 1777, cited in Glarbo 1940:66). Similar praise, and the rather brief time frame, is expressed in the diary of Baroness Prangins, written while Juel visited the Prangins' castle to paint her portrait. While it became evident that the painting and the position of the figure in the landscape were constructed, the baroness expressed that from the very first sitting the painting was well composed. Juel brought the painting with him to Geneva and returned later to finish the head and figure which, she described, took three sittings over three days. According to the diary, Juel was to return a few weeks after to varnish the painting (Monrad 1993). These stories provide several pieces of information with regard to Juel's practice: that Juel and Clemens transported

[7] "Da Pløtz saae det Knæstykke, som Juel havde malet af Clemens i Paris, blev han saa indtaget deraf, at han strax fik det spændt paa Blindramme og viist til flere …"
[8] "L'artiste, dont il s'agit, exerce son talent avec une supériorité étonnement et scait rendre également l'ame et le corps, et ce que vous surprendra, il ne lui faut que trois séances, dont la plus longue n'est pas de 3 heures"

paintings, possibly rolled as the portrait required mounting; that the task of setting up the palette was a moiling work; that Juel worked quickly and that he varnished his paintings.

Back in Denmark

When Juel returned to Denmark in 1780, he was considered a cosmopolitan artist with an international reputation and he was not challenged by competition from other painters (Poulsen 1991). He quickly gained status as the primary painter in Denmark. The aforementioned Professor Peder Als had passed away and the Swedish-born portrait painter Carl Gustav Pilo was forced to leave the country along with many other foreigners as part of the rising distrust of foreigners after Johan Friedrich Strueenses' (1737-1772) downfall (Monrad 1996:17; Christensen 2016). The portrait painter Vigilius Eriksen (1722-1782) had returned from Russia but no longer painted, and other portrait painters at the time did not have the same talent – or, at least, were not able to establish the same popularity – as Juel. The return to Denmark of both Juel and Abildgaard had been awaited since the mid 1770s, to fill the gaps and take over the responsibilities at the art academy (Kunstakademiet, 5 August 1776). Following their return, they followed largely parallel careers as professors at the art academy in Copenhagen.

2.5 Juel's Subjects and Production

Juel produced close to a thousand portrait and landscape paintings, drawings, sketches and pastels. As is evidenced by his production, Juel was, first and foremost, a portrait painter. The first known paintings by Juel are dated to 1764, during his apprentice years. Seven of the seventeen known paintings from this year are portraits, while the remaining ten are Dutch-inspired genre paintings copied from, or in the style of, works by painters such as Balthasar Denner (1658-1749), Jan van Huijsum (1682-1749) and Aert van der Neer (1603-1677) (Poulsen 1991; Monrad 1996; Slotsgaard 2019). Upon arrival in Copenhagen, Juel managed to tap into the increasingly demanding market for portrait painting and, while he appears to have done well in commissions both in the early years in Copenhagen and during his years abroad, the most productive and busy period took place during the two decades following his return to Denmark in 1780. Following 1779, Juel also developed an interest in landscape painting which, along with portraits, garnered the interest of new collectors (Svenningsen 2015:103,125). During the 1780s and 1790s, landscape paintings made up almost ten percent of Juel's production. Figure 2.4 displays an overview of Juel's production throughout his career, divided into the subjects of portraits, landscape paintings and others, which include genre, still-lifes and copies.

Juel's primary support for paintings was canvas. Many of the portraits were in a standard-size bust-length oval format, generally measuring 68 to 75 centimetres in height. These simple portraits without attributes, represent a conscious distancing from the portrait depictions of traditional hierarchical society. Individuality gained more importance than symbols of position and influence (Arnheim 1982; Heiberg 2003:89).

While Juel's paintings and technique have often been praised, by his contemporaries as well as art historians (Hansen 1907; Bobé 1934:54; Swane 1944:598; Poulsen 1991:20), the portraits from the later period of his career are at times critiqued by art historians for having an expression of repetition or a rushed and over assertive paint handling, likely due to an increasing number of commissions (Høyen 1828; Madsen 1909). For instance, Karl Madsen expresses: "… the work has slipped from his hand too easily. The sinuous elegance of the paint handling does not outweigh the loss of the fresh energy in the perception of the character seen in the portraits of his youth. The vast majority of Juel's medallion [oval] portraits from the time after 1780 have not escaped the notice of originating from a fashion painter's diligent and confident studio practice"[9] (1909:330). The commercial aspect of Juel's production, may have prompted him to develop a more rapid technique over the years, and inspired him to use pastels increasingly.

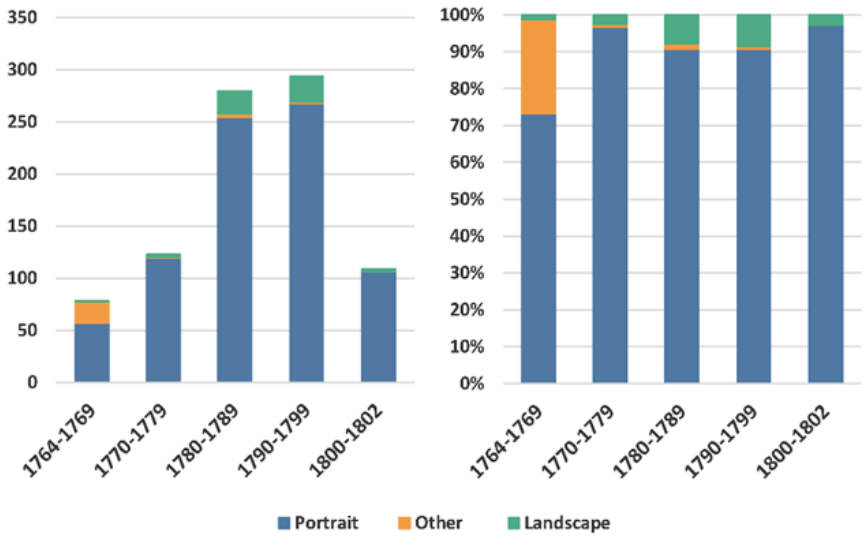


Fig. 2.4 The distribution of subjects for paintings and pastels by Juel per decade by number (left) and percentage (right). The subjects are divided between "Portrait", "Landscape" and "Other", which includes genre, still-lifes and copies (based on the 1991 catalogue raisonné by Ellen Poulsen) (Slotsgaard 2019).

In the last decade, pastels make up almost forty percent of the production. Although pastels had come into fashion, they were also faster for the painter to execute and cheaper for the client (Bobé 1934:42; Baitjer & Shelley 2011; Slotsgaard 2019). Figure 2.5 displays an overview of Juel's use of different media and supports throughout his career. The fame and speed of painting by portrait painters were described and critiqued by Rouquet in 1755: "His [the portrait painter's] aim then is not so much to paint well, as to paint a great deal; his design is to be in vogue, one of those exclusive vogues which for a while shall throw into his hands all the principal portraits in England. If he obtains vogue, to make proper use of it, he is obliged to work extremely quick,

[9] "… Arbejdet er gledet ham alt for let fra Haanden. Behandlinges smidige Elegance opvejer ikke tabet a Ungdomsværkernes friske Energi i Karakteropfattelsen. Det store Flertal af Jens Juels Medaljonportrætter fra Tiden efter 1780 har ikke undgaaet præget af at stamme fra en Modemalers flittigt og sikkert arbejdende Værksted"

consequently he draws a great deal worse, by having a great deal more business" (Rouquet 1755:39). Juel strikingly seems to fall into this category and whether Juel was a product of his time, read Rouquet's book or gained knowledge of this approach while in Hamburg is unclear. Juel not only exceeded other portrait painters in talent and fame, also it was considered prestigious to have one's portrait painted by him. While some of the standard portraits do appear to have been quickly executed, others display careful execution with great attention to detail. Either way, there does not appear to be any obvious decrease in the quality and durability of the resultant artworks (Slotsgaard 2019).

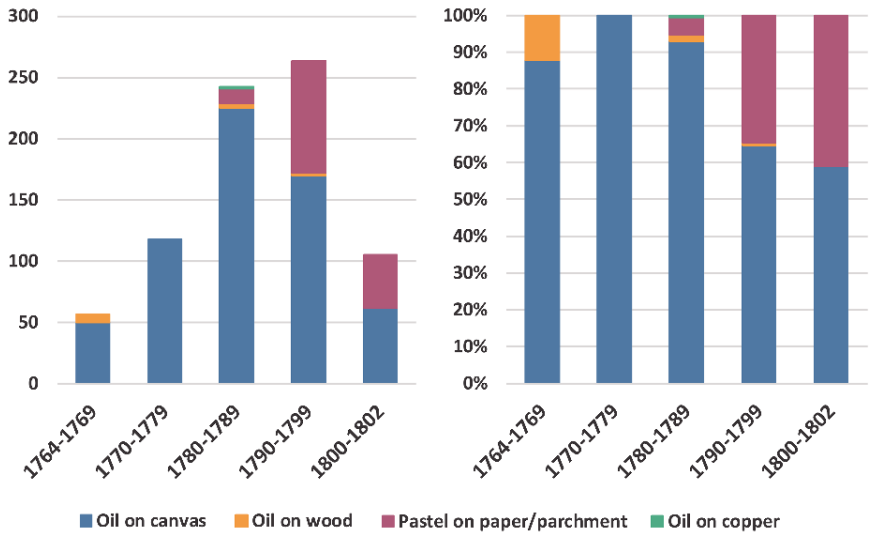


Fig. 2.5 The distribution of media and supports used by Juel per decade by number (left) and percentage (right) (based on the 1991 catalogue raisonné by Ellen Poulsen) (Slotsgaard 2019).

2.6 Juel's Studio

Letters, diaries and other descriptions from Juel's contemporaries, the estate auction after his death, as well as Juel's self-portraits in the studio, provide clues about his technique, materials, tools and studio practice. Juel produced around ten self-portraits, of which three represent him in the practice of drawing or painting and with tools and other attributes.

Tools and practice

In Juel's self-portraits from 1766 and 1791 he has depicted himself in front of the easel holding a palette with prepared colours of paint. In the self-portrait from 1766, a small oil- or varnish-containing bottle and glass muller sit on the windowsill and the table next to him displays pig bladders, a shell with oil, a *porte-crayon*, several brushes and his brush-cleaning box (*kladpot* or *pinceliere,* referred to as a tin-container by Madsen 1909, cf. Chapter 1). The use of pig bladders for storing either pigments or paint was common before glass and metal tubes became available during the first half of the nineteenth century (Jombert 1766:63-64; Massing 1998:339; Fairbairn & Beal 1982:67-69). The estate auction lists at least four palettes and four easels. Numerous

spaces were needed, with assistants and students working in the studio besides Juel. It also lists eleven strainers, a roll of canvas and two stretched canvasses (Fugl 1803:29-30). A *gliedermann* (lay figure) and a mannequin are also listed, likely used for arranging drapery. The use of lay figures by portrait painters as an aid to painting draperies has occured since the fifteenth century (Walsh 1996:55; Chapman 2007). It would shorten the time the sitter would have to model for the portrait and lay figures could hold poses in odd positions longer than a live model. It appears commonly used in artist's studios and the figures came in different sizes up to life-size (Chapman 2007; Woodcock 1995). It is described, with regard to Reynolds' studio practice, how the sitter's clothes were sometimes sent to the studio and placed on lay figures to be painted by assistants (Kirby-Talley 1986:57-59). Both Juel's predecessor Pilo and his successor Eckersberg are supposed to have possessed and made use of life-sized lay figures, and they were likely used similarly in Juel's studio (Salling 1994:11-14; Christensen 2016:140-141).

Juel's painting- and showroom

In both the self-portraits mentioned above, from 1766 (Fig. 1.1) and 1791 (Fig. 2.6), Juel is located in what looks like a common room. In 1766 it is likely at the Klingberg residence where he stayed at the time, while the later self-portrait is from his studio at *Prinsens Palæ* in Stormgade.[10] Juel's studio functioned both as a workshop and a public showroom.[11] Several sources from Juel's era recounted visiting the studio, including the future King Christian VIII, members of high society and visitors to the city, both as amusement to see the paintings on display and to experience sittings (Lindvald 1943; Ramdohr 1792:162; Poulsen 1991; Christensen 1996a). Countess Reventlow reported: "We walked … to Stormgade to the painter Juel … where we in haste saw a very strange collection of lifelike portraits: Klopstock next to Pomade Schack, Guldberg with Berger, the old Scheel and the small von Lühe, Julie Rewentlow and old Adam [Moltke], in brief youth and old age, sense and simplicity, good and bad were all here in brotherly society."[12] (Reventlow 1902:8 Januar 1781). This custom appears common, as it is reported for portrait painters in other countries as well. As no commercial galleries existed yet, the studio of the artist also functioned as a showroom, and artists employed by the court would sometimes have their studio within the walls of the palace – just as Juel did (Peter 2016:105). In 1755 the artist André Rouquet (1701-1758) noted: "Every portrait painter in England has a room to shew [show] his pictures, separate from that in which he works. People who have nothing to do, make it one of

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[10] From 1781-90 Juel's studio was located in Stormgade at Christiansborg Palace; from 1790-1802 in Prinsens Palæ, first in the Great Hall (until 1794) and then in some rooms towards the street. His private residence was at Charlottenborg Palace (at the art academy) (Poulsen 1991:23). Ramdohr reports that the portraits of Juel's parents are displayed in Juel's "room" (1792:162).

[11] The term *studio* in the English language did not come into usage until the nineteenth century, before then it was more referred to as a *painting room* (Peter 2016). In the Danish language, the studio is similar called *malestue* (Poulsen 1991:24; Christensen 1996a:33)

[12] "Vi gik … til Stormgade til maleren Juel … hvor vi in hurry saa et meget ilde sammensat Selskab af meget lignende portrætter: Klopstock ved siden af Pomade Schack, Guldberg hos Berger, den gamle Scheel og den lille von Lühe, Julie Rewentlow og gamle Adam [Moltke], kort sagt ungdom og alderdom, forstand og Enfold, gode og onde vare her i broderligt Samfund."

their morning amusements, to go and see their collections" (1755:42). Gainsborough's house and studio in Bath was arranged on several floors, and included a large showroom where people could see his work before deciding whether to commission a portrait. Most on display were waiting to be varnished as this could not be done until the oil had dried, normally after five months, allowing time for the portrait to serve as a promotional tool (Sloman 2002; Ayres 2014; Peter 2016:103-104). In contrast, Abildgaard was more reserved. He was not known for inviting visitors to view his work in progress, and there are few eyewitness accounts of his studio (Filtenborg 2014:x). Besides that all seem to have made use of assistants, hardly any information exists on the procedures in the studios of Juel's predecessors such as Carl Gustav Pilo, Johann Salomon Wahl or Peder Als (Christensen 2016:229-230).

Fig. 2.6 Jens Juel, *The Artist and his Wife Rosine, née Dørschel*, 1791. National Gallery of Denmark (SMK) (KMSsp864), oil on wood, 52.5 × 41.5 cm.

Students and assistants in Juel's studio

Throughout his career Juel employed several assistants. As early as the first Copenhagen years he employed the painter Christian Rafn (1740-1825) and not long after Juel's return to Copenhagen he employed Herman Kofoed, who had also been an assistant to Pilo (Poulsen 1991:24;

Christensen 2016:229). It is commonly known that the great artists made use of assistants in the studio (Sperling 1885:2-3; Waterfield 2009; Peter 2016). Portrait painters often employed other hands to do the drapery or make copies (Rouquet 1755:43-44; Clark 1985:38, Kirby-Talley 1986:57-59; Christensen 2016:231). To what extent Juel's assistants assisted in the drapery and first versions of the portraits is unclear; however, that they executed copies is well known. The painter Hans Hansen (1769-1828) was a student in Juel's studio and on several occasions mentions in his diary that Kofoed was copying portraits for Juel, and Kofoed even offered Hansen the opportunity to make a copy as he had too much work. On another occasion Hansen, while working around Denmark, was asked to make a copy of one of Juel's portraits for a client (Hansen 1907:61). Such evidence makes it troublesome to make a clear distinction between the hands that actually managed the brush, as well as a proper attribution to some of the portraits in Juel's style, which continue to emerge from private ownership. This is made even more difficult by the fact that Juel did not consistently sign and date his paintings. In any case, a correlation and assessment between portraits as to whether they were painted by Juel's own hand or aided by assistants is outside of the scope of this study.

As professor at the art academy, Juel frequently had students training in the studio; of these, Hans Hansen, as well as the German painters Caspar David Friedrich (1774-1840) and Phillip Otto Runge (1777-1810), are best known. Although they made occasional comments about their time in the studio, little information is given about to the practice of painting and they complain that neither Juel nor Abildgaard spoke very much or put learning into words. Hans Hansen wrote: "[I spent] the morning at Juel's and admired his creations. The conversation was rather short, for he does not speak very much, but is probably more of a thinker"[13] (Hansen 1907:116; see also Poulsen 1991:24). Runge is one of the few who commented on Juel's actual painting technique and rapid approach (see Section 10.2), but otherwise, like Hansen, he mostly complained about the lack of information: "So often I wanted to approach Abildgaard or Juel for help … They say nothing more than, for example, if you have drawn a head: 'You have to always keep the highest light on the part that stands out the most, as well as the strongest shadow; downwards all light has to be more dimmed, and what lies within the piece, both light and shadow, must be kept softer and more muted …'"[14] (cited in Christensen 1996a:66). These comments only provide limited evidence on Juel's technique. However, examination of the paintings as part of this study, which is presented and discussed in the following chapters, will deepen the knowledge of Juel's technique and use of materials.

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[13] "Formiddagen hos Juel og beundrede hans skabende Haand. Samtalen var temmelig kort, thi han taler ikke meget, men tænker vel des meere"

[14] "Ich habe so oft Abildgaard oder Juel um Hülfe ansprechen wollen, aber immer erst vorher ein wenig sondiert und wurde dann immer mit Protest zurückgeschickt. Sie sagen weiter nichts als, wenn man zum Beispiel einen Kopf geziechnet hat: 'Sie müssen das höchste Licht imme auf den Teil halten, der am meisten hervorsticht, so wie auch den stärksten Schatten; nach unten muss alles Licht mehr abgedämpft sein, und was im Stück hinein liegt, da muss sowohl Licht als Schatten alles leichter und neblicher gehalten werden …'"

3 Selected Paintings for the Investigation

Twenty-two paintings by Jens Juel, all portraits on canvas, were selected for this thesis: sixteen paintings from the collection of the National Gallery of Denmark (SMK) and six paintings belonging to the Svenstrup Foundation. Additionally, information from eight paintings examined in 2013 is included or referenced in certain instances when providing supporting information (Slotsgaard 2013; 2015). An overview of the paintings from the preliminary investigation is given in Appendix 26.

3.1 Portraits from the National Gallery of Denmark (SMK)

SMK is the collection that holds the largest number of artworks by Juel in Denmark. The collection includes close to 400 paintings, pastels, sketches and drawings. Juel was primarily a portrait painter and the selection of paintings for this investigation has focused on portraits painted in oil on canvas. Out of the forty-five portraits painted on canvas in the SMK collection, sixteen were selected for in-depth analyses. This total is based on an estimate of the number of paintings possible to analyse within the timeframe of the project and the budget for analyses.

Portraits that are signed or dated provided the basis for the selection, to aim for the most complete timeline to detect and confirm changes in Juel's technique, materials and studio practice throughout his career. Juel signed and dated some, but not all, of his paintings. Many portraits have been dated art-historically in accordance with surviving receipts or biographical information of either the artist or the portrayed, as well as style. In the selection process, the production year of the eight portraits previously investigated, of which five are in the collection of SMK, were taken into consideration as supplements to the timeline (Appendix 26; Slotsgaard 2013; 2015).

The selection had certain limitations as it was preferred not to include paintings that were on loan to other institutions, large-format paintings or paintings currently on display, to the extent possible to meet the aims of the thesis. In these cases, it was attempted to select another portrait, which could represent the year of production.

The criteria for the selection of portraits were as follows:

- Only portraits on canvas
- Dating of the portrait should represent a timeline of Juel's production
- The portrait has to be available for examination
- The portrait needs to be a manageable size allowing for handling and analyses
- Avoid selecting portraits that are currently on display if alternatives are available

This selection resulted in one of the earliest portraits by Juel, his self-portrait from 1764 from his apprentice years in Hamburg (Fig. 3.1); three paintings from the years in Copenhagen while he

was a student at the art academy before his Grand Tour (Fig. 3.2-Fig. 3.4); six paintings from the eight years Juel spent abroad in Dresden (Germany), Paris (France) and Switzerland (Fig. 3.5-Fig. 3.10); finally, six portraits from the latter half of his career starting in 1780, the year Juel returned to Copenhagen and up until 1800, shortly before his death (Fig. 3.11-Fig. 3.16). Of the last six paintings, two sets of portraits considered pendants were selected to investigate possible relations in the technical execution of the paintings, for instance, the use of the same canvas and ground layer in the preparation.[15]

Figures 3.1 to 3.16 present the paintings in chronological order. Further information and larger images are given in Appendices 1 to 16. The headline given in the figure captions, for example *Rahr KMS3499*, is the abbreviation which will be used for the portrait throughout the text of this thesis, consisting of the last name of the sitter and the inventory number of the collection. In instances when more than one sitter shares the same last name, the initials of the first name are included, such as *H.Gerner KMS1444.*

The portraits entered the collection of SMK at different times from 1838 to 1958. Some of the paintings were purchased through auctions while others were bequeathed to SMK or donated by descendants of the portrayed. This means that the paintings have different histories of provenance and have been exposed to different environments, conservation treatments, and storage and exhibition conditions.

Fig. 3.1 ***Self-Portrait KMS3990***
Jens Juel, *Self-Portrait by Candlelight,* 1764.
National Gallery of Denmark (SMK) (KMS3990),
oil on canvas, 57.1 x 49.7 cm.
Signed: "I.Juel"

Fig. 3.2 ***Rahr KMS3499***
Jens Juel, *Peder Rahr, Merchant in Ribe,* 1770.
National Gallery of Denmark (SMK) (KMS3499),
oil on canvas, 78.5 x 62.5 cm.

[15] Possibly pendant portraits: Husband and wife *H.Gerner KMS1444* and *C.S.Gerner KMS1445;* related family portraits of *P.J.Schouw KMS1113*, *A.C.Schouw KMS1114* and *Bagge KMS1115.*

Fig. 3.3 ***Battier KMS3634***
Jens Juel, *Anna Elisabeth Battier née Storp,* 1771.
National Gallery of Denmark (SMK) (KMS3634),
oil on canvas, 79 x 63.5 cm.
Signed: "J.Juel pinxit 1771"

Fig. 3.4 ***Saly KMS4801***
Jens Juel, *The Sculptor Jacques-François-Joseph Saly,* 1772.
National Gallery of Denmark (SMK)
(KMS4801), oil on canvas, 82 x 67 cm.
Signed: "J.Juel pinx 1772"

Fig. 3.5 ***Self-Portrait KMS3275***
Jens Juel, *Self-portrait with Portfolio,* 1773-74.
National Gallery of Denmark (SMK) (KMS3275),
oil on canvas, 56.5 x 44.5 cm.

Fig. 3.6 ***Hauch KMS349***
Jens Juel, *Postmaster General Frederik Hauch as a Young Man*, 1776.
National Gallery of Denmark (SMK)
(KMS349), oil on canvas, 59 x 49 cm.

Fig. 3.7 ***Clemens KMS396***
Jens Juel, *The engraver Johann Friderich Clemens at his Work Table*, 1776.
National Gallery of Denmark (SMK)
(KMS396), oil on canvas, 52.5 x 42 cm.

Fig. 3.8 ***Holm KMS1766***
Jens Juel, *Susanne Elisabeth Holm, the Artist's First Betrothed,* 1778-79.
National Gallery of Denmark (SMK)
(KMS1766), oil on canvas, 52.8 x 42.9 cm.

Fig. 3.9 ***Prangins KMS4810***
Jens Juel, *Madame de Prangins in Her Park at Lac Leman,* 1778-79. National Gallery of Denmark (SMK) (KMS4810), oil on canvas, 86.5 x 72 cm.
Signed: "Peint par Juel Peintr(e danois) 177[8/9?]"

Fig. 3.10 ***Tronchin KMS6151***
Jens Juel, Jean-Armand Tronchin, Ambassador to the French and English Courts, Switzerland., 1779.
National Gallery of Denmark (SMK) (KMS6151), oil on canvas, 71 x 57 cm.
Signed: "Juel pinxit 1779"

Fig. 3.11 ***Hielmstierne KMS349a***
Jens Juel, *Henrik Hielmstierne,* 1780.
National Gallery of Denmark (SMK) (KMS349a), oil on canvas, 64.5 x 50 cm.

Fig. 3.12 ***H.Gerner KMS1444***
Jens Juel, *Henrik Gerner,* 1785.
National Gallery of Denmark (SMK) (KMS1444), oil on canvas, 70.5 x 55.5 cm.
Signed: "Juel pinx 1785"

Fig. 3.13 ***C.S.Gerner KMS1445***
Jens Juel, *Charlotte Sophie Gerner née Rasch,* 1785.
National Gallery of Denmark (SMK) (KMS1445), oil on canvas, 70.5 x 55.5 cm.

Fig. 3.14 ***P.J.Schouw KMS1113***
Jens Juel, *Peter Johan Schouw,* 1799-1800.
National Gallery of Denmark (SMK) (KMS1113), oil on canvas, 70 x 54 cm.

Fig. 3.15 ***A.C.Schouw KMS1114***
Jens Juel, *Ane Christine Schouw née Poulsdatter,* 1799-1800.
National Gallery of Denmark (SMK) (KMS1114), oil on canvas,
69.5 x 53.5 cm.

Fig. 3.16 ***Bagge KMS1115***
Jens Juel, *Distiller Bagge's Widow,* 1799-1800.
National Gallery of Denmark (SMK) (KMS1115), oil on canvas,
69.5 x 53.5 cm.

3.2 Portraits from the Svenstrup Foundation

In addition to the selected paintings from SMK, six portraits by Juel from a private collection of paintings belonging to the Svenstrup Foundation were included in the study. The six portraits from Svenstrup Estate were to undergo conservation treatment at the National Museum of Denmark and on this occasion it was possible to examine the paintings. The portraits were produced during the 1780s and 1790s and add to the timeline of Juel's production in the second half of his career. The paintings were assessed before conservation treatment.

The Svenstrup Estate can be traced back to at least around the mid-thirteenth century (Wedell-Neergaard 1921:233). In 1751, the estate was taken over by Peter Johansen Neergaard (1702-1772) (Fig. 3.23) from Count Frederik Oertz (1712-1779). The Neergaard family were among the many peasants who climbed up the social ladder due to increasing landholdings and wealth during the seventeenth and eighteenth centuries (Wedell-Neergaard 1921:247). The estate was passed down through generations and still belongs to descendants of the Neergaard family today, now called the Wedell-Neergaards.

The six portraits by Juel portray Jens Bruun Neergaard (1742-1788), son of Peter Johansen Neergaard and Kirstine Tønnesdatter (1717-1751) (Fig. 3.17), and his wife Anne Marie Bruun Neergaard née Møller (1743-1802) (Fig. 3.18); their son Jens Peter Bruun de Neergaard to Eckhof (1764-1842) (Fig. 3.20); their daughter Ellen Moltke née Bruun Neergaard (1778-1845) (Fig. 3.22) and her husband Count Joachim Moltke to Rønnesbækholm (1769-1820) (Fig. 3.21). The last portrait portrays Marie Christine Buchwaldt née de Svanenskiold (1762-1789) (Fig. 3.19). She was also the granddaughter of Peter Johansen Neergaard and Kirstine Tønnesdatter by their daughter Johanne Neergaard who married Niels Jørgensen de Svanenskiold.

Fig. 3.17 ***J.B.Neergaard SV1***
Jens Juel, *Jens Bruun Neergaard of Svenstrup*, 1788.
Svenstrup Foundation,
oil on canvas, 70 x 54.8 cm.

Fig. 3.18 ***A.M.B.Neergaard SV2***
Jens Juel, *Anne Marie Bruun Neergaard née Møller,* 1788.
Svenstrup Foundation,
oil on canvas, 68.5 x 53.5 cm.

Fig. 3.19 ***Buchwaldt SV3***
Jens Juel, *Marie Christine Buchwaldt, née de Svanenskiold,* Mid-1780s.
Svenstrup Foundation,
oil on canvas, 70 x 54.4 cm.

Fig. 3.20 ***J.P.B.Neergaard SV4***
Jens Juel, *Jens Peter Bruun Neergaard to Eckhof*, 1790.
Svenstrup Foundation,
oil on canvas, 68.5 x 54 cm.

Fig. 3.21 ***J.Moltke SV5***
Jens Juel, *Joachim greve Moltke to Rønnesbækholm,* 1797.
Svenstrup Foundation,
oil on canvas, 69 x 53.5 cm.

Fig. 3.22 ***E.Moltke SV6***
Jens Juel, *Ellen Moltke née Bruun Neergaard*, 1797.
Svenstrup Foundation,
oil on canvas, 69 x 53.5 cm.

The six paintings are presented in Figures 3.17 to 3.22. Further information and larger images are given in Appendices 17 to 22. For this thesis, the portraits are given an identification number SV1 through SV6, to aid in identification throughout the text. As with the SMK paintings, the headline given in the figure captions is the abbreviation which will be used for the portrait throughout the thesis, consisting of the last name of the portrayed preceded by first name initials in instances where the last name are the same and followed by identification number.

Fig. 3.23 ***P.J.Neergaard SV7***
Herman Kofoed(?), *Peter Johansen Neergaard*, 1790/91?
Svenstrup Foundation, oil on canvas, 69.6 x 54.4 cm.

Fig. 3.24 ***Tønnesdatter SV8***
Herman Kofoed(?), *Kristine Tønnesdatter*, 1790/91?
Svenstrup Foundation, oil on canvas, 69.6 x 54.4 cm.

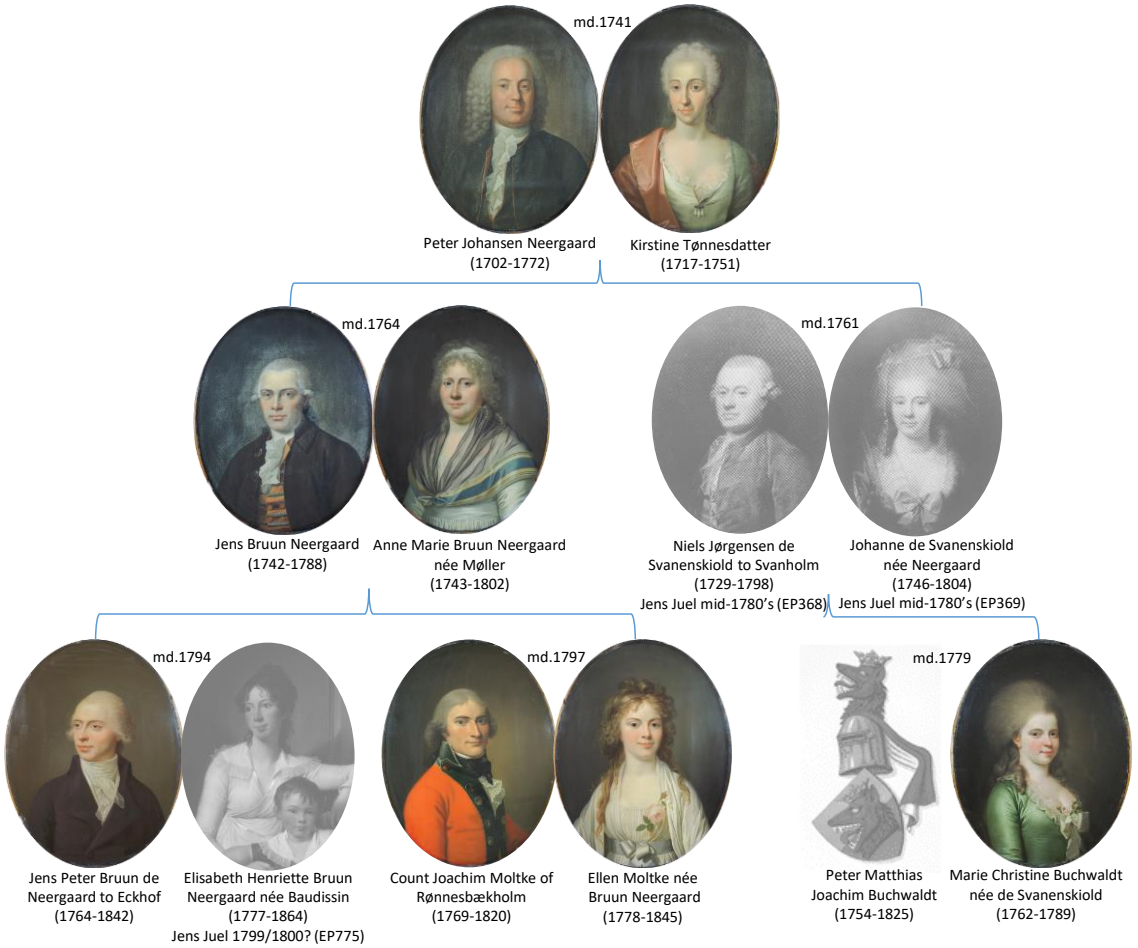

Fig. 3.25 Family connection of the eight portraits from the Svenstrup Foundation including three additional portraits in the family (b/w), painted by Jens Juel, not included in this study.

Two additional portraits of Peter Johansen Neergaard (SV7) and his wife Kirstine Tønnesdatter (SV8), painted posthumously in 1790/91, are reproduced here as well and are, according to receipts in the estate accounts, believed to be painted by Juel's assistant Herman Kofoed (Fig. 3.23 and Fig. 3.24) (Andrup 1921:305). The two paintings attributed to Kofoed display comparable technique and materials to those from Juel's studio and are referred to in this study only when adding information on materials in more general terms (Appendices 23 and 24). The eight portraits represent three generations of the Neergaard family (Fig. 3.25).

None of the paintings are signed or dated by Juel. In the history of Svenstrup, Otto Andrup makes accounts for the inventory of the estate and the dating of the portraits based on receipts and letters (Andrup 1921). These dates have been adopted in the catalogue raisonné (Poulsen 1991). According to Andrup the decoration of the walls with paintings at Svenstrup Estate prior to Jens Bruun Neergaard's death in 1788, had been very scarce. His widow took over the administration of the estate until she died in 1802. From her accounts, she transferred 180 *rigsdaler* to Jens Juel in 1788. Andrup believes with no doubt this payment relates to the two oval portraits of her and her deceased husband, though he questions whether it was executed after the husband's death:

> Surely, the paintings are not signed, and they show, in drapery and some minor sections, clear traces of another and more inferior brush, but this can be seen by the majority of Juel's paintings. The gentleman portrait is perhaps a bit lifeless and stiff, rather impersonal, in a way to think that the painter did not receive the commission until after the sitter's death, but the character of the wife is depicted with cheerful spirit and elegance and shows a picture of a very worthy and strong-willed, a bit sullen, but impressive landowner lady.[16] (Andrup 1921:304).

Another receipt from 1790 for a painting with frame and packaging shows a purchase from Juel of 89 rigsdaler. This, Andrup considers, can only be that of Jens Peter Bruun de Neergaard to Eckhof, the eldest son (Andrup 1921:304). The portrait of the cousin, Marie Christine Buchwaldt née Svanenskiold, the author believes painted at least ten years prior. This painting is not registered in any of the estate accounts and is thought to have entered the estate later, perhaps after the death of the sitter's husband in 1825, as the couple did not have any children to inherit the painting (Andrup 1921:304, Poulsen 1991:106). In the catalogue, however, Ellen Poulsen has estimated the date to be the mid-1780s. The portraits of Buchwaldt's parents, also by Juel but not included in this study, are estimated by Poulsen to be of similar date. The last two portraits, depicting Ellen Moltke née Bruun Neergaard and her husband Count Joachim Moltke, were likely

[16] "Ganske vist er Billederne ikke signerede, og de viser i Klædedragt og paa underordnede Punkter tydelige Spor af en anden og mere underlegen Pensel, men det ser man paa de fleste af Juels Billeder. Mandsportraitet er maaske noget dødt og stift, lidt upersonligt opfattet, saa man kunne tænke sig, at Maleren først havde faaet sin Opgave efter Modellens Død, men Etatsraadindens Karakteristik er givet med Munter Kraft og elegant Lune og viser et Billede af en meget værdig og viljestærk, lidt mut, men imponerende Godsejerfrue."

painted upon occasion of their marriage in 1797. This corresponds with the delivery of a container from Juel in March 1798, described in a letter from the grandfather on the mother's side, Brewer Jens Andresen Møller (Andrup 1921:307).

Uniquely, seven of the eight paintings have not undergone structural conservation treatment and have retained what is believed to be their original mounting and strainer. They therefore provide a more uncontaminated appearance of the preparation and use of materials than other paintings that have undergone several treatments or been lined. Although the paintings have remained within the family, they may not always have been in the same location. The family has owned several estates throughout the years and records suggests some items, including paintings, have been transferred back and forth between estates (Andrup 1921:306).

4 Methods of Examination and Analysis

Founded in an object-based empirical approach, twenty-two paintings on canvas by Juel were selected for examination and analyses to meet the aims of this thesis. The selected paintings are presented in Chapter 3. As outlined in the research design (Section 1.4), the purpose of the methods presented in this chapter is to investigate the materials and technique used in the selected paintings. The examination and analyses selected intend to characterise both the original use of material in the different layers and to identify alterations and applications of non-original material, which may produce false results in analyses. A further aim is to evaluate the state of preservation of the paintings and the influence of different materials on the degradation patterns.

Various methods of analysis offer different insights. Investigations into the use of materials and techniques combine various methods and analyses; the different results all contribute to an understanding of the material, its character and the technique by which it was applied to the painting (Pinna et al 2009; Colombini et al 2010). This includes information regarding the structure, composition and character of the entire painting as well as the individual layer. The information looked for in the investigation includes the following elements:

- Auxiliary support - original construction, wood species identification, mounting and preparation
- Canvas - fibre identification, weave pattern, weave direction, thread count, thread thickness, spinning direction and angle, crimp, cover factor, selvedge, cusping and weave matches between paintings
- Sizing - presence and character
- Ground layers - composition, colour, thickness, number of layers, pigments, fillers and binders, application method and visibility in composition
- Paint layers - sketch/underdrawing, number of layers, thickness, pigments, application, adjustments and *pentimenti*
- Original varnish - presence and identification
- Preparation - tacking margins, tool marks, application edge of ground and paint layers, mounting and format
- State of preservation - condition, interventions, lining, retouching, visual surface phenomena, losses and cracking

The examination of the paintings is to a large extent visual, while the specific investigations into material compounds are based on technical analyses. Visual analyses and other non-invasive techniques are highly favoured, as destructive analysis has always been a controversial issue since, even if minimal, it requires removal of original material from unique artworks (EN 16085:2012). Visual analysis is supported by microscopy and non-invasive imaging techniques:

ultraviolet fluorescence, infrared photography and X-radiography. Several non-invasive analytical instruments provide information on the elemental composition or molecular compounds. X-ray Fluorescent Spectroscopy (XRF), Fibre Optics Reflectance Spectroscopy (FORS), External Reflectance-Fourier Transform Infrared Spectroscopy (ER-FTIR) are used through the surface to identify pigments in the ground and paint layers. Other more invasive techniques require sampling from the painting to determine materials used in the individual layers, including those that are not immediately visible or detectable through the surface. Cross-sections are used to study the stratigraphy of the painting and to allow analyses of individual layers. Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (SEM-EDX), Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR) and Raman Spectroscopy are used on the cross-sections to analyse specific layers in the mounted samples to obtain information on pigments, fillers and binders in the ground and paint layers. Furthermore, Gas Chromatography/Mass Spectrometry (GC/MS) is used to analyse the binding media in the ground layers.

Table 4.1. Overview of technical analyses performed on paintings by Juel examined during this study.

Painting id.	Year	UV	IR	X-ray	Canvas	Cross-section	SEM-EDX	ATR-FTIR	Raman	XRF	FORS	ER-FTIR	GC/MS
KMS3990	c. 1764	x		x	x	x	x	x		x	x		x
KMS3499	1770	x		x	x	x	x	x	x	x	x	x	x
KMS3634	1771	x		x	x*	x	x	x	x	x	x	x	x
KMS4801	1772	x		x	x*	x	x	x	x	x	x		x
KMS3275	1773-74	x		x	x	x	x	x		x	x		x
KMS349	1776	x	x	x	x	x	x	x		x	x	x	x
KMS396	1776	x	x	x	x	x	x	x	x	x	x	x	x
KMS1766	1778-79	x		x	x	x	x	x		x	x	x	x
KMS4810	1778-79	x		x	x	x	x	x		x	x		x
KMS6151	1779	x		x	x	x	x	x	x	x	x	x	x
KMS349a	1780	x	x	x	x	x	x	x		x	x		x
KMS1444	1785	x		x	x	x	x	x		x	x	x	x
KMS1445	1785	x		x	x	x	x	x	x	x	x		x
KMS1113	1799-1800	x		x	x	x	x	x	x	x	x	x	x
KMS1114	1799-1800	x		x	x	x	x	x	x	x	x	x	x
KMS1115	1799-1800	x		x	x	x	x	x		x	x	x	x
SV1	1788	x		x	x	x	x	x					x
SV2	1788	x		x	x	x	x	x					x
SV3	1780s	x		x	x	x	x	x	x				x
SV4	1790	x		x	x	x	x	x					x
SV5	1797	x		x	x	x	x	x					x
SV6	1797	x		x	x	x	x	x					

*Limited access to canvas

The applied methods are all commonly used in analyses of paintings within the field of conservation and technical art history to investigate the use of techniques and materials (Thomson et al 1977; Ciliberto & Spote 2000; Faries 2003; Pinna et al 2009; Burnstock 2017). The quantitative character of the methods allows for reproduction and verification of the data and results obtained, and for comparison with other technical studies on painting techniques and materials. In the following sections, the individual research methods used in the technical investigation of the paintings are described. Each section gives a brief introduction to the method, how it contributes to the investigation, its limitations, on which paintings the analyses are performed and a description of the instrumentation and procedure by which it was executed. Results of the examinations and analyses are presented and discussed throughout the subsequent chapters or in appendices.[17]

4.1 Visual Analysis and Photographic Documentation

Visual analysis for the investigation of paintings involves the observation of what is visible to the naked eye. It is primarily a descriptive analysis with a structured and systematic approach to the different layers and elements that make up a painting. It aids in establishing a detailed knowledge of the painting and in decision making for further analyses, as well as supporting the interpretation of these analyses.

A thorough visual analysis was undertaken of all of the selected paintings for this project. The majority of descriptive observations are supported by high-quality photographic documentation. Not all documentary images from the visual analysis are included in this thesis, but all of them have been archived. Should the reader be interested in documentation of specific observations, which are not reproduced in this thesis, they can be requested by contacting the author. Overall images and selected details are presented in Appendices 1 to 24.

4.2 Microscopy

Optical microscopy is a non-invasive technique that supports visual analyses by magnification of elements and structures through the surface of the painting that are not detectable by the naked eye. A great deal of information about surface features, stratigraphy (through cracks) and the condition of the painting can be obtained by magnification (Eastaugh and Walsh 2012:306-317).

The type of microscope used varies depending on the area investigated in the painting and for which purpose it is being used. High-magnification images of select areas of the paintings at SMK were performed with a Leica M205A stereomicroscope 20.5:1 motorized zoom with 7.8x to 160x magnification range with a Leica MC170 HD Camera applied or a Leica M50 Microscope with a magnification range between 5.0x to 32x and a IC80 HD microscopy camera. Additionally, a

[17] Weighting in probability vocabulary used in results and interpretations: Likely, probably, possibly, perhaps, likely not.

portable handheld USB digital microscope (Veho and ScopeEye) in conjunction with a laptop was used for paintings at SMK and on the Svenstrup paintings. This was used especially for examination of the tacking margins and canvas analyses as the computer software allows for measurement of thread thickness and spinning angle (see Section 4.6).

4.3 Ultraviolet (UV) Fluorescence

Ultraviolet (UV) Fluorescence is a non-invasive surface visualisation technique, which uses UV fluorescence to analyse the fluorescent colour emitted by a painted surface under UV radiation. Different materials on the surface of a painting which appear similar in normal light, will display different coloured fluorescence when interacting with UV radiation, thus allowing the different materials to be differentiated. This technique primarily distinguishes between organic materials such as paint and varnish layers applied at different times, and can show whether any revisions have been made to the paintings such as retouching, which will usually appear as darker patches on the surface. This provides indicators for the differentiation between original representation and the preservation history of the artwork. The identification of retouches is especially helpful in circumstances when analysis of the original paint layers and pigments are to be performed with a surface analysis technique such as X-Ray Fluorescence (XRF) or when removing samples for material analysis. Old retouches and overpaint that lies underneath the varnish layers will not be detected however, which is a limitation of the technique. The varnish layer can also aid in the visualisation and documentation of the presence of cracking and craquelure in the varnish and underlying paint layers, as these often interrupt the surface emission of the varnish and appear as dark lines (Rorimer 1931: De la Rie 1982; Macbeth 2012:294-296).

UV examination and imaging of the Svenstrup paintings was performed at the National Museum using two Deffner & Johan UV 400W Flood Lamps, with a wavelength range of 315 to 405 nm and peak at approximately 365 nm. A 2A Kodak, Wratten gelatin filter is applied. UV examination and imaging of the SMK paintings was performed using a Reskolux® UV 365 source, which emits high-intensity UV wavelenght of 365 nm +/-5 nm (UV-A). In this case, no filter was applied. UV images are presented in Appendices 1.2 to 24.2.

4.4 Infrared Photography (IR)

Infrared photography (IR) is a non-invasive imaging technique that can penetrate through most paint layers, depending on thickness, paint composition and the used wavelength range. It is mainly used to look beneath the surface of the paint layers to detect the presence of underlying features such as an underdrawing, which cannot be seen with the naked eye. The effectiveness of the method depends on the pigmentation of the underdrawing as well as the colour of the ground layers (Van Asperen de Boer 1970; Bomford & Billinge 2002; Eastaugh and Walsh 2012:296).

IR was executed on three of the paintings from SMK: *Hauch KMS349*, *Clemens KMS396* and *Hielmstierne KMS349a*. Both Infrared Photography and Transmitted Infrared Photography (TRIR) were executed and recorded using a Canon EOS 5D Mark III, Modified, spectral response 700 to 1100nm camera with Canon Compact-Macro LENS EF 50mm, 1:2.5 lens and an RG380 visual blocking filter. For IR a Hedler light 1150W is used for illumination and for TRIR a Hedler (halogen) 650W is used. The TRIR method allows for an enhanced contrast between ground and underdrawing (Moutsatsou 2011; Cosentino 2016). Infrared images are presented in Appendices 6.4, 7.4 and 11.4.

4.5 X-Radiography

X-radiography of paintings is a non-invasive imaging technique that uses X-rays to capture features beneath the paint surface that are not visible to the naked eye. X-rays can reveal several kinds of information about the physical structure of a painting such as insights into the preparation, the layer structure and painting technique as well as display compositional changes made by the painter during the painting process. X-radiographs can, furthermore, give indications of how the painting has changed over time. It displays losses and allows for the identification of features in the ground and paint associated with past interventions, such as size reduction, as well as cracking and ageing of the paint layers. As all materials and layers are superimposed onto each other in the same X-radiograph, it can at times be challenging to distinguish which features belong to which layer. The visibility of features is dependent on the contrast between light and heavy chemical elements. The lowest possible kilovoltage (kV) is desirable for maximum contrast: the higher the kilovoltage the smaller the wavelength and deeper the penetration. For paintings, a range of 15 to 40 kV is usually adequate (Bridgman 1964; Van Asperen de Boer 1968; 1970; Gilardoni et al 1994; Van de Wetering 1995:14-15; Noble & Verslype 2017).

X-radiography has been carried out on all the paintings included in this project. X-radiography of the sixteen paintings from SMK was performed at SMK, executed with an Yxlon portable constant potential X-ray unit SMART Evo 160D X-ray tube at 30 to 34 kV, 5 mA, 30 to 100 sec. on 30 x 40 cm DürrNDT high definition image plates. Distance between X-ray source and film was 110 cm with a 3mm AlMg3 Filter. Each painting required a combination of between four and eight exposures, which were joined in Adobe Photoshop. X-radiographs are presented in Appendices 1.3 to 16.3.

On the eight paintings from Svenstrup Estate, X-radiography was performed at the National Museum of Denmark, and was executed with an Yxlon portable constant potential X-ray unit SMART 160E/O.4 X-ray tube at 25 to 30 Kv, 3 mA, 60 to 70 sec. on 30 x 40 cm high definition image plates (HD-IP) and scanned with a CR-35 NDT image plate scanner from Dürr. Distance between X-ray source and film was 110 cm with no filter (Appendix 25). Each painting required a combination of four exposures, which were joined in Adobe Photoshop. X-radiographs are presented in Appendices 17.3 to 24.3.

4.6 Canvas Analysis

Canvas analysis is a thorough analysis of the structures in the canvas. Characteristics traditionally used to describe and explain the structure and behaviour of a fabric are examined: fibre identification, weave pattern, thread count, thread thickness, spinning direction, weft and warp direction, crimp, cover factor and the presence of selvedge (Rouba 1992; Andersen et al 2007: Hackney 2020). Depending on the state of preservation, it can at times be challenging to perform a complete canvas analysis as the lining canvas can prohibit the visual access to the original canvas. Furthermore, the tacking margins can be either absent, distorted and/or encrusted with lining adhesive. In cases like this, the X-radiographs can assist in providing information on the canvas structure. A summary of the results of the canvas analysis is presented in Table 7.2 and 7.3.

Fibre identification

A single thread was sampled from each direction of the canvas of each painting. A small section of each thread was placed on a glass slide and investigated by polarised-light microscopy. Based on optical properties and characteristics of the fibres, it is possible to determine the plant origin (Ilvassalo-Pfäffli 1995:336-339; Bergfjord & Holst 2010).

Thread count

For the unlined paintings, thread counts were executed in multiple points on the canvas on the reverse, each point covering 3 x 3 cm. The thread count in each region has been divided by three to obtain the thread count per centimetre in each direction. Visual access to the original canvas in the lined paintings was limited. The thread count was therefore performed in visible areas along the tacking margins. In all cases, the number of threads per centimetre is compared in the calculated weave maps described in the next section. In two instances, *Rahr KMS3499* and *Holm KMS1766*, a sample from the canvas, before wax-resin lining, had been collected and preserved in the archives at SMK. In these instances, the thread counting was done on the sample. In two instances, *Battier KMS3634* and *Saly KMS4801*, it was not possible to obtain any access to the original canvas, thus the thread count as well as thread thickness measurement rely entirely on the weave-map calculations.

Thread thickness and spinning degree

Measurements of the thickness of the threads and their spinning degree angle were assisted by microscopy. A ScopeEye Digital Microscope was used at SMK, while a MicroCapture Veho VMS-004 Digital Microscope was used at the National Museum for the Svenstrup paintings. Both are portable USB microscopes with software that supports measuring distances and angle degrees on the micrographs. Spinning degree angle is characterised in the following range: 0-10° = loose, 10-25° = medium, 25-45° = tight (Andersen et al 2007).

Weft and warp direction

The direction of the weave can be identified by the presence of a selvedge, which runs in the warp direction along the edges of the canvas. In some cases other features such as thread irregularity, crimp and differences in the number of threads in each direction provide indication as well (Rouba 1992; Young & Hibbert 1999; Van de Wetering 2009:301; Franken 2017; Hackney 2020:72-73).

Cover factor

Cover factor is a number that indicates the extent to which an area of a fabric is covered by one set of threads. For any woven fabric, there are two cover factors, one for each direction of the weave: C1 = Horizontal, C2 = Vertical. These combined give the total cover factor percentage (Cf), which represents the density of a fabric (Rouba 1992; Gabrijelčič & Dimitrovski 2004; Mathur & Seyam 2011). The following equations are used to calculate cover factor (Mathur & Seyam 2011):

$$C = \text{average thread count/cm} \times \text{average thread thickness}$$

$$C_f = (C_1 + C_2 - C_1 \times C_2) \times 100$$

Thread-folding test

A thread-folding test is used to evaluate the degradation state of the canvas threads. With time, the cellulose in the canvas degrades, resulting in embrittlement and decreased fibre strength. The folding test is suggested as a minimal intervention test to evaluate the level of degradation (Oriola et al 2011).

An individual thread is removed from each direction of the weave. The thread is folded and pressed between fingertips. If the thread breaks the result is "0" and it is considered in an advanced state of degradation. If it does not break it is unfolded and gently pulled apart. If it does not break, the procedure is repeated, folding the thread in opposite directions. This is repeated until the thread either breaks or has been folded ten times. A thread folded ten times remains strong with low degradation (Oriola et al 2001). A limitation of the test, is that the thread along the tacking margin, which is often most degraded, may not necessarily be representative of the rest of the canvas (Hackney 2004).

4.7 Computer-Assisted Weave Mapping

Computer-assisted automated thread counting and weave mapping is a rather new type of non-invasive scientific examination of paintings consisting of computer-generated 'weave maps', created from the X-radiographs. Weave maps generate information about threads and weave patterns that help to display underlying patterns more clearly and allow for comparison of the character of the canvas support in different paintings. This aids in the determination of whether canvas supports of two different paintings originate from the same canvas roll (or 'bolt'). Weave maps can be a useful tool for assessing questions of pendant relationships and dating, and at times authenticity. In addition, thread-angle maps help to gain insight into the structure of the canvas,

the presence and degree of cusping along the edges and thus the way it was prepared and mounted (Johnson et al 2009; 2010; 2011; 2013; Johnson 2017; Franken 2017; Wheelock 2017).

Automated thread counting and weave mapping was performed on all paintings in this study, in support of manual canvas analyses. Thread counting and weave mapping of the sixteen paintings from SMK was executed on an earlier version of the weave-mapping program developed by Rick Johnson (Cornell University) and Don Johnson (Rice University). This software arose from collaboration between the Van Gogh Museum Amsterdam and the Thread Count Automation Project (TCAP) and makes use of signal processing algorithms to detail variations in canvas-thread density across a painting. A more recent version of the weave-mapping program was used for the Svenstrup paintings and in re-evaluation of some of the paintings from SMK. The more recent software for generating weave maps is written by William A. Sethares (University of Wisconsin and Rijksmuseum Amsterdam) (2017a; 2017b). It is released under an open-source license and can be freely downloaded at the Counting Vermeer website: http://countingvermeer.rkdmonographs.nl/appendix-vii-software/. The online publication, *Counting Vermeer: Using Weave Maps to Study Vermeer's Canvases,* provides a thorough account of the process and application for generating weave maps, as well as how to interpret them (Johnson 2017). Weave- and angle maps are presented in Appendices 1.3 to 22.3.

4.8 Cross-Sections

Cross-section analysis is an invasive micro-sampling technique that provides a valuable window into the structure and composition of the different layers of a painting. The stratigraphy of the layers can be examined under a microscope and in various light sources and UV radiation. Organic materials generally emit fluorescence under UV, which allows for identification of varnish, sizing or intermediate layers. Individual layers and particles can be analysed to determine their chemical composition by using complementary techniques (Plesters 1956; Khandekar 2003:52-64; Wolbers et al 2012). The applied complementary techniques are described in the following sections.

Cross-sections were collected from each of the paintings. Since removing physical material from the paintings should be limited, as standard only one sample was taken from each painting for cross-section analysis (EN 16085:2012). Samples were collected after studying the paint surface visually and with a UV source to carefully select an area that would be representative of the painting, including all paint and ground layers and unaffected by retouching and overpaint. Samples were generally collected along the edge of the painting where damages or losses had already occurred. In many cases, the paint surface in the body of the paintings was in such good, undamaged condition that performing sampling would be too invasive. Only in the cases of *P.J.Schouw KMS1113* and *Bagge KMS1115* were the samples taken from the flesh in the area of the cheek. This was done as the areas were displaying extensive cracking and minor losses, allowing access to remove a small sample. Furthermore, these two paintings are painted on

different colour grounds, making it favourable to compare the build-up of paint layers of the flesh between different ground colours.

All cross-sections were prepared at CATS – Center for Art Technological Studies and Conservation. The samples were transferred to EasySections and embedded in Technovit 2000 LC liquid (acrylic resin). Technovit 2000 LC covering varnish was applied to the samples during the process of curing. Silicon carbide grinding paper was used for the coarse grinding of the samples (320-500), after which they were polished with micromesh cloth (1500, 1800, 2400, 3200, 3600, 4000, 6000, 8000 and 12000). The cross-sections were placed with Blu Tack on a transparent glass slide and levelled before documentation under the microscope. Images were recorded in dark-field (DF) illumination, differential interference contrast (DIC) and UV fluorescence with filter cubes A and I3. The entire preparation procedure and protocol for documentation can be found in Appendix 30. Cross-section images (DF, UVA and UV13) with indication of sampling location and descriptions of layers are presented in Appendix 29.

4.9 Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (SEM-EDX)

Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (SEM-EDX) offers detailed information on the elemental composition of specific particles and layers in the cross-sections. This allows for identification and quantification of pigments and fillers (Pinna et al 2009:191; Townsend & Boon 2012:345).

SEM-EDX is performed on cross-sections from each of the twenty-two paintings included in the project. Elemental analysis and EDX maps were carried out at The Royal Danish Academy – Institute of Conservation with a HITACHI S-3400N scanning electron microscope equipped with a Bruker Quantax 200 energy-dispersive X-ray spectroscopy detection system with two Peltier-cooled XFlash silicon drift detectors. The detectors have an active area of 20 mm^2 each. Measurements were performed in variable pressure mode (30 Pa) on non-coated polished sections and analyses were related to internal Virtual Standard using 20 kV voltage, 50 µA probe current and 10 mm working distance. The acquisitions, spots and maps, were respectively 60 and 600 seconds live time. The results and EDX maps are presented in Appendix 31 and included in Table 9.1.

4.10 Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR)

Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR) is used to obtain a qualitative identification of the molecular composition of material, mainly organic and simple inorganic compounds (Meilunas et al 1990, Pilc & White 1995; Derrick et al 1999; Rocco et al 2007; Spring et al 2008; Townsend & Boon 2012:352-354).

ATR-FTIR mapping on cross-sections from each of the twenty-two paintings included in the project was performed at CATS. ATR-FTIR mapping-mode was used to identify binders, pigments and fillers. It was executed primarily on the ground layers and, in a specific case, on an insoluble organic surface layer on *J.B.Neergaard SV1* (see Section 10.4). The samples were analysed with a Bruker Tensor 24® spectrometer, coupled to a Hyperion® 3000 microscope equipped with focal plane array (FPA) detector. ATR measurements were performed using a 20x objective and a Ge crystal with a refractive index of 4.01, which has an anvil design with an 80-µm tip. FPA maps were acquired in the 3800 to 900 cm^{-1} spectral range with 8-cm^{-1} spectral resolution and 128 scans. At least one to four maps were acquired for each sample. The significant band numbers for the identification of different compounds are presented in Appendix 32 and the overall interpretation is included in Table 9.1 and Table 9.2.

ATR-FTIR analysis on canvas-thread samples from three paintings, *Holm KMS1766, J.B.Neergaard SV1* and *A.M.B.Neergaard SV2,* was performed at the National Gallery of Art, Washington D.C. to test whether the method could be applied to detect the presence of sizing layers. Furthermore, a sample of glue from the original strainer of *J.Moltke SV5* was analysed for identification. ATR-FTIR spectra were collected on a PerkinElmer Spotlight 400 Imaging System and Frontier spectrometer in the range of 4000 to 750 cm^{-1} at 4 cm^{-1} resolution with a liquid-N_2-cooled MCT detector. The spectra were analysed using the Perkin Elmer Spectrum IR (version 10.6.1) software package. Canvas samples were placed on a glass slide and data were acquired using a drop-down micro ATR accessory with 100-µm Ge ATR crystal. Individual fibre samples were gently flattened with an Al roller and placed on a KBr disc for transmission measurements. The significant band numbers for the identification of different compounds and their interpretation are presented in Appendix 33.

FTIR analyses of varnish samples from *J.B.Neergaard SV1* and *A.M.B.Neergaard SV2* were performed at the National Museum of Denmark (Brede). The varnish sample was removed from the painting surface via swab action using fat-free cotton and ethanol 96%. Following Soxhlet extraction of the varnish, the samples were analysed by FTIR. The procedure and results are presented in Appendix 34.

4.11 Raman Spectroscopy

Raman Spectroscopy can be used to determine molecular structures and compositions in organic and inorganic material. Raman was carried out on the ground layers of cross-sections in support of ATR-FTIR mapping. The two analyses are complementary techniques. Raman is generally used in instances when red, black and yellow particles are present in the sample, as some elements such as carbon are more easily detected by Raman than other techniques such as SEM-EDX and ATR-FTIR (Pinna et al 2009: 188-190; David Buti, personal communication August 2018).

Raman analyses were carried out at CATS using a dispersive Bruker Senterra Raman spectrometer coupled to an Olympus microscope and equipped with a thermoelectrically cooled charged-coupled device (CCD) detector. Raman spectra were recorded by focusing a 785 nm or 53 2nm laser beam through a 50x Olympus objective. 400 lines/mm gratings and 1200 lines/mm gratings were used. The laser power at the sample was kept between 1 and 25 mW with an acquisition time between 1 and 100 seconds for each spot and 1 to 3 accumulations. The significant band numbers for the identification of different compounds and their interpretation are presented in Appendix 32 along with ATR-FTIR mapping results (see above), and are included in Table 9.1.

4.12 X-Ray Fluorescence Spectroscopy (XRF)

X-Ray Fluorescence Spectroscopy (XRF) is a non-invasive spot-analysis technique performed on the surface of the painting that offers identification of chemical elements in the paint and ground layers. It is used to identify pigments, obtain information on the artist's palette and pigment mixtures applied.

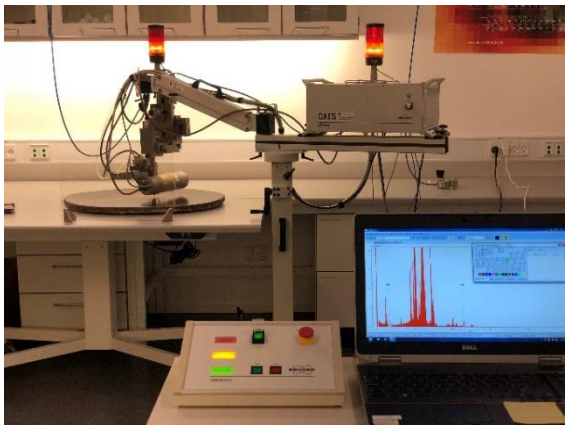

Fig. 4.1 XRF set-up at CATS during analysis.

Fig. 4.2 FORS set-up at CATS during analysis of *H.Gerner KMS1444.*

It is important to consider that XRF can pass through numerous paint layers, and sometimes even the ground layer is included, which means that the elemental information of all paint and ground layers will collectively be present in the spectrum. The information generated by XRF can be combined with other techniques and visual examination of the painting, including microscopy, to provide a sense of the artist's use of pigments (Glinsman 2004:19-26; Pinna et al 2009:210-213).

XRF was performed at CATS on the sixteen paintings from SMK (Fig. 4.1). Spectra were generated from between thirteen and twenty-six points on each painting. XRF examination was not performed on the Svenstrup paintings. XRF measurements were carried out with a Bruker ARTAX 400 spectrometer equipped with a transmission Rh anode X-ray tube, a 1.5-mm-diameter collimator (1 mm diameter focused spot size) and a Silicon Drift Detector (SDD). The instrument was operated at 50 kV and 700 μA, with acquisition times of 200 seconds per point. All areas

were examined with a UV fluorescence to avoid retouched paint surfaces. All analysed points were compared to micrographs of the surface to detect the mix of pigments present in the analysed area. Micrographs of the analysed points and the interpretive results of analyses are listed separately for each painting in Appendix 35, in combination with FORS and ER-FTIR results. Elements are listed in order of abundance and a general interpretation of the primary or identifiable pigment is suggested. An overview of Juel's palette is suggested and presented in Table 10.1.

4.13 Fibre Optics Reflectance Spectroscopy (FORS)

Fibre Optic Reflectance Spectroscopy (FORS) is a non-invasive surface-analysis technique. It is used to confirm the identification of a pigment, dye or lake either separately or complementary to SEM-EDX, XRF and ER-FTIR or other elemental analyses. The ability of a reflectance spectrum to identify a material depends on the quality of the spectrum acquired and reliable date reference materials. FORS is unable to produce accurate results when complex mixtures are present and cannot differentiate between certain pigments such as cadmium red and vermilion as they reflect similar spectra (Ciliberto & Spoto 2000:321-361; Pinna et al 2009:197-200).

FORS was performed at CATS on the sixteen paintings from SMK (Fig. 4.2). It was carried out in the same points on the paintings as XRF and, in some instances, additional points were analysed to support possible interpretation and identification of pigments present in the ground and paint layers (Fig. 4.2). Site-specific FORS measurements were performed with a FieldSpec 4 fibre optic spectro-radiometer (ASD Inc., a Malvern PANalytical company, CO). Spectra were collected over the range of 350 to 2500 nm, with a spectral sampling of 1.4 nm from 350 to 1000 nm and 2 nm from 1000 to 2500 nm. The spectral resolution was 3 nm at 700 nm and 10 nm at 1400 nm and 2100 nm. Measurements were carried out using a bifurcated fibre optic probe; each of the bifurcated ends is composed of 78 fibres and all the 156 fibres (2000-µm core) are well mixed in the common end. The sampling area was about 4 mm in diameter and 64 spectra averaged for each sample. The instrument was calibrated using a white reference panel from ASD, which is made of a total reflective material. The Cultural Heritage Science Open Source, FORS Spectral Database of Historical Pigments in Different Binders, developed by Antonino Cosentino (Cosentino 2014) was the main reference database used for interpretation of spectra. The interpretive results are presented in Appendix 35 and included in Table 9.1 and Table 10.1.

4.14 External Reflectance-Fourier Transform Infrared Spectroscopy (ER-FTIR)

External Reflectance-Fourier Transform Infrared Spectroscopy (ER-FTIR) is a non-invasive surface-analysis technique. It is used to contribute to the identification of a pigment in support of XRF and FORS analyses, and is particularly useful for dark paint surfaces. Generally, in dark

paint areas, identification with FORS is troublesome as most light is absorbed and hence does not reflect and create a spectrum (Handke et al 1991: Nodari &Ricciardi 2019).

ER-FTIR was performed at CATS on select points to support XRF and FORS pigment analyses. ER-FTIR spectra were collected using a Bruker Alpha FT-IR spectrometer equipped with a reflection accessory with video-option and a DLATGS detector. Reflectance spectra were acquired over the range of 4000 to 650 cm^{-1}, with 64 scans at a resolution of 4 cm^{-1}. Background spectra were run at hourly intervals. The interpretive results are presented in Appendix 35 and included in Table 9.1 and Table 10.1.

4.15 Gas Chromatography/Mass Spectrometry (GC/MS)

Gas Chromatography/Mass Spectrometry (GC/MS), after appropriate sample pre-treatment, is the most common analytical technique for the characterisation of organic materials in cultural heritage objects including samples from paintings (Mills 1966; Mills & White 1972; Bonaduce et al 2015). GC/MS was chosen as a method for binding media analysis to obtain more detailed information on the binding media of the ground layers in comparison to other techniques such as ATR-FTIR mapping. Lipids, polysaccharides and proteins are the main binders found in traditional painting samples, such as oils, gums, starch, glue and egg, as well as waxes and resins (Andreotti et al 2008; Colombini & Modugno 2009). These materials are mixed with pigments and fillers, making complex samples with a variety of molecules with different chemical characteristics and reactivity, which are then subjected to ageing. Therefore, GC/MS is carried out as a step-wise procedure where components commonly found in paint samples are extracted and analysed separately in different fractions of lipids, polysaccharides and proteins. The extraction and separation into different fractions allows for the analyst to control substances which are present in the chromatograms, as many organic materials contain the same chemical components.

Several studies have focused on extraction and identification of the individual organic components in a sample by GC/MS. These have included lipids (Schilling & Khanjian 1996b; Van den Berg et al 2002; Blaŝco et al 2008; Colombini et al 2010), resins (Baumer et al 2009), polysaccharides (Bonaduce et al 2007; Lluveras et al 2012a; 2012b) and proteins (White 1984; Schilling et al 1996; Schilling & Khanjian 1996; Colombini & Modugno 2004; Bonaduce et al 2009). Different approaches for improving and optimising the simultaneous detection of various organic materials from the same sample and removing possible interferences caused by inorganic elements present in the sample, are proposed (Andreotti et al 2006; 2008; Singer & McGuigan 2007; Doménech-Carbó 2008; Van Keulen 2009; Lluveras et al 2010; Colombini et al 2010, Bonaduce et al 2009; 2015 and references therein; Witkowski et al 2017; Sutherland 2018; Mazurek et al 2019).

For all the methods under consideration here, samples first underwent wet-chemical preparation that included various solvent extraction procedures to reduce the complexity of the samples before the extracts were subjected to hydrolysis and derivatisation procedures. Organic materials in cultural-heritage samples are mainly polar and have low volatility. Since gas chromatography requires molecules volatile enough to pass through the column for separation, most samples require pre-treatment before injection into the GC/MS. All polar molecules must be converted to non-polar forms, a process called derivatisation. Before derivatisation, the original macromolecules must be fragmented, in this case by acid hydrolysis, to smaller molecules that are then subsequently derivatised to non-polar forms (Andreotti et al 2006, Colombini et al 2010).

Samples from twenty-one of Juel's paintings were prepared and analysed by GC/MS. Sample preparation and analyses were carried out at the Scientific Research Department at the National Gallery of Art (NGA), Washington D.C. A sample of the ground layers, equivalent in size to one to two pinheads was taken from the tacking margin of each painting, either close to the outer edge or in areas already damaged or displaying losses. Paint layers and lining materials present on the sample were removed to the best ability under a microscope. In some cases, it was not possible to remove all of these materials and some residue remained. Initially, it was attempted to separate samples that included two ground layers into individual layers. However, it was concluded that this could not be done with certainty that residue of the one layer would not remain on the other, which would mean that the analytical results of each separate layer could be contaminated. It would have been ideal to separate the layers in order to investigate differences between ground layers in the same painting, but samples were very brittle and crushed easily upon separation attempt, risking loss of the sample in the clean-up process. Therefore, each sample, whether constituting of one or more ground layers, was analysed as a bulk.

The sample preparation procedure used at the NGA is a modified version of the procedure presented by Ursula Baumer from the Doerner Institute, Munich ("Doerner Method"), at the MaSC Group, GCMS Workshop, held at the Philadelphia Museum of Art, Winterthur Museum, 10-14 September 2007 (MaSC Group 2007; Koller & Baumer 2000). The Doerner Method was modified into a five-day scheme and some approaches adjusted based on new information published in scientific literature since the workshop in 2007 (Chris Maines, personal communication September 2019). The procedure includes extraction, derivatisation, hydrolysis and silylation and is divided into six steps aimed to detect separate components characteristic of painting materials from the same sample with GC/MS, if present. Step 4, which is the metal soap analysis step, was only carried out on samples from seven of the twenty-one paintings (see Table 5.4). The analytic procedure resulted in nine chromatograms for each sample, with an additional two if step 4 was included. Figure 4.3 displays a simplified schematic representation of the steps in the wet-chemical sample preparation procedure and analyses protocol. A detailed scheme of the entire sample preparation procedure, including a complete list of solvents, reagents, equipment and settings for the GC/MS analysis is given in Appendix 36.

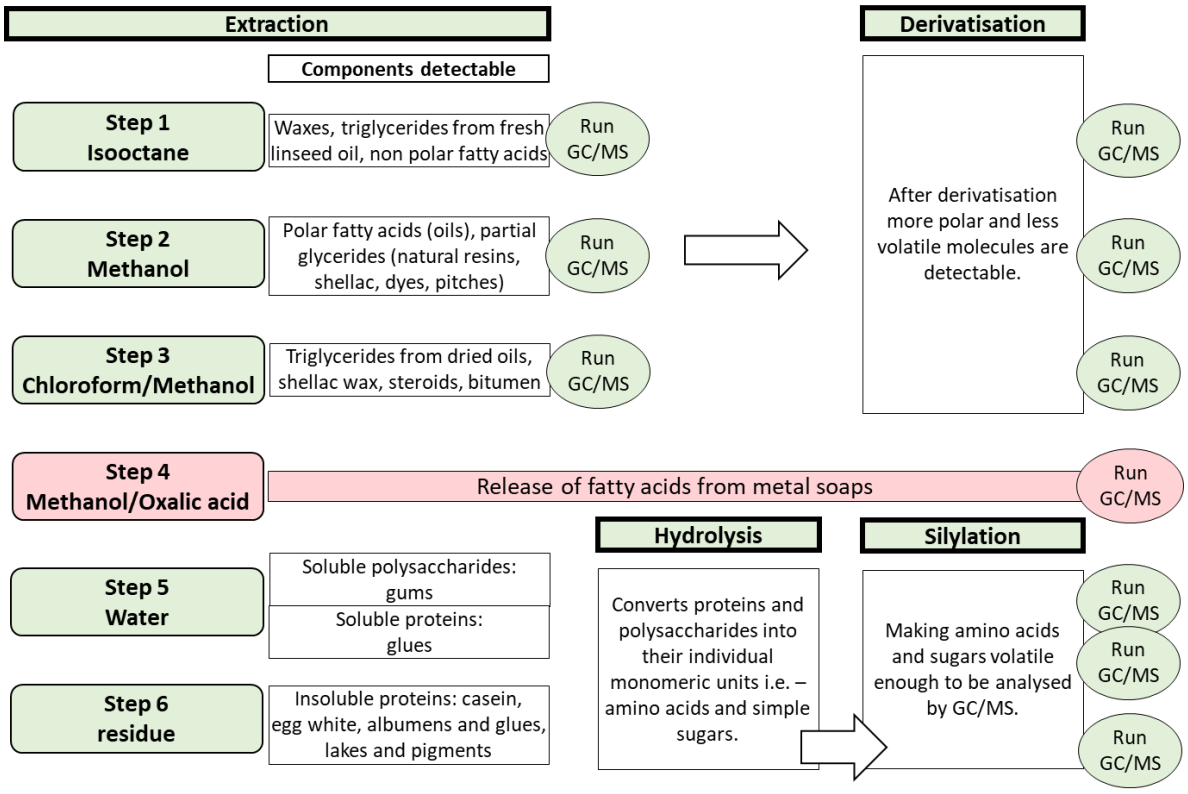

Fig. 4.3 Simplified schematic representation of steps in the wet-chemical sample preparation procedure for analyses by GC/MS performed at the National Gallery of Art for this project. The listed components represent the components which can possibly be detected from each step given they are present in the sample.

Following sample preparation, GC/MS analyses were performed on a Shimadzu GCMS-QP2010 SE advanced standard gas chromatograph-mass spectrometer with a general-purpose, low-polarity phase Shimadzu SH-Rxi™-5Sil MS capillary GC column (L. 30m x I.D. 0.25 mm x D_f 0.25 µm). This type of low-polarity column is very similar to those used in the references mentioned above. Chromatograms from each step were compared to references in the NIST Mass Spectral Database 2014 (National Institute of Standards and Technology) and amino profiles further analysed using AMDIS Version 2.72 (Automated Mass Spectral Deconvolution & Identification System), which aids in separating noise and overlapping peaks and is especially helpful when there are only trace amounts of compounds. The identification of organic compounds in paint samples in the chromatograms is generally based on either specific marker compounds, recognition of the chromatographic profile or a quantitative analysis of significant compounds (White 1984; Bonaduce et al 2009; Colombini et al 2010). Interpretations and chromatograms are displayed in Appendix 37. An overview of samples analysed and a summary of the results are presented in Table 9.2.

5 State of Preservation and Degradation Patterns

The state of preservation and degradation processes rely on inherent properties and external physical factors to which the painting is exposed over time. The materials in each layer of a painting have their own distinctive chemical and mechanical behaviour, and therefore, every layer contributes in its own way to the formation of craquelure and other patterns of degradation. Further, the layers can influence each other. All these factors can affect the long-time stability of paintings (Keck 1969; Mecklenburg 1982; Bucklow 1997; Giorgiutti-Dauphiné & Pauchard 2016).

In this chapter, general trends and some exceptions in the state of preservation and degradation patterns in the examined paintings by Juel are described. These concern the extent of losses of ground and paint layers, lining treatments, crack patterns and surface phenomena, including a brief overview of the theory of their common causes. This will be correlated to material analyses of the paintings, which are presented and discussed in the following chapters.

That there are relatively few conservation records could suggest that not many degradation issues in Juel's paintings exist. However, it is important to differentiate between actual treatments and the historical practice of documentation. In the past, unlike today, in many museums, it was not always standard to record and report treatments of the paintings (Blewett 2012). Like many other museums, the level of documentation at SMK varies and generally increases over time. For the examined paintings by Juel from SMK, in most cases, the old index cards simply hold a brief remark "seen by conservator" or "with conservator" and it is unclear how much was done to the painting while in the hands of the conservator. Sometimes brief descriptive comments are added, such as "cleaned", "retouched" or "wax-resin lined", providing an idea about a treatment or condition of a painting at a certain time (Appendices 1-16). That the paintings have undergone treatments is evident from the paintings themselves. The examined paintings from SMK display a lining canvas and adhesive residue along the edges from previous treatments. Examination such as X-radiography displays losses and UV fluorescence displays various varnish layers, overpaint and retouching. The reason for treatment is rarely mentioned in the records. In the past half-century, documentation has increased significantly and conservation records from these years provide more detail on the treatments and condition of a few of the paintings. Treatments performed in the past on paintings from private collections are rarely documented.

The art historian Ellen Poulsen included sporadic remarks on the state of preservation of many of the paintings in the catalogue raisonné (1991). Here and there, she moreover suggests a specific use of colour, pigment, material or technique. Her terminology is at times different from that normally used by conservators. Some remarks imply whether the paintings are lined ("New canvas") or not lined ("Old canvas"). At times, she includes information on when or who made a restoration, how the condition is or if the painting is particularly well preserved. For the majority

of canvas paintings, no remark was added. Poulsen collected the information over fifty years (since 1936; Møller 1982), and it is not known when during that period each remark was made. Indeed, the state before and after any conservation treatment is not recorded, nor the reason for the treatment in the specific case. It does give the impression that a fair number of paintings are lined, as is usual for paintings that age and importance. As will be discussed in the following, lining of paintings might be a result of an earlier preventive conservation approach and not necessarily due to structural issues. Only a small number seem to be in a badly preserved state, while Poulsen specifically states about 10% to be well preserved. Figure 5.1 displays an approximate overview of the remarks applied to paintings on canvas in the catalogue.

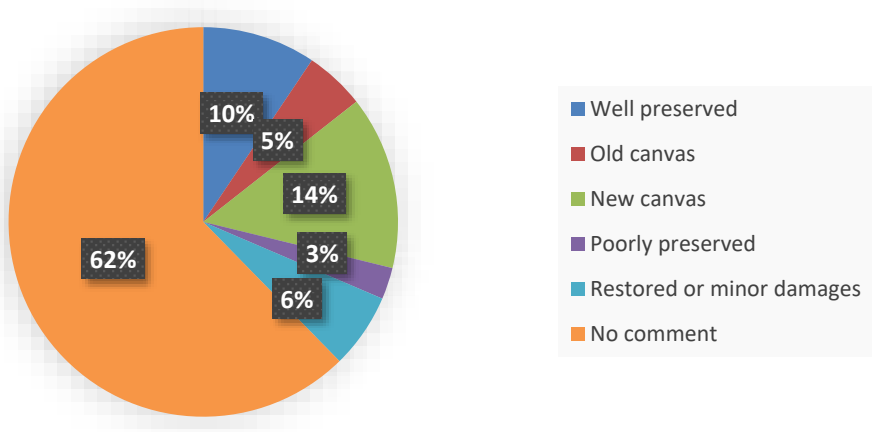

Fig. 5.1 Approximate overview of preservation comments in the catalogue raisonné regarding paintings on canvas (Poulsen 1991).

That numerous of Juel's paintings are in good condition, without having undergone structural conservation treatments, is evidenced for instance by the portraits from the Svenstrup Foundation included in this investigation. Only one of the Svenstrup paintings is lined (*Buchwaldt SV3*), while *J.B.Neergaard SV1* may have been subject to impregnation as the painting displayed a darkened substance applied to the verso of the canvas (Appendix 17.2). Those paintings that are not lined remain in good condition with only minor losses. At some point in time, they have all been re-varnished while remaining in their frame and minor retouches have been carried out. They are still mounted on their original strainers and present only slight slackness or minor local bulging. Private conservator Britt Christmas Møller, owner of *Konserveringsværkstedet*, informs that a significant number of Juel's paintings from private collections that enter her studio for treatments are in a similar well-preserved state (personal correspondence May 2020). As with the Svenstrup paintings, they generally display few losses and only minor buckling when still mounted on the original strainer. Often they remain unlined, and if any treatment was done in the past, it is usually that a layer of varnish was applied and perhaps minor retouching. The paintings often enter the studio due to degraded varnish and surface dirt that needs to be cleaned and removed, but often do not suffer from other troublesome issues.

5.1 Lining

The selected paintings from SMK have all undergone several treatments and all are lined. Some of the paintings were lined before entering the collection and some have been re-lined with different methods. Only one of the paintings from Svenstrup is lined. Information on lining treatments is listed in Table 5.1. That the paintings are lined does not necessarily mean that any issues were inherent to the paintings' state of preservation. In previous conservation history, lining was often performed as a standard and preventive measure (Percival-Prescott 1974, Phenix 1995; Andersen 2013; Hackney et al 2012; Hackney 2020:76). As is mentioned in the following section, few paint losses have occurred that suggest structural instability and the majority of the paintings pass the thread-folding test with more than ten folds. Thus, the canvases do not display significant signs of degradation and brittleness of the threads. This supports the notion that lining was often performed as a preventive measure. A few threads indicate fragility that suggest the need for structural reinforcement of the paintings; however, as the threads are sampled from the tacking margins they may not always be representative of the overall state of preservation of the canvas (Hackney 2004). The results of the thread-folding test performed during canvas analyses are included in Chapter 7, Table 7.3.

Glue-paste lining

All sixteen paintings from SMK have been subject to glue-paste lining. Seven of them have since been re-lined with wax-resin (Table 5.1.). Five of the SMK paintings that are lined with glue-paste are lined with the so-called technique "lining on the stretcher" (Monaghan et al 2013). This technique differs from the more common glue-paste lining technique as the painting is attached to a lining canvas already stretched on the final stretcher and can be identified by a double set of tacks, one in each canvas. Painter and conservator F.R. Greve described a similar technique in 1855 (Monaghan et al 2013). The portrait of *Buchwaldt SV3* from the Svenstrup Foundation appears to have undergone the same type of lining. The aged appearance of the lining proposes that it could originate from the nineteenth century. This suggests that the technique was perhaps commonly used in Denmark in the last half of the nineteenth century and well into the early twentieth century; *Self-portrait KMS3990* is recorded lined "on the stretcher" in 1933. In the oval SMK paintings lined with this technique, the tacking margins of the original are slit (Fig. 5.2). The slitting may have been carried out as part of the lining treatment.

Fig. 5.2 Slit tacking margins on *C.S.Gerner KMS1445*. Slit tacking margins are present on all of the oval SMK paintings lined "on the stretcher". They are not present on *Buchwaldt SV3.*

Table 5.1 Summary of preservation state regarding lining treatments, tacking margins and paint losses (%) on examined paintings by Juel.

Painting id.	Year	Painting entered collection	Glue-paste lining (G-P)	Wax-resin lining (W-R)	Condition of lining and tacking margins	Loss of ground and paint from X-radiograph (approx. %)
KMS3990	c. 1764	1932	G-P 1933 (on stretcher)	-	Lining adhesive brown and deteriorated	0.5
KMS3499	1770	1921	G-P	W-R 1964	Stable lining	1
KMS3634	1771	1923	G-P	W-R 19??	Stable lining Tacking margins are removed	0.5
KMS4801	1772	1954	G-P	W-R 1965	Stable lining Tacking margins are removed	1
KMS3275	1773-74	1914	G-P before 1930 (on stretcher)	-	Seemingly stable lining, deteriorated adhesive	1
KMS349	1776	1838	G-P old	-	Stable lining Tacking margins severely damaged	1
KMS396	1776	1841	G-P old	-	Seemingly stable lining Tacking margins severely damaged	1
KMS1766	1778-79	1903	G-P	W-R 1964	Stable lining Tacking margins severely damaged	1-1.5
KMS4810	1778-79	1954	G-P before 1954	-	Stable lining Tacking margins are removed	1-1.5
KMS6151	1779	1958	G-P before 1958	-	Stable lining Tacking margins are removed	1
KMS349a	1780	1938-39	G-P before 1946	-	Stable lining	0.5
KMS1444	1785	1891	G-P (on stretcher)	W-R 1959	Stable lining. Tacking margin slit	0.3
KMS1445	1785	1891	G-P older (on stretcher)	-	Deteriorated adhesive, initiated delamination Tacking margin slit	0.3
KMS1113	1799-1800	1878	G-P (on stretcher?)	W-R	Stable lining Tacking margin slit and brittle	1
KMS1114	1799-1800	1878	G-P (on stretcher?)	W-R 1959	Stable lining. Tacking margin slit	0.5-1
KMS1115	1799-1800	1878	G-P (on stretcher)	-	Seemingly stable lining Tacking margin slit	0.3-0.5
SV1	1788	1788	Unlined (possibly impregnated)		Tacking margin well preserved	0.1
SV2	1788	1788/1798	Unlined		Tacking margin well preserved	0.1
SV3	1780s	After 1825?	G-P very old (on stretcher)	-	Deteriorated lining adhesive, delamination initiated. Tacking margin well preserved	0.1
SV4	1790	1790	Unlined		Tacking margin well preserved	0.1
SV5	1797	1798	Unlined		Tacking margin well preserved	0.1
SV6	1797	1798	Unlined		Tacking margin well preserved	0.1

Wax-resin lining

Seven of the selected paintings from SMK are re-lined with wax-resin. Wax-resin lining was invented in the Netherlands in the 1880s and came to Denmark in the early 1900s (Bjarnhof 1981). At SMK its use gradually increased during the 1940s and 1950s and reached a peak in the mid-1960s (Andersen 2013:17 and references herein). The mixture was always the same at SMK: seven parts unbleached beeswax and three parts dammar resin (Andersen et al 2014).

A rough approach

The surfaces of the paintings from SMK at times display evidence that the lining treatment was carried out with a rough approach, resulting in permanent changes to the surface texture such as iron marks (Fig. 5.3), flattening of impasto and a systematic pattern of tiny losses (Fig. 5.4 and Fig. 5.5). Unfortunately, this is not an uncommon consequence of lining treatments in the past (Percival-Prescott 1974; Cummings & Hedley 1974). One of the former conservators at SMK, Bent Hacke (1934-2019), witnessed this rough approach. He has expressed that the treatment during the 1950s and 1960s was done rather uncritically and the approach often harsh and rough on the paintings, using irons, hot tables and manual pressure, sometimes causing an immediate negative impact on the surface texture of the paintings (Aalling & Baadsgaard 2012).

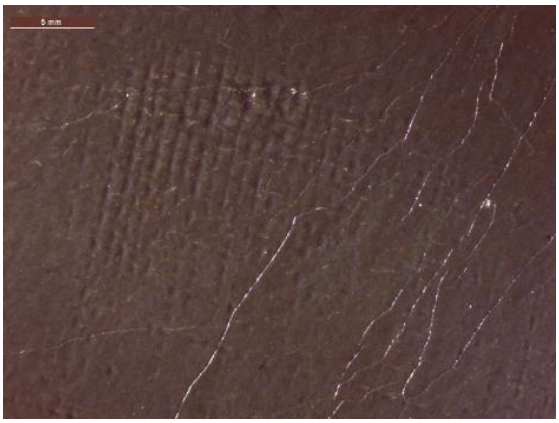

Fig. 5.3 Marks in the paint surface of *Holm KMS1766,* likely originating from the hot iron during lining treatment.

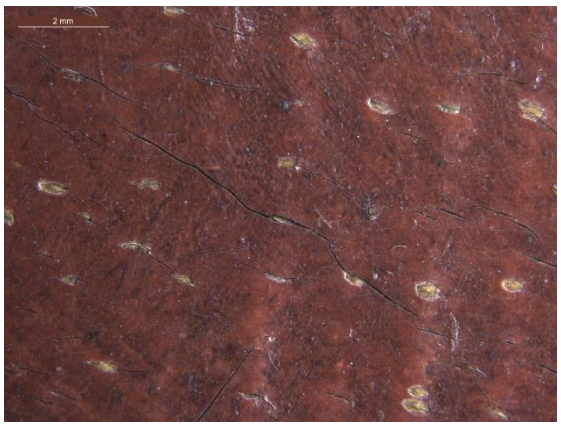

Fig. 5.4 Systematic pattern of small losses of ground and paint layer in the intersecting points of the canvas in *Hielmstierne KMS349a,* likely because of pressure or excessive heat during lining treatment.

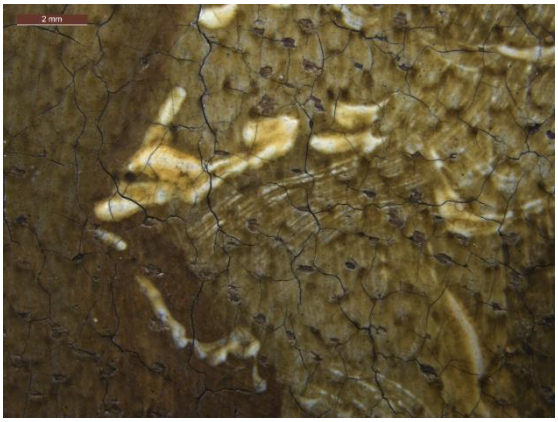

Fig. 5.5 Systematic pattern of losses of ground and paint layer in *Bagge KMS1115,* likely as a result of pressure during lining treatment. In addition, the paint layer presents with a darkened and severely degraded varnish layer, altering the intended visual colour of the paint layer.

A systematic pattern of tiny losses possibly related to the lining treatments is evident in the upper quadrant of *Rahr KMS3499* (Appendix 2.2), and more extensively in the composition of the red jacket of *Hielmstierne KMS349a* (Fig. 5.4) and throughout the surface of *Bagge KMS1115* (Fig. 5.5). The losses appear mainly located above the intersections of the canvas threads where the ground layer is the thinnest. Weave interference and texture magnification in the surface is a common problem in traditional lining techniques (Berger 1966; Cummings & Hedley 1974). Excessive heat, high pressure, insufficient cushioning or swelling of the fibres may have caused either deformation or crushing of the thinner paint layer on top of the canvas intersections, resulting in increased local stress and hence fracture. In addition to the systematic losses, *Bagge KMS1115,* as well as *A.C.Schouw KMS1114,* displays many micro losses related to cupping along the cracks. It is unclear whether the cupping and losses along the cracks were the reason for lining or these losses also occurred during lining.

5.2 Losses of Ground and Paint Layers

Overall, the paintings display limited losses of ground and paint layers due to structural instability. Generally, limited losses are present in the centre of the paintings; however, small sporadic losses do occur associated with cracking. In Table 5.1 an approximate percentage of ground and paint loss is estimated based on blackened areas in the X-radiographs (Appendices 1.3-22.3). Instances in which losses are most abundant correspond with paintings that are lined (Table 5.1). Where most losses occur, they are located along the fold-over edge of the tacking margin. Similar to the small losses mentioned in the previous section, these losses might also have occurred due to mechanical stress during treatment and handling. The paint and ground layers on the tacking margins and along the fold-over edge are sensitive to delamination during flattening, lining and re-stretching, to rusty tacks and abrasion against the rebate of the frame (Scharff 2012:402; Hackney 2020:208). In four instances, the tacking margins have been cut along the paint application line, and have been completely removed during conservation treatments in the past. This is the case for *Rahr KMS3499*, *Battier KMS3634*, *Prangins KMS4810* and *Tronchin KMS6151*. The Svenstrup paintings, which have not undergone structural treatment, present with rather intact tacking margins and fold-over edges, likely as a result of being less frequently handled. This confirms that whenever a canvas is removed from the auxiliary support and re-mounted, there is a large risk of damage to the edges and loss of information that could be valuable to the understanding of the production of the artwork.

Retouching and overpaint

For the majority of the paintings, retouches correspond with losses, while others exceed losses and cover some of the original paint layer, as displayed by X-radiographs and UV images (Appendices 1-22). In some paintings, the wider cracks are retouched to minimise their visual appearance. In only a few instances are larger sections of the painting retouched or overpainted. *Holm KMS1766* displays retouching and overpaint in the area along the side of the nose, by the proper right ear, under the chin and on proper upper-left neck area (Fig. 5.6). The reason for

overpainting is unclear, but could be lead-soap related (see section 5.4.4). In *Saly KMS4801* some of the cravat appears reconstructed, although the ground layer looks unaffected in the X-radiograph. The conservation report from 1965 suggests it may have suffered from water damage (SMK archives KMS4801; Appendix 4).

The relatively low proportion of paint loss generally evident in the paintings shows that the adhesion between layers is good despite that fact that the paintings display comprehensive cracking (see section 5.3). No general tendency to cleave seems to occur between ground and paint layers, nor between paint layers.

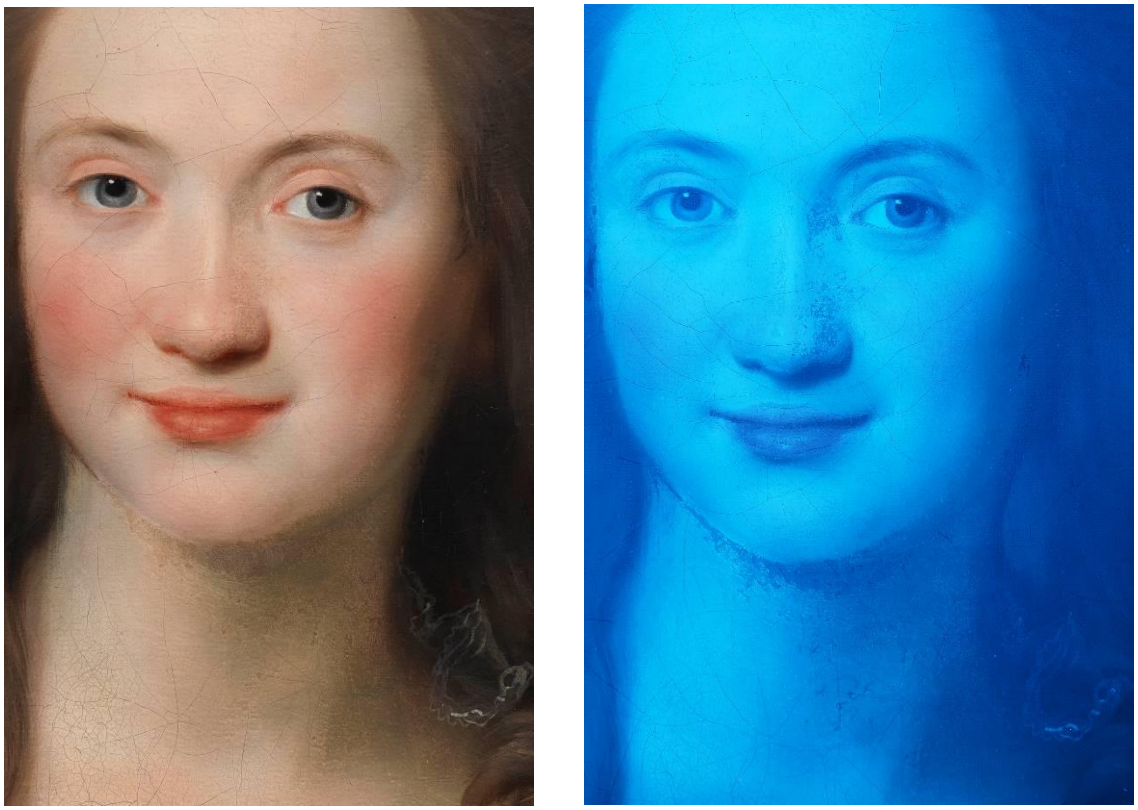

Fig. 5.6 Detail of *Holm KMS1766* in normal light (left) and UV (right) displaying retouching and overpaint in the area along the side of the nose, by the proper right ear, under the chin and on the proper upper-left neck area.

5.3 Cracks and Craquelure

As is common for aged paintings, Juel's paintings display cracks and craquelure throughout the surface.[18] When examining the paintings it is evident that several types of cracks and craquelure of different character are simultaneously present in each painting on both a macro and a micro scale, globally throughout the painting and in local areas. Some of the paintings display different

[18] The term "cracks" usually refers to individual cracks in a surface, while "craquelure" is a network or pattern of cracks that develops across the surface or in sections.

primary crack patterns that appear related to changes in materials and techniques between time and location throughout Juel's career. This is confirmed in the following chapters by material analyses. The different crack patterns and their distribution in Juel's paintings are described and characterised below.

Ageing craquelure

Ageing craquelure is structurally and globally present throughout Juel's paintings. Ageing cracks usually develop later in the life of a painting and are attributable almost entirely to the mechanical stresses originating when the painting is exposed to environmental changes (Keck 1969; Mecklenburg 1982; Karpowicz 1990; Paquette et al 2002). Stresses can also occur due to mechanical impacts or when a painting is stretched or keyed out (Keck 1969; Mecklenburg 1982; Karpowicz 1990). The formation of crack patterns is generally a result of the combination of tension sources within the structure of the painting and the mechanical properties of the materials in the different layers. The initial crack development in grounds and paint layers is initiated by tensile stress. The amount of stress required to cause a crack depends on the strength of the ground and paint layers. Depending on the type and character of the support and materials used for the ground and paint layers, binding media, pigments and the thickness of the layers, characteristic craquelure develops (Keck 1969; Mecklenburg 1982; Mecklenburg & Tumosa 1991b; Bucklow 1997; Paquette et al 2002; Giorgiutti-Dauphiné & Pauchard 2016).

Local variations

The paintings display local variations in how prominent the craquelure is: for instance, relative to the wooden auxiliary support, the thickness of layers or specific colour segments. A less dense crack pattern is generally present in the paintings in the areas coinciding with the original strainer. This is largely due to moisture-buffering properties of the wood, which reduces the relative humidity and temperature fluctuations from the surrounding environment, as well as the strainer acting as a stiff substrate (Berger and Russell 1988; Michalski 1991; Ligterink & di Pietro 2007; Buckley (ed.) 2008:7-8; Padfield et al 2020). In some of the paintings, the character of the craquelure significantly changes between the area coinciding and not coinciding with the strainer. In these cases, the craquelure overlapping the auxiliary support present in a much more linear character, as is seen for instance in the micro-craquelure of *Hauch KMS349* (Fig. 5.7). Most paintings display cracks, or creases, related to the inside edge of the original strainer. These occur independently of the structure of materials in the ground and paint layer due to climate fluctuations and impact or bending of the support against the bars (Keck 1969; Michalski 1991; Buckley (ed.) 2008:7-8). Furthermore, local cracking such as spiral or sigmoid cracks, or fishbone- or feather-type cracks, caused by mechanical impacts and tacking, cusping and keying-out cracks, are present and interconnected with the global crack pattern.

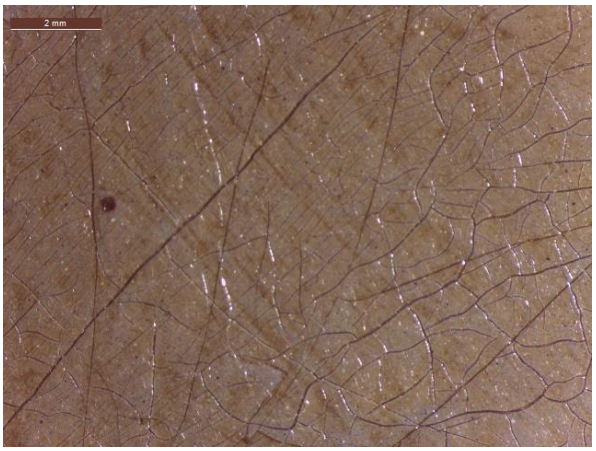

Fig. 5.7 Micro-craquelure in *Hauch KMS349* presenting a more linear character in the area coinciding with the strainer compared to a more wavy and branched character in the centre of the painting. The large diagonal crack from the lower-left corner corresponds to the inside edge of the strainer.

5.3.1 Characterisation of Primary Craquelure

The paintings produced in Denmark, and to some extent Germany, generally display a different primary and global crack pattern than those produced in France and Switzerland. Definition and characterisation of crack patterns have been studied, and several articles propose ways of distinguishing a particular type of cracking from another (Boers 1959; Keck 1969, Stout 1974, Bucklow 1997; 1999; 2000; 2012; Willigen 1999). Bucklow has shown that different ageing cracks and craquelure can be related to various painting techniques and materials, which he allocates into four different technical traditions: Italian or Flemish on wooden panels, and Dutch or French on canvas support (Bucklow 1997; 1999; 2000). Bucklow presents eight dichotomous distinctions for a numerical representation of the different craquelure patterns (2000). These distinctions can be numerically evaluated between 1 and 5 (Table 5.2). Number 1 represents the adequate description by the left term, and 5 the adequate description by the right term, while 3 that either both or neither are adequate. This result in eight values for each painting, which characterise a specific crack pattern (Bucklow 2000).

Table 5.2 Eight dichotomous distinctions for a numerical representation of different craquelure and their characteristics (Bucklow 2000).

Score	Characteristic	1	2	3	4	5
i	cracks	CONNECTED				BROKEN
ii	network	ORDERED				RANDOM
iii	direction	HORIZONTAL				VERTICAL
iv	islands	SQUARE				NOT SQUARE
v	cracks	SMOOTH				JAGGED
vi	cracks	STRAIGHT				CURVED
vii	thickness	UNIFORM				SECONDARY
viii	islands	SMALL				LARGE

The primary (global) crack pattern observed in Juel's paintings is characterised by applying the eight distinctions suggested by Bucklow. X-radiographs used for the characterisation of the primary craquelure are displayed in Appendix 28. The images represent an area of approximately 3 centimetres by 3 centimetres. The images are digitally enhanced to clarify the craquelure. Although variations are seen throughout each painting, the image provides a representation of the

overall primary crack pattern, which penetrates all layers of the paint structure.[19] The values are listed in Table 5.3.

When comparing the craquelure in Juel's paintings with Bucklow's technical categories, Juel's paintings produced in Denmark display similarities with the craquelure of seventeenth-century Dutch canvas paintings, while Juel's paintings produced in France and Switzerland display much more similarity with eighteenth-century French canvas paintings. This is visualised in Figure 5.8 showing a principal component analysis between the numerical representations of the ten paintings from each of the two technical categories made by Bucklow, to those applied to the crack pattern in Juel's paintings.

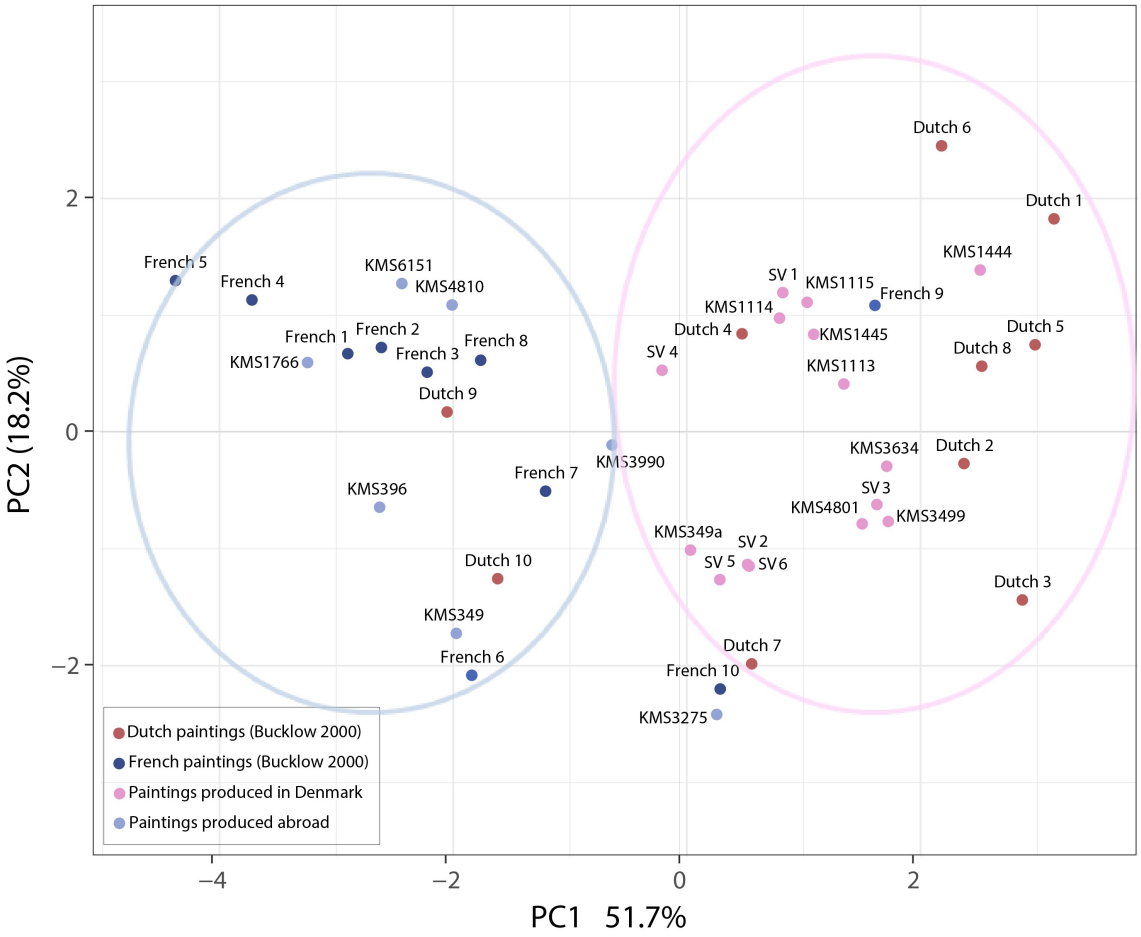

Fig. 5.8 Principal Component Analysis (PCA) between the numerical representations of the primary crack pattern in Juel's paintings compared to the numerical representations for Bucklow's Dutch and French paintings (Made with ClustVis).

[19]A number of authors have demonstrated the application of mathematical studies and computer algorithms for the detection and classification of craquelure from images. This approach was not attempted in this thesis. See Willigen 1999; Abas 2004; Crisologo et al 2011; El-Youssef et al 2014; Sizyakin et al 2018; Siderof & Hardeberg 2019 and references herein.

The paintings produced in Denmark (and Germany) are generally characterised by a rather orthogonal pattern in a random network of larger and smaller islands made of straight and curvy lines. Some lines are smooth but most are slightly wavy or jagged with few prongs and barbs (Fig. 5.10). This corresponds to the description of Dutch seventeenth-century craquelure by Bucklow. Sometimes a minor dominant direction is visible, in which cases the dominant direction corresponds with minor contraction seen in raking light, which so far has not resulted in severe cleaving and flaking (Fig. 5.9). As is discussed in Section 7.1, contraction coincides with the direction opposite to the direction with the largest cover factor. In none of the paintings does a strong dominance seem to be apparent. In the paintings that are lined, the flattened paint structure may camouflage a dominant direction of the cracks, which for this examination remained unnoticed.

Fig. 5.9 Dominant vertical cracks corresponding to contraction in *Buchwaldt SV3* (detail), seen in raking light.

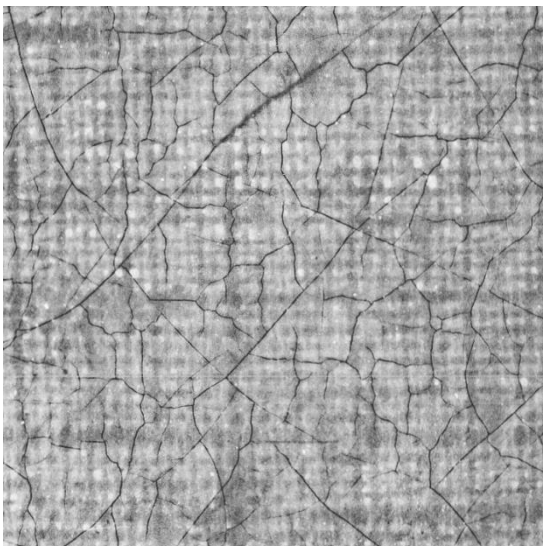

Fig. 5.10 Detail of X-radiograph of *Battier KMS3634,* showing an example of the type of craquelure typically found in paintings produced in Denmark (image represents approx. 3 x 3 cm).

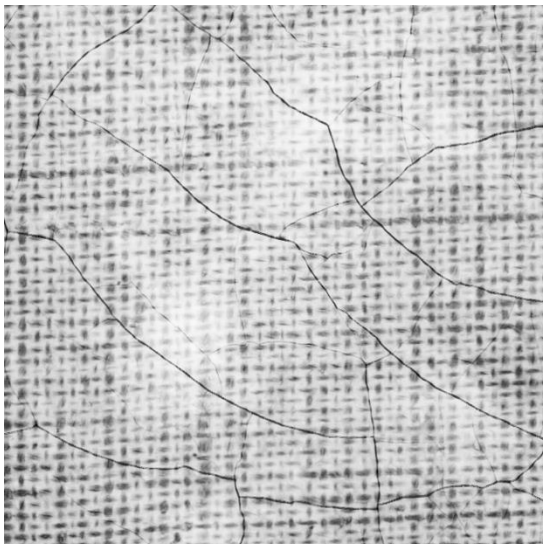

Fig. 5.11 Detail of X-radiograph of *Holm KMS1766,* showing an example of the type of craquelure typically found in paintings produced in France and Switzerland (image represents approx. 3 x 3 cm).

The paintings produced in Paris and Switzerland display different global crack patterns from the paintings produced in Denmark. Both on a macro- and microscopic level. They are generally characterised by a pattern exhibiting no particular direction, often with diagonally orientated cracks that are smooth, curved and at times spaced in larger islands (Fig. 5.11).

Table 5.3 Numerical representation for the characterisation of craquelure, presence of drying cracks and extent of micro-cracks in the examined paintings by Juel. Micro-cracks are quantified with a rating between 1 (not evident) and 5 (elaborate presence). Paintings marked in blue signify paintings produced outside of Denmark.

Painting id.	**Year**	**Numerical representations of primary craquelure in all layers, detectable in X-radiograph (Bucklow 2000)**								**Drying cracks or crackle in paint layer**	**Micro-cracks in X-radiograph**
		i	ii	iii	iv	v	vi	vii	viii	Description	1-5
KMS3990	c. 1764	2	3.5	2.5	3.5	2.5	3.5	1.5	3.5	-	1
KMS3499	1770	2.5	3	3	3.5	3.5	2.5	2	2	Micro-drying cracks (5-10 µm) in several sections	4
KMS3634	1771	2	3	3	3.5	3.5	2.5	2	1.5	Tiny drying cracks in small sections: dark areas in bouquet, folds in dress, neck string, light background	2
KMS4801	1772	2	3	3	3.5	3.5	3	2.5	2	-	5 related to larger cracks
KMS3275	1773-74	2	4	3	4.5	3.5	4	3.5	2.5	Drying cracks in dark sections and between lips, wrinkling	2
KMS349	1776	2.5	5	3	5	2	4.5	2	3	Drying-like micro-cracks in most of paint surface	(5 mainly in interstices)
KMS396	1776	2	5	3	5	2	4.5	1.5	3.5	Drying-like micro cracks in most of paint surface	2
KMS1766	1778-79	1	5	3	5	1.5	4.5	1.5	3.5	Drying cracks and crackle mainly in bust and dress in lower section	5
KMS4810	1778-79	1	4	3	4.5	1	4	1.5	2.5	Drying cracks in many sections. Some crackle in light areas	4
KMS6151	1779	1	4.5	3	4.5	1	3.5	1.5	3.5	Drying cracks in many sections and mostly throughout	2
KMS349a	1780	2	4	3	4	3.5	4	2	2	Microcissing	3
KMS1444	1785	1.5	2.5	3.5	2.5	3.5	2	2	2	Microcissing	2
KMS1445	1785	2	2.5	3.5	3.5	3.5	3	1.5	3	Micro-drying issues in local areas	1
KMS1113	1799-1800	1.5	3	3	2.5	3.5	3.5	2	2	Some drying cracks in brown jacket	5 seemingly connected to larger cracks
KMS1114	1799-1800	1.5	3	3.5	3.5	3.5	3.5	1.5	2	-	1
KMS1115	1799-1800	1.5	3	3.5	3.5	3.5	3	1.5	2	-	4 possibly related to micro-losses
SV1	1788	1.5	3	3.5	3.5	3.5	3	1.5	2.5	-	1
SV2	1788	2	3	2.5	4	4	3.5	2	2.5	Subtle crackle in lower light area of dress	4 possibly connected to larger cracks
SV3	1780s	2	3	3.5	4	4	3	2.5	2	Microcissing	4
SV4	1790	2	4.5	4	4	3.5	3.5	1.5	3	-	2
SV5	1797	2	3.5	2.5	4	4	3.5	2	2.5	-	2
SV6	1797	2	3	2.5	4	4	3.5	2	2.5		3

Causes of craquelure morphology

According to Bucklow, the characteristics representing Dutch seventeenth-century canvas painting craquelure display a strong influence from the canvas structure due to thin and brittle ground layers (Bucklow 1997:136). As the following investigation shows, a more correct term for this type of ground would seemingly be "weak", rather than brittle (see Fig. 9.6). In contrast, the characteristics representing French eighteenth-century canvas painting craquelure are related to a stronger ground layer, which helps to decouple the ground and paint layer from the movements of the canvas support (Bucklow 1997:136).

Bucklow does not go into any detail regarding the specific components of the paintings and the different types of ground layers as to why the Dutch grounds are brittle – or, rather, weak – or why the French grounds are stronger. The exact relationship between these craquelure features and artists' techniques, he explains, remains to be demonstrated and requires a correlation between observed patterns and data from paint-sample analyses (Bucklow 1997:136). That Juel's paintings display craquelure between the two groups of paintings, which are similar to Dutch and French respectively, suggests the use of weaker grounds while in Denmark and stronger grounds while abroad. In the subsequent chapters, this investigation will characterise the materials used in the different layers and the correlation between crack patterns and the structure and materials of the paintings. As the results and discussion here show, material analyses do display differences in use of pigments and fillers (Section 9.2), where especially the quantitative presence or absence of lead white and calcium carbonate have a significant influence on the mechanical properties of the ground layers between these two groups.

5.3.2 Drying Cracks and Initiation of Craquelure

In addition to the differences in primary craquelure morphology between the two groups, it appears that the initiation of cracks begins in different layers. Boers (1959) gives a simplified illustration of the various formations of cracks depending on the initiating layer and level of propagation (Fig. 5.12). The paintings produced in Denmark and Germany display crack formation that originates in the ground layers as a response to movements in the canvas and propagates through to the paint layers, resembling diagrams d to c from Boers' illustration. Most of the cracks and craquelure in the paintings produced in Paris and Switzerland, however, appear to originate in the paint layers and have subsequently propagated into the ground layers, resembling diagrams e to f. Although, it should be noted that both types of initiation commonly exist in this group of paintings, which is for instance testified by the presence of the micro-cracks described in the following section corresponding to d (Table 5.3). The paint-layer initiation is evident as some of the craquelure seems restricted to the paint layer with or without aperture exposing the underlying ground layer (Fig. 5.13a-f). Occasionally this craquelure is interrupted by larger cracks, where the paint has retracted, which have a greater aperture, either only exposing the underlying paint or ground layer or, in some cases, further, demonstrating that the crack has propagated into the underlying layers (Fig. 5.13c-f).

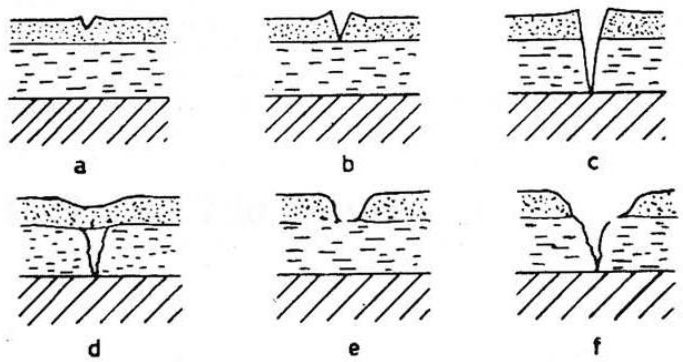

Fig. 5.12 Simplified illustration of cracks in relation to depth and formation depending on the initiating layer and state of propagation (Boers 1959).

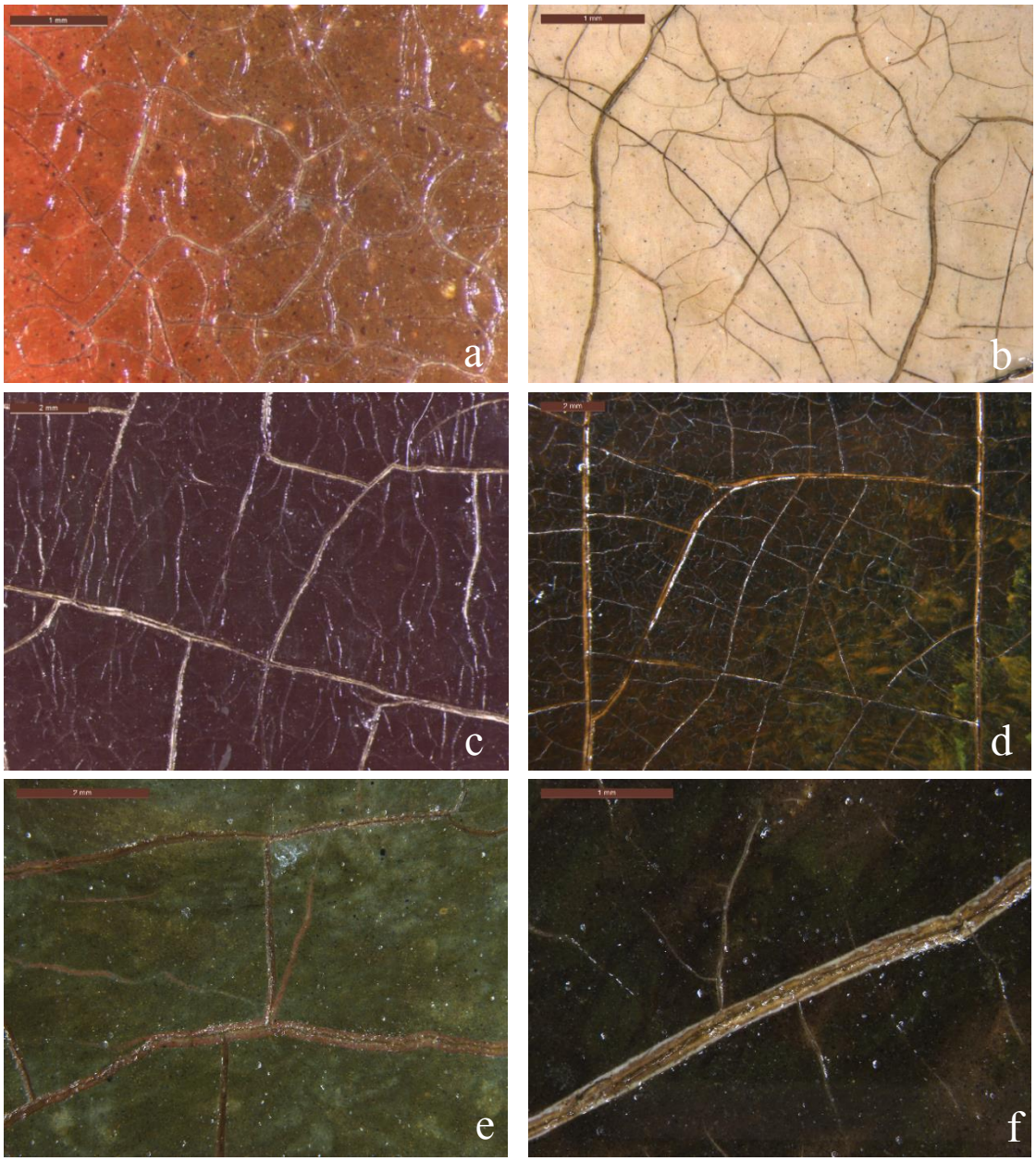

Fig. 5.13 Micrographs of cracks and craquelure in paintings produced in France and Switzerland related to drying issues between ground and paint layers. Drying cracks in the paint layers with or without aperture, some with greater aperture, which has propagated into the underlying layers, *Hauch KMS349* (a), *Holm KMS1766* (b), *Clemens KMS396* (c), *Prangins KMS4810* (e), *Tronchin KMS6151* (e and f).

This type of craquelure in the paint layers of the paintings produced in Paris and Switzerland is related to drying issues between the ground and paint layers. While the primary crack patterns characterised above are mainly related to ageing cracks, which penetrate the entire structure from support to surface, in contrast, drying cracks often confine themselves to a specific layer and are primarily due to internal stresses induced by the drying process (Keck 1969:15-17). When the artist applies a layer of paint leaner than the previous one, or if the ground layer was not sufficiently aged (dried) before the paint layers were applied, there is not enough grip between layers, which permits shrinkage forces of the paint to overcome the paint's cohesive energy and the adhesive bond between paint and ground layer. The second layer thus tends to slide or contract over the first one during the drying process, causing this type of crack and, consequently, the underlayer is exposed (Thompson 1915; Keck 1969; Van Loon et al 2012:225).

Although ageing and drying cracks are often described as two different classes, there is still not a reliable method of distinguishing them, and uncertainty remains regarding the influence they may have upon one another during cumulative crack formation within the structure of the painting (Bucklow 2012). As argued by Willigen (1999), sometimes pre-existing drying cracks can encourage ageing cracks to run through them, resulting in an intermediate character between typical ageing and drying cracks. As the creation of new cracks requires energy, it is easier to propagate existing cracks than to create new ones (Bucklow 1997:136; Smith et al 2001). From the observations made on the paintings produced in France and Switzerland, it appears that it is these described mechanisms, which have taken place; the cracks initiated as drying cracks in the upper paint layer, where the paint contracted and exposed the underlying layer, and later the underlying layer cracked due to other tension forces by following the path of least resistance. As discussed in section 9.3.1, the binding medium used for these ground layers may have consisted of a slower-drying oil and a seemingly low oxidation state implies issues in the curing process.

Some of the paintings produced in Denmark and Germany also display microscopic drying cracks in local colour areas of the paint layer (Table 5.3). In these cases, the underlying paint or ground layer is exposed, but not cracked, as is seen for instance in *Battier KMS3634* and *Rahr KMS3499* (Fig. 5.14 and Fig. 5.15).

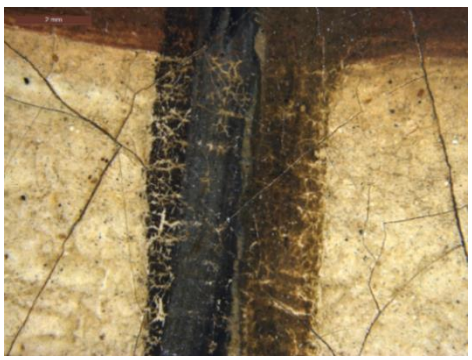

Fig. 5.14 Micrograph of drying cracks in the string around the neck of *Battier KMS3634*.

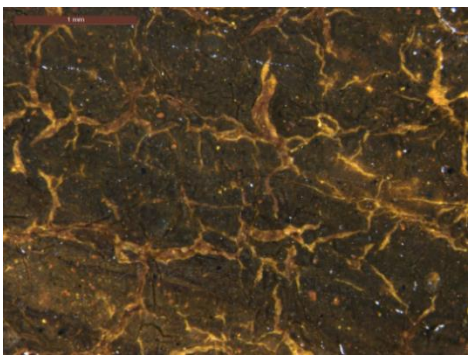

Fig. 5.15 Micrograph of drying cracks in the background of *Rahr KMS3499*.

5.3.3 Micro-cracks

A type of micro-cracks not visible in the surface of the paint layer can be observed in high-resolution X-radiographs in the majority of the examined paintings (Fig. 5.16). Some display only a sporadic presence, while others appear more extensive. These micro-cracks are not found universally in any of the paintings examined. The distribution of micro-cracks in Juel's paintings is roughly quantified by examination of the X-radiographs with a number between 1 and 5. A rating of 1 is given to paintings in which micro-cracks are not seemingly evident, while 5 is given to those that display an elaborate presence of micro-cracks (Table 5.3).

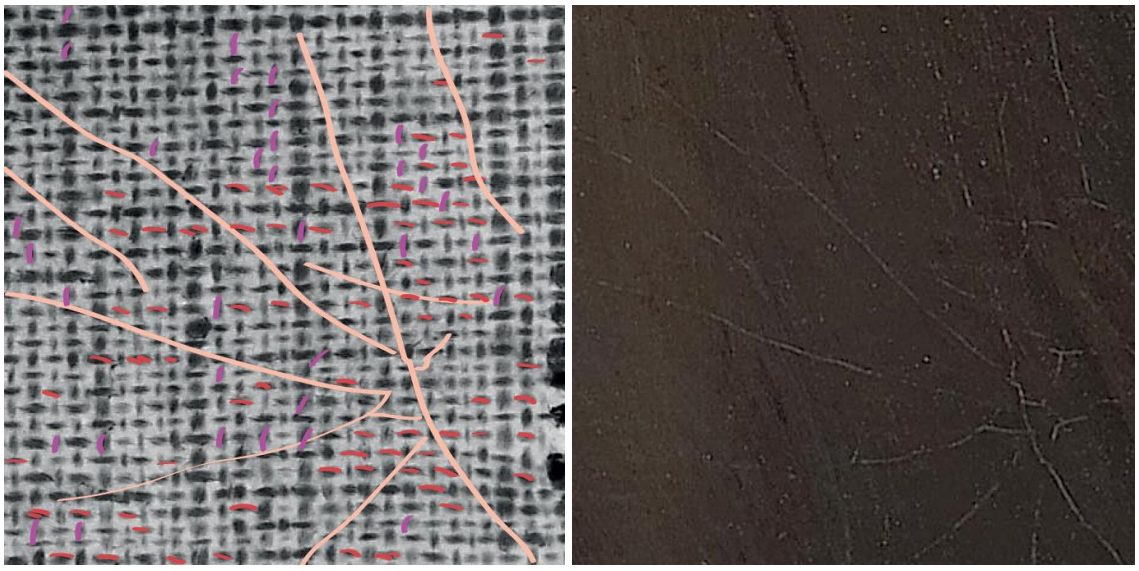

Fig. 5.16 Micro-cracks observable in the X-radiograph (left) in the background of *Holm KMS1766* that are not visible in the surface of the paint layer (right). The larger cracks are visible both in the X-radiograph and in the surface. In the X-radiograph, the most evident micro-cracks are enhanced with red and purple respectively for each direction of threads, while the larger cracks are enhanced with light pink. The images represent approx. 2 x 2 cm.

The occurrence of this type of micro-cracking, recognised in a large number of paintings by Eckersberg, one of the leading painters in the generation after Juel, is by Scharff et al (forthcoming) proposed to be contributing to the initiation of larger cracks. This relates to the initiation of cracks in the ground layer as discussed above. In Eckersberg's paintings as well as in Juel's paintings, the micro-cracks are sometimes separately located, while at other times, the micro-cracks appear to have led to the formation of cracks, which are also visible in the paint layer. The direction of micro-cracks is usually parallel to the spinning degree and direction of the fibres of the thread and they are located above the intersecting threads, where the ground layer is thinnest. The location and orientation of the micro-crack is likely connected to fibre swelling during exposure to high relative humidity, which applies local stress to the ground layer in the direction transverse to the individual fibres (Scharff et al forthcoming). The crack-formation initiation is relative to diagram d in Figure 5.12. The observations of micro-cracks in Juel's paintings correspond to those found in Eckersberg's paintings and support the suggestion made by Scharff et al, that some cracks initiate in this manner and contribute to the propagation of larger

cracks. It is still unclear why micro-cracks are only seen in some instances or why they propagate into larger cracks in some paintings and not in others. Scharff et al do not take conservation treatments of the examined paintings into account as a cause for the occurrence of micro-cracks in their study due to the lack of data concerning the extent of micro-cracks before these interventions (forthcoming). However, the fact that micro-cracks can be observed in Juel's paintings – both in those that have undergone structural conservation treatments and those that have not – suggests that there is no particular correlation between lining treatments and the occurrence of micro-cracks.

5.4 Paint Surface Phenomena

The examined paintings by Juel generally display limited surface phenomena, although their presence is evident in certain paintings. Various types of surface phenomena are frequently detected in aged oil paintings. Some surface phenomena are a result of deterioration over time, while others that may not have been intended by the artists occur because of the technique or material applied, such as the drying cracks discussed above (Van Loon et al 2012:234). In Juel's paintings occasional wrinkling, microcissing, pigment fading and metal-soap aggregates are visible in the paint surface. The observed surface phenomena are briefly presented in this section; however, as they are only sporadically present in some paintings and do not appear to signify general issues in Juel's paintings, they have not been subject to further in-depth investigation.

5.4.1 Wrinkling

Self-Portrait KMS3275, which Juel is thought to have painted while in Dresden, displays wrinkling in the lighter paint layers of the flesh tones and the collar (Fig. 5.17). It is generally believed that Juel studied with Anton Graff (1736-1813) while visiting the city in 1773-74 (Poulsen & Monrad 1982; Poulsen 1991:17, 64; Christensen 1996:68). In this painting, Juel was possibly using a different technique or material under the influence of Graff, as this type of wrinkling is highly associated with Graff's technique and is seen in almost all of his paintings (Mösl 2013). The formation of wrinkling is concentrated in the thickly applied light paint layers, such as the highlights of the flesh and the white collar, as seen in Juel's self-portrait. Like Juel, contemporaries describe Graff as a fast painter. Mösl suggests that the wrinkling in Graff's paintings is a result of applying paint layers too quickly, in order to meet commission deadlines. As with drying cracks, wrinkling occurs due to uneven drying between the upper paint layer and the underlying paint or ground layer. In such a case, during the curing process the top layer of the paint forms a skin while the underlying layer dries more slowly. As the lower layer dries it reduces in volume and, relatively, the upper layer becomes too large and, while it is still elastic, contracts causing wrinkling (Nicholson 1941; Yang et al 2010). According to Mösl, no contemporary sources mention the formation of wrinkling in Graff's paintings, so the process is perhaps well underway before the wrinkles become detectable or before they are perceived as disturbing (Mösl 2013).

Fig. 5.17 Detail of *Self-portrait KMS3275* (1773-74) presenting drying wrinkles in the flesh and collar (left). The phenomenon seen in the nose is enhanced in the micrographs (right).

The phenomenon of wrinkling does not appear as a widespread issue in Juel's paintings, but has been detected in a few additional paintings. The portrait of *Johan Ludvig Count Reventlow to Brahetrolleborg* (1751-1801), for instance, displays similar wrinkling in the cheeks, nose and forehead (Poulsen 1991 entry no. 147). The painting is signed "J.Juel pinx 1773". Whether it was painting in Hamburg before Juel moved on to Dresden in May is unclear, but as with *Self-portrait KMS3275,* it could be influenced by the use of a different material or technique inspired by Graff. Three additional paintings – two portraits and a landscape painting executed in Switzerland – according to Poulsen also display wrinkling.[20] Over time, dirt and degraded varnish can accumulate in the furrows of the wrinkling, which if it becomes darker, enhances the visibility of the phenomenon and can become aesthetically disturbing. In addition, during a procedure such as lining, which applies an even heat and pressure on the entire surface, the impasto effect of the wrinkling are at risk of being permanently pressed. If the paint surface is not properly cleaned before this treatment, the dark dirt and varnish can be pressed down together with the wrinkling and become irreversibly embedded (Mösl 2013).

[20] *Portrait of Colombine Baraban-Diodati*, EP entry no. 188; *Portrait of Marie Antoinette Diodati*, EP entry no. 189; *Landscape from Switzerland. Creux de Genthod (?)*, EP entry no. 467.

5.4.2 Microcissing

In three of the examined paintings, a phenomenon called microcissing is detected (Jones et al 2013). Microcissing is a microscopic drying crackle that appears as tiny craters or islands of paint in different formations. It can occur throughout an entire painting or in certain areas. In the three instances microcissing occurs in Juel's paintings, it is only present in certain areas.

In *Hielmstierne KMS349a* microcissing is present in the scarf around the neck where craters sit in linear rows along the grooves of the brush strokes (Fig. 5.18a) and the lighter part of the background area, as well as in the hairband. In the latter, microcissing is more elaborate and evenly distributed in small singular islands across the surface area, exposing the lighter ground layer and creating an uneven colour appearance (Fig. 5.18.b). A similar occurrence can be seen in the background area of *Buchwaldt SV3* (Appendix 19.2).

Fig. 5.18 Detail of *Hielmstierne KMS349a* with micrographs displaying microcissing in the paint layers of the neck and hairband (a, b).

In *H.Berner KMS1444,* microcissing is more widespread throughout the painting in different sections and presents various formations. Here, craters are present in clusters or groups mainly in the furrows of the brushstrokes or the depth of the interstices of the canvas (Fig. 5.19). At times, the paint has contracted into islands of craters, exposing the underlying paint layer (Fig. 5.19d).

The occurrence of microcissing is likely linked to vortex action that happens in the drying phase of the paint layer due to the volatilisation of thinners or loss of diluent. The paint film is set in motion as the thinner below the surface starts to evaporate, causing denser particles to sink. The centre of evaporation becomes slightly depressed and surrounded by a raised ring and thus showing as cells, also known as Bénard cells. If the polymerisation of the paint sets in while the cells are still present they become fixed in the paint film (Bartell & Van Loo 1925; Keck 1969;

Bentley & Turner 1998:144; Bubat & Scholz 2002; Jones et al 2013). The ground is usually not an active participant in the process (Jones et al 2013).

Fig. 5.19 Detail of *H.Berner KMS1444* with micrographs displaying various formations of microcissing (a-d).

The phenomenon is particularly associated with British eighteenth-century paintings, with more than half of British paintings painted between 1720 and 1760 estimated to be affected (Jones 1990; Jones et al 2013). Although microcissing is believed to form early, the artists were likely not aware of the issue, as the microcissing is not visible to the unaided eye and only with time becomes a visual problem. Old varnish residues are trapped in the craters and hollows and build up over time, as they are often not removed during cleaning (Jones et al 2013). Although they are present on a microscopic scale, microcissing will eventually become visible as dark bands and blotches, which reduce the saturation of the colours, and the dark material creates a dirty appearance to lighter paint sections as seen in Juel's paintings. Jones et al (2013) discuss several suggestions as to why microcissing occurs in paintings, but the cause is still not clear. For instance, there has been found no relation between the development of microcissing and type of oil medium (linseed or walnut). It might be related to the presence of lead soaps or a lead-based siccative, but not in the form of lead white, as the microcissing also occurs in dark paint layers with no white pigment particles (Jones et al 2013). The social pressure for a rapid production may have encouraged British painters to add a quick-drying medium, which together with an increasing supply of ready-made paints resulted in altered chemical responses of the paint film (Jones et al 2013).

No visual evidence has been found of lead soaps being present in *Hielmstierne KMS349a* nor *Buchwaldt SV3,* and although *H.Gerner KMS1444* presents some visual evidence of lead soaps being present, this could not be confirmed by chemical analyses (Table 5.4). Thus, a correlation between lead soaps and the formation of microcissing is not apparent in this study. No direct paint-layer binder analyses were performed during this thesis, only on the ground layers; it is therefore not possible to determine whether Juel used any additives or siccative in his paint, nor to explain why microcissing is present in only a few of the paintings and seemingly not in the other paintings. The three paintings displaying microcissing were produced in the 1780s, and *Hielmstierne KMS349a* is from 1780 shortly after Juel's return. In these years, Juel's production of paintings started to increase. We can only speculate as to whether Juel purchased any pre-made siccative agent, experimented with the use of siccative agents in general, or tried out other diluent mixtures in these cases. A more elaborate study may be required in order to investigate how widespread this phenomenon is in Juel's paintings, and what its possible causes are; however, this research falls outside the scope of the present thesis.

5.4.3 Pigment Fading

In Juel's paintings, no obvious pigment colour fading or degradation issues with regard to pigment-use are immediately evident to the naked eye. No specific pigment alteration was discovered when the paint surfaces were investigated under a microscope. However, in at least four paintings some differences in colour appearance could be detected between the paint surface exposed to light within the sight size of the frame and the area protected by the rebate of the frame.

Many pigments are known to fade or change colour over time, usually due to interaction with the oil media, oxidation or light-induced photochemical reactions (Van Loon et al 2012:18-23). The pigment fading identified in Juel's paintings is limited to blue and red paint passages. The blue background in *P.J. Schouw KMS1113* displays fading, as seen along the edge in Figure 5.20. As is presented in Chapter 10, the blue pigment in *P.J. Schouw KMS1113* is a Prussian blue. Similar fading in blue paint passages is seen in paintings by Abildgaard and in paintings by Danish Golden Age painters in which the pigment has also been identified as Prussian blue (Filtenborg 2014:57, Filtenborg et al 2015). The pigment's inclination to discolour or fade is a well-known phenomenon (Kirby & Saunders 2004; Kirby 1993; Berrie 1997; Samain et al 2013)

In three paintings, the red passages present some fading. This is seen in the red jacket of *Hielmstierne KMS349a* and *J.Moltke SV5,* and in the shawl of *Bagge KMS1115* (Appendices 11.2; 21.2 and 16.2). In *Hielmstierne KMS349a* and *J.Moltke SV5,* pigment analyses suggest the use of a red lake over red ochre (see Chapter 10). As with Prussian blue, red lakes are well known to deteriorate under the influence of light or other environmental conditions (Saunders & Kirby 2004; Van loon et al 2012:220 and references herein).

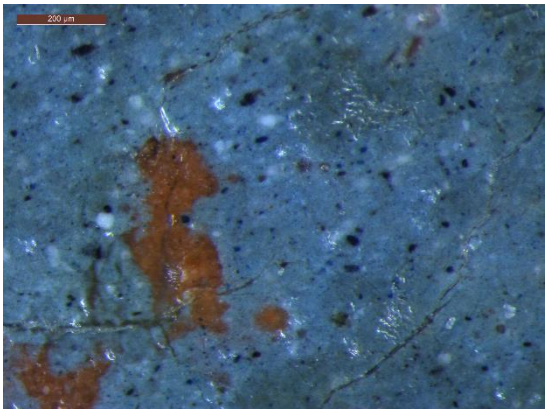

Fig. 5.20 The upper-left quadrant of *P.J.Schouw KMS1113* (left), displaying fading of Prussian blue in blue paint layer uncovered by the rebate of the frame and micrograph of the unfaded blue paint layer along the edge over a red ground (right) (XRF point 12, Appendix 35.14).

5.4.4 Metal-Soap Formation

The presence of metal soaps, likely lead-based, are indicated in at least ten of the examined paintings by Juel – some by visual identification in the paint surface and others by analyses (Table 5.4). Metal soaps are a frequently occurring type of chemical degradation in oil paintings caused by interactions between metal ions and fatty acids in the binding media, creating metal-soap aggregates (Noble & Boon 2007). Metal-soap aggregates can take on various manifestations, including protrusions, darkening, increased transparency and efflorescence (Boon et al 2002; Noble et al 2005; Noble & Boon 2007; van Loon et al 2012; Cotte et al 2016).

Seven of Juel's paintings display indications of lead soaps in the surface of the paint layers. Protrusions are most evidently and extensively visible in the paint surface of *P.J.Schouw KMS1113*, which displays small, pinhead-sized, crater-like eruptions sporadically in all paint passages (Fig. 5.21). A few similar protrusions are seen in *Bagge KMS1115* (Fig. 5.22). Despite the strong visible presence in *P.J.Schouw KMS1113,* lead-soap aggregates were not confirmed by analyses in this case; in contrast lead-soap presence was confirmed by both ATR-FTIR and GC/MS in *Bagge KMS1115* (Table 5.4). Comparable indications are only detected as sporadic, isolated occurrences in *Battier KMS3436*, *Saly*

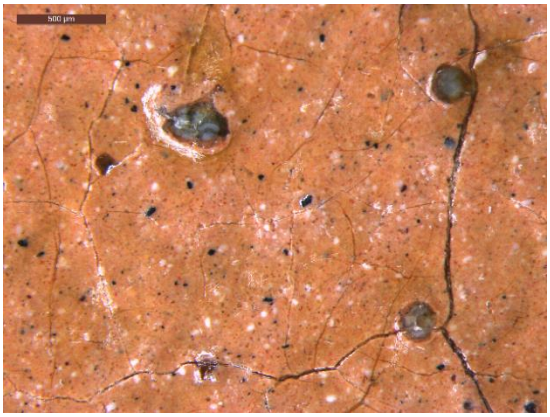

Fig. 5.21 Micrograph of the paint surface of *P.J.Schouw KMS1113,* displaying lead-soap protrusions as pinhead-sized crater-like eruptions.

KMS4801 and *H.Gerner KMS1444* (Appendices 3.2, 4.2 and 12.2). Lead soaps were not confirmed by analyses in any of these three paintings. This may suggest that the visual signs, which seemed to suggest the presence of lead soaps, could relate to other causes, or it may be that lead soaps are not universally present in the paintings, and that the regions sampled did not contain detectable levels. *Bagge KMS1115* (Appendix 16.2) and *Hauch KMS349* (Fig. 23) display sections with white spots in the surface, which could be inclusions that have become visible but have not yet erupted through the surface. Analyses of *Prangins KMS4810*, *Tronchin KMS6151* and *Holm KMS1766* all indicate the presence of lead soaps although no protrusions are apparently visible in the surface. However, the overpainting and retouching seen in *Holm KMS1766* may cover an area with protrusions, which would explain why the overpaint was applied in the first place (cf. Fig. 5.6 and Appendix 8.2).

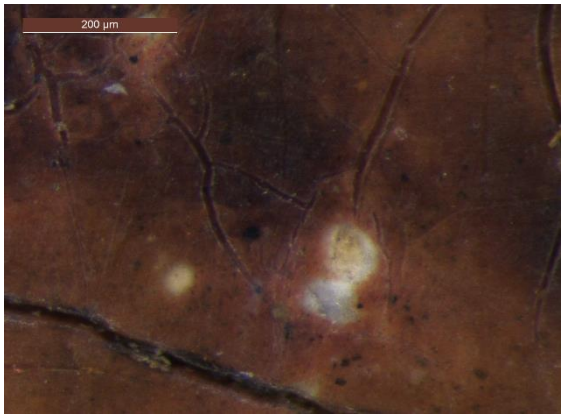

Fig. 5.22 Micrograph of the paint surface of *Bagge KMS1115* displaying lead-soap protrusions.

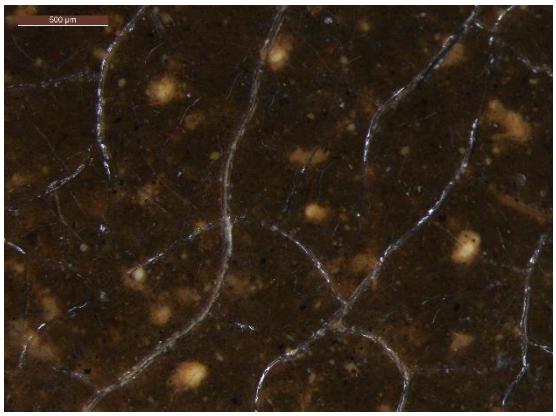

Fig. 5.23 Micrograph of the paint surface of *Hauch KMS349* displaying white spots, which could be lead-soap inclusions.

Table 5.4 Visual observations and analyses of lead-soap presence in examined paintings by Juel. Blue = paintings produced while abroad.

Painting id.	Microscope/visual	ATR-FTIR-mapping	GC/MS (step 4)
KMS3990	None evident	yes	Probably
KMS3634	Possibly	None confirmed	n/a
KMS4801	Possibly	None confirmed	n/a
KMS349	Possibly	Yes	Probably
KMS1766	Possibly	Yes	Yes, probably
KMS4810	None evident	Yes	n/a
KMS6151	None evident	Yes	Possibly
KMS1444	Possibly	None confirmed	None evident
KMS1113	Yes	None confirmed	None evident
KMS1115	Yes	Yes	Yes

Questions remain as to the conditions in which metal-soap formations occur, the process involved and the rate at which they form (Cotte et al 2016; Noble 2019). The consequences of conservation treatments, such as applied heat and moisture or the role of solvents, are of particular concern

(Cotte et al 2016; Noble 2019; Burnstock 2019). Currently, the extent of lead soaps in the examined paintings by Juel is not overly visually disturbing, nor does it appear to contribute to the formation of craquelure in the paintings (Keune et al 2019). The question and the biggest concern is whether their presence could progress and become an aesthetic or structural issue in the future.

5.5 Chapter Summary and Conclusions

With regard to the composition of the materials and their state of degradation, it appears that Juel's paintings are in relatively good condition. Although Juel's paintings display various surface phenomena, cracks and craquelure, and many have undergone structural conservation treatments, the examined paintings display relatively few paint losses, canvasses which are generally in a low state of degradation and a decent overall visual appearance.

All of the included paintings from SMK are lined; however, this appears to relate to the traditional museum practice of lining as a preventive approach, rather than in response to structural issues within the paintings. The lining treatments were sometimes carried out using a rather rough approach, which may in several instances have done more harm than good. Numerous untreated paintings by Juel remain in good condition. X-radiography and UV examination reveal that the paintings display limited paint losses. A few of the examined paintings exhibit some pigment fading and the presence of metal-soap aggregates, while others display other surface phenomena such as wrinkling or microcissing. Furthermore, some of the paintings present with a degraded and yellowed varnish layer.

The biggest common issue in Juel's painting is the crack patterns. A characterisation of the primary crack pattern in Juel's paintings shows that paintings produced in Denmark (and Germany) generally present a different craquelure morphology than paintings produced in France and Switzerland. The differences in craquelure depend upon tension forces within the structure of the paintings and the mechanical properties of the materials in the different layers. The paintings produced in Denmark display craquelure that shows strong influence from the canvas structure, corresponding to a weak ground layer. In contrast, the character of craquelure in the paintings produced in France and Switzerland is commonly related to a stronger ground layer. Furthermore, it appears that the initiation of cracks begins in different layers. The differences between crack patterns support the hypothesis that Juel used other materials while abroad than while working in Denmark. This hypothesis is investigated through material analysis in the following chapters. As the results and discussion here show, material analyses between the two groups do differ. Differences in the use of pigments and fillers, especially the quantitative presence or absence of lead white and calcium carbonate, have a significant influence on the mechanical properties of the ground layers between these two groups. In the following chapters, it is further discussed whether this was a matter of choice, practicality or changes in availability of materials.

6 Auxiliary Support

Traditional strainers have commonly been replaced by expandable stretchers as a step in conservation treatments since the nineteenth century due to their often weak construction and inability to expand.[21] Few examples of original strainers from the eighteenth century or earlier still exist (Buckley 2008; Buckley 2012:148; Noble & Verslype 2017:2.5.1). The development of stretchers was related not just to studio practice but also to advances in commerce and technology (Buckley 2012:150). Over time, a stretched and mounted canvas, as exposed to cycles of changes in temperature and humidity, tends to lose tension and become slack. A slack and bulging canvas can obscure the appearance of the painting and is at risk of increased vibrations, which may result in losses of ground and paint layers (Berger & Russell 2000:45; Andersen et al 2019). By the addition of keys for expansion of the stretcher joints, tension can be restored in the painting.

In the past, the auxiliary support was considered disposable, but from the 1970s onwards more attention was paid to the preservation of strainers and early stretchers as an artefact, and, it was considered, at least, that they should be well documented. The original strainer or stretcher represents an integral part of a painting, as it conveys the history of its production, manufacture and preparation for painting, while inscriptions and labels indicate provenance and exhibition history (Buckley 2008:3-5; Buckley 2012:148,159).

For the majority of Juel's paintings, stretchers with characteristics that postdate the eighteenth century have replaced the original auxiliary support. The replacement with stretchers has taken place at different times, and the stretchers themselves represent a history of the development in the construction of stretchers throughout the past two centuries, and gives some insight to conservation history (their description and development is not included in this thesis). The original auxiliary support – in all cases strainers – is still present in some of Juel's paintings. They provide rare evidence of shape, construction, availability, format and the production of strainers in the late eighteenth century. This chapter will examine the original strainers in Juel's paintings, their construction and manufacture, where Juel acquired them, as well as the availability of expandable stretchers in Denmark. Furthermore, the structural stability of the original strainers and their influence on the preservation state of the paintings are considered.

6.1 Original Strainers in Juel's Paintings

Replacement of the auxiliary support has taken place on the majority of Juel's canvas paintings. Yet, some paintings remain with the original auxiliary support, providing evidence of their

[21] A strainer has fixed corners, while a stretcher has expandable corners. Differentiation between the terms strainer and stretcher is made in the English language, while in Danish the terms *blindramme* or *blændramme* applies for both and does not allow differentiation. At times, the term *kileramme* (*kile* = key/wedge) is used to signify a stretcher type.

construction. In all cases, the preserved original auxiliary support presents as a strainer with fixed corners. The eight paintings from Svenstrup Estate that are included in this study, are all mounted on the original strainer. Of the sixteen paintings from SMK included in this study, only one appears to have the original strainer. Only a few additional paintings by Juel in the museum inventory remain with the original strainer and a few images in conservation reports before replacement provide evidence of the original strainers of other paintings. Craquelure and creases in the paint layer corresponding to the inside of the original auxiliary support occur due to interactions between the canvas and strainer bars (Keck 1969:20; Michalski 1991; Buckley 2012:150). These cracks act as testimony of the shape and approximate width of the original strainer bars in paintings where they have been replaced. Table 6.1 presents an overview of information on the original strainers.

6.1.1 Rectangular Strainers

None of the rectangular paintings included in this study retain their original strainers, but the creases and craquelure in the paint layers indicate that strainer bars had a width ranging from 4 cm to 6 cm (Table 6.1). The only rectangular painting by Juel in the inventory at SMK which is found to remain with its original strainer is *The Roman Dwarf Francesco Ravai, called Bajocco* (KMS370) (Fig. 6.2). The painting is believed to have been painted in Rome between 1773 and 1776 (Poulsen 1991:65; Kragelund 2006). No direct information on the transfer of the painting from Rome exists; therefore it is unclear if the strainer is of Danish or Roman origin.

Fig. 6.1 The verso of *Flowers and Fruit on a Table*, 1791, displaying an image of the original, now replaced, strainer. National Gallery of Denmark (SMK) (KMS3943), oil on canvas, 27.5 x 39.5 cm. Image from SMK archives.

Fig. 6.2 The verso of *The Roman Dwarf Francesco Ravai, called Bajocco,* 1773 – 1776 (1775), displaying the original strainer. National Gallery of Denmark (SMK) (KMS370), oil on canvas, 48.5 x 34 cm.

However, an image of the verso of *Flowers and Fruit on a Table*, 1791 (KMS3943), in the archives at SMK, displays a similar original strainer before its replacement, suggesting a Danish origin (Fig. 6.1). Both strainers resemble original rectangular strainers, which have survived on

Abildgaard's paintings (Filtenborg 2014:8-10). Filtenborg reports that the original strainers on Abildgaard's paintings are made of softwood in a rather slight and simple construction, and the corners are joined with either bridle joints or half-lap joints. There are no signs that keyable stretchers were employed (Filtenborg 2014; 2015).

6.1.2 Oval Strainers

The oval format in Juel's portraits appears mainly after 1770, with a single oval format appearing in 1768 (Poulsen 1991). Following Juel's return to Copenhagen in 1780, the oval format was widely used for standard portraits. Of the original oval-shaped strainers from the later period, several have survived. On all of the Svenstrup portraits, the original strainers are preserved. All are of a simple construction and made of softwood. Wood species identification on *Buchwaldt SV3* and *P.J.Neergaard SV8,* both suggest pine (*Pinus Sylvestris*) (Claudia Baittinger, curator at the Department of Environmental Archaeology and Materials Science at the National Museum of Denmark, September 2018). Pine and spruce (*Picea*) are typical softwoods used for strainers and stretchers (Buckley 2012:148).

The oval strainers used in Juel's paintings produced in Denmark are very similar in construction to one another with only minor variations, and all have a rectangular inner shape. They consist of four members with the corner joints assembled in a simple half-lap with animal glue (significant UV fluorescence and confirmed by ATR-FTIR, Appendix 33). Evenly sawn edges suggest they were cut into an oval shape after assembly into a rectangular figure, while the inside of the strainer remains rectangular. Depending on the side facing the verso, the top and bottom will appear in full width, overlapping the sidebars while on the other facing side, the sidebars will appear in full height, overlapping the top and bottom (Fig. 6.3 and Fig. 6.4). The visible side varies between different paintings.

The members on the oval strainers are wider than the members of the rectangular strainers. The top and bottom bars are generally about 13 centimetres wide at the widest central point, while the sidebars are slightly slimmer of between 10.5 centimetres and 12.5 centimetres. The larger width is required for this type of construction, as otherwise it would not give sufficient overlap in the joints when cut into the oval shape. Similar types of oval strainers are seen in one instance in the SMK collection on *Dameportræt 1790-1799* (KMS247) (Fig. 6.5) and in an image from the records of a previous strainer of *Holm KMS1766* (Fig. 6.6). As with the Svenstrup paintings, both display cracking in the paint layer corresponding to the inside rectangular shape. The examined oval paintings from SMK, whose strainers have been replaced, all display cracking corresponding to a strainer with an inner rectangular shape, supporting the use of a similar type of strainer originally. The same is observed in additional oval paintings in the inventory at SMK such as the portrait of *Elisabeth de la Calmette* (KMS1098) and *Johanne Sophie de Coninck,* (KMS1619) as well as at least five oval portraits previously researched (Slotsgaard 2013; Sæter 2016). The two additional portraits from Svenstrup, likely painted by Juel's assistant Kofoed, remain with similar

original strainers (Appendices 23 and 24). This suggests a rather standardised approach to oval-shaped strainers in this period, which may be supported in the future by inspection of strainers used in paintings by other artists.

Fig. 6.3 The verso of *J.B.Neergaard SV1* presenting the original strainer. The reverse facing side is opposite to Figure 6.4 and shows the full length of the upper and lower bar. Similar positioning is seen on *Buchwaldt SV3.*

Fig. 6.4 The verso of *A.M.B.Neergaard SV2* presenting the original strainer. The reverse facing side is opposite to Figure 6.3 and shows the full height of the sidebars. Similar positioning is seen in *J.P.B Neergaard SV4*, *J.Moltke SV5* and *E.Moltke SV6.* The strainer also displays incised lines of the major and minor axes.

Fig. 6.5 The verso of *Dameportræt 1790-1799* (KMS247), from the collection of SMK displaying an original strainer similar to original strainers found in the Svenstrup portraits.

Fig. 6.6 Image of the verso of *Holm KMS1766,* before replacement with a modern stretcher, displaying a strainer similar to the original strainer in the Svenstrup portraits. The strainer bears an inscription: “Julie Holm, Professor Jens Juels/ første forlovede, død I sit 22de/ Aar / Malet af Jens Juel”.

Table 6.1 Overview of information regarding original strainers. Where marked in green, the painting remains mounted on the original strainer.

Painting id.	Year	Dimension, cm (h x w)	Shape of original strainer	Width of original strainer bars (cm)			
				Top	Bottom	Left	Right
KMS3990	c. 1764	57.1 x 49.7	Rectangular	5.7	5.5	4.2	4.2
KMS3499	1770	78 x 62.1	Rectangular	4-4.5	4-4.5	4-4.5	4-4.5
KMS3634	1771	79 x 63.8	Rectangular	4-4.5	4-4.5	4-4.5	4-4.5
KMS4801	1772	83 x 67.3	Rectangular	n/a	n/a	n/a	n/a
KMS3275	1773-74	56.4 x 44.5	Rectangular	n/a	n/a	n/a	n/a
KMS349	1776	59 x 49	Oval, oval inside shape	6.2	6.2	6.2	6.2
KMS396	1776	52.4 x 41.8	Rectangular	n/a	n/a	n/a	n/a
KMS1766	1778-79	52.7 x 42.8	Oval, rectangular inner shape	13	13	10-11	10-11
KMS4810	1778-79	87 x 72.5	Rectangular	5.5-6	5.5-6	5.5-6	5.5-6
KMS6151	1779	71.7 x 57.2	Rectangular	4	4	4	4
KMS349a	1780	64.2 x 49.9	Rectangular	4	4	4	4
KMS1444	1785	70.5 x 55	Oval, rectangular inner shape	13.2	n/a	10.5-11	10.5-11
KMS1445	1785	70.5 x 55	Oval, rectangular inner shape	13.2	n/a	10.5-11	10.5-11
KMS1113	1799-1800	69.5 x 54	Oval, rectangular inner shape	13	13	12.5	12.5
KMS1114	1799-1800	69 x 53.5	Oval, rectangular inner shape	13	13	11.5	11.5
KMS1115	1799-1800	69.4 x 53.4	Oval, rectangular inner shape	13	13	12	12
SV1	1788	69.8 x 54.6	Oval, rectangular inner shape	13.2	13.5	10.8	10.9
SV2	1788	69 x 53.5	Oval, rectangular inner shape	13.7	13.3	12.5	12.5
SV3	1780s	69.9 x 54.5	Oval, rectangular inner shape	13.3	13.2	10.6	10.5
SV4	1790	68.5 x 53.5	Oval, rectangular inner shape	13.1	13.3	12.5	12.4
SV5	1797	69 x 53.4	Oval, rectangular inner shape	13.4	13.4	12.3	12.3
SV6	1797	69 x 53.5	Oval, rectangular inner shape	13.4	13.3	12.4	12.4

The surface of the original strainer bars of the Svenstrup paintings bear marks corresponding to tools used in the eighteenth century. After sawing, different types of planes would have been used to remove sawing marks and other irregularities (Williams 2008:112). A multitude of planes existed in the eighteenth century for different purposes (Diderot et D'Alembert 1769, vol.7, Joinery work in building, pl. 13.). Longitudinal lines and indentations from the edge of the plane iron are seen on the surface parallel to the wood grain in the length of the boards (Fig. 6.7). In a couple of instances, comb-like marks are seen as deeper indentations in the wood (Fig. 6.9). This suggests the use of a toothing plane. A toothing plane more aggressively cut down the surface and is often used for the initial surfacing before the finer plane. The toothing plane was also good for

scratching up surfaces to be glued together (Williams 2008:111-112). A regular rippling, seen as shadowy indentations and undulations with 0.5 to 1 millimetre intervals, corresponds to chatter marks from a hand plane without a cap iron (Fig. 6.7 and Fig. 6.8) (Hoadley 2000:160-165; Alberdi 2013:73). The invention of the cap iron in the second half of the nineteenth century prevented this occurrence and the invention significantly improved wood-surface-smoothing abilities (Welsh 1966:219; Hoadley 2000:160-165; Alberdi 2013:73). In wooden surfaces planed before the mid-nineteenth century, this type of rippling can thus often be seen. Also visible in the surface of the wood are curvilinear indentations adjacent to each tack, indicating the use of a type of stretching pliers (Fig. 6.7 and Fig. 6.9). This occurrence is discussed concerning mounting of the canvas in Section 7.3. Four of the Svenstrup paintings have visible lines incised by a sharp tool into the surface across the centre of each member (Fig. 6.4). These lines represent the major and minor axes, which likely aided the construction of the oval shape (López Mozo 2011; Mazzotti 2019).

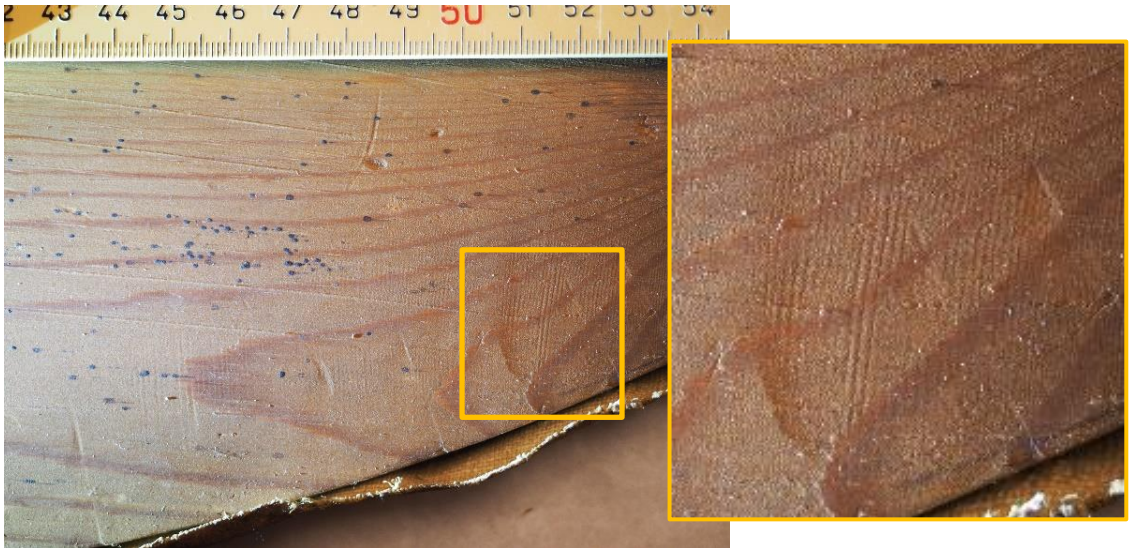

Fig. 6.7 The wooden surface of the original strainer of *E.Moltke SV6* showing linear lines from the plane iron, rippling from the hand plane (enhanced right) and canvas-plier indentations.

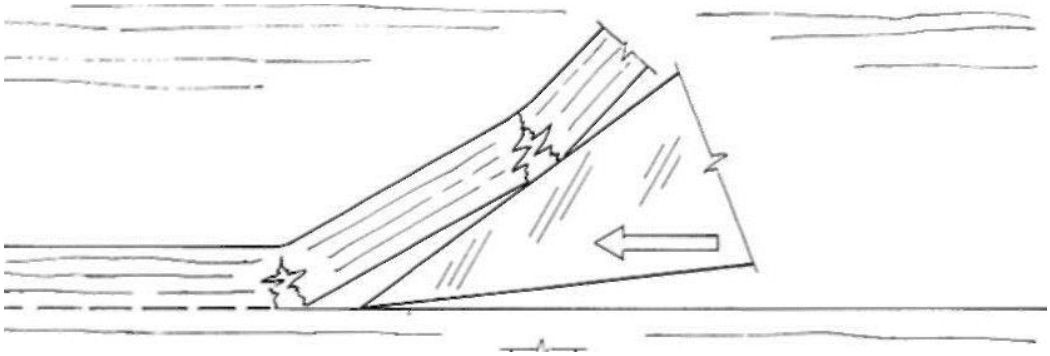

Fig. 6.8 Fractures in chipped wood during hand planing without a cap iron. The chip bends as it slides up the cutting-iron and the wood fails ahead of the edge due to tension perpendicular to the grain. Finally, the chip breaks, whereupon the next segment of the cut starts. The fractures reflect onto the wood surface resulting in shadowy rippling (Hoadley 2000:162).

Fig. 6.9 The wooden surface of the original strainer of *Buchwaldt SV3* showing deep indentations running parallel to the wood grain likely from a toothing plane. Indentations from the use of stretching pliers are visible along the edge.

Fig. 6.10 Detail of the central lower member of *Hauch KMS349* displaying rippling from a hand plane and a pencil line indication of the major axis.

Only one of the portraits painted outside of Denmark seems to remain with the original strainer. The portrait of *Hauch KMS349*, supposedly painted in Paris in 1776 while both the sitter and Juel were there, is mounted on a strainer displaying some similarities, yet a different shape from the Danish strainers (Fig. 6.11). An older inscription on the strainer reads that the portrait was painted by Professor Juel in Paris in 1776. Juel, however, did not become Professor until the mid 1780s, thus the inscription must have been added to the strainer after production. The strainer on Hauch's portrait displays an inside oval shape and the bars have different dimensions, being only 6.2 centimetres wide. Like in the Danish strainers, the members are joined in half-lap joints and the surface displays similar tool marks consistent with an eighteenth-century hand plane with a single iron (Fig. 6.10). The overall dimension of the strainer (59 by 49 centimetres) fits closely with the dimensions of one of the standard-size strainers reported by the French writer Antoine-Joseph

Fig. 6.11 The verso of *Hauch KMS349* displaying the likely original French strainer with the inscription "F.v. Hauch Malet i Aaret 1776 i Paris af Professor Juel" and a detail (below) displaying the half-lap joint.

Pernety (1716-1796) (1757): *Toile*, no. 12: *1 pied, 10 pouces, 6 lignes by 1 pieds, 6 pounces, 6 lignes*, which is equal to approximately 60 by 50 centimetres). The strainer on *Hauch KMS349* is seemingly similar to other French strainers from the same era (personal correspondence with Pascal Labreuche, May 2020).

The strainer of *Holm KMS1766*, as seen in the image from the records (Fig. 6.6), displays a strainer similar to the other oval strainers produced in Denmark, although it was likely painted in Switzerland. Poulsen dates the portrait to 1778-79 – "or Posthumously?" (1991:74). Susanne Elisabeth Holm (1760?-1781) was Juel's first betrothed. Tragically, she fell ill and died in 1781 on her way from Geneva to Denmark, where she was to marry Juel (Poulsen 1991:20,74). The painting came to SMK from Eckersberg's daughters, Juel's granddaughters, and may have been in Juel's possession for the remainder of his life and passed down after his death. Is not unlikely that Juel kept it, as the story goes that he carried a miniature portrait of Miss Holm around his neck for the rest of his life (Poulsen 1991:75). If the painting was indeed painted in Switzerland, it may have been transported unstretched to Denmark and re-mounted on a locally-purchased strainer. Actually, the proper-left quarter of the painting displays cracks associable with an auxiliary support with an oval inner shape (Appendix 8). These cracks does not correspond to the width of the present stretcher and thus could be related to an original [Swiss] strainer, similar to the strainer of *Hauch KMS349*. The fact that Juel transported paintings unstretched is confirmed by the story regarding the portrait of *Clemens KMS396*, referring to Plötz having it mounted on a strainer and shown to multiple people (see Section 2.4). What happened to said strainer after that is unknown, although the painting remained in Clemens' possession until his death, and it has in any case been replaced by a new stretcher during the nineteenth century (Høyen 1828). The portrait of *Hauch KMS349*, also painted in Paris, was likely finished and handed over to the client in Paris and must have remained in its finished and stretched state during transport to Denmark, resulting in the strainer from Paris being preserved.

6.1.3 Bevelling

One of the arguments for replacing old strainers has been the lack of bevelling on the inside of the strainer facing the reverse of the canvas (Buckley (ed.) 2008:7-8). The lack of bevelling causes greater risk of microclimate formation and interaction between the canvas and the inner edge of the strainer, resulting in corresponding cracking and creases in the paint layers (Keck 1969; Michalski 1991; Buckley (ed.) 2008:7-8). According to Michalski, a sagging canvas leaning against the bars of an un-bevelled strainer or stretcher will result in these cracks, as the paint film near the bars can act like a thin, stiff plate, which cracks during bending under the draping weight of the painted canvas (1991:234). As described above, these types of cracks are visible in the majority of the examined paintings and seemingly correspond to the original strainer.

Before the nineteenth century, strainers and stretchers were typically rectangular in profile rather than bevelled or beaded (Buckley (ed.) 2008:7-8; Buckley 2012:150). The awareness of the

advantages of a bevelled or beaded stretcher profile did not seem to occur until the late 1880s, at least not by commercial manufacturers, when it starts to be mentioned in patents and advertisements (Buckley (ed.) 2008:8; Buckley 2012:150).

Contrary to common belief, the original strainers from Juel's paintings present with a primitive beading and a slight bevelling; they display a slimmer depth of the inside edge compared to the outside edge of the strainer, resulting in a gap between the strainer-bar and the verso of the canvas of about 0.3 to 0.5 centimetres. On at least two of the strainers, most evident on *A.M.B.Neergaard SV2* and *E.Moltke SV6*, a flat margin in the sense of a beading of about 1.5 centimetre is present, before an initiated bevelling, along the perimeter facing the reverse of the canvas. The strainers of *J.B.Neergaard SV1* and *Buchwaldt SV3* similarly have a 4-centimetre flat margin along the perimeter before an initiated bevelling. The bevelling on *J.B.Neergaard SV1* and *Buchwaldt SV3* is done in such a way that the corners remain in the full depth while the centre is slimmer creating a concave curvature when viewed from the inside (Fig. 6.12). This suggests that some bevelling and a primitive beading was utilised to some extent from an earlier time than previously thought; however, this was evidently not enough to prevent strainer-bar marks in the paintings. Filtenborg found a primitive bevelling on one of Abildgaard's preserved strainers in only one instance (Filtenborg 2014:9).

Fig. 6.12 The inside of the strainer of *Buchwaldt SV3* exhibiting a concave curvature of a primitive bevelling.

6.2 Who Made Juel's Strainers?

The strainers for Juel's portraits were not manufactured in his studio, but purchased from a supplier specialised in a woodworking craft. This could have been a carpenter (*tømrer*), but most likely a joiner and cabinetmaker (*snedker*). Carpenters usually did coarser building work while joinery involved finer tasks such as installing of panelling, moulding, mantelpieces, windows, staircases, and similar interior trim in houses, as well as furniture of the plainer sort. Cabinetmaking demanded skills of a higher order to create furniture having such refinements as curved surfaces, joints, carved ornamentation, veneering or inlaid surfaces (Heuvel 1969; Clemmensen et al 1954:80; Edwards 2000:110; Duus & Duus 2002:203; Alberdi 2013:59).

From the Middle Ages up until the mid-nineteenth century, these crafts were connected to the guilds and guilds' trade organisations, which were strongly influenced by German guild cultures called *Zünften* as a result of mutual migration of workers and the wandering journeymen. The guild had strict rules with regard to competition and who was allowed to import, distribute and

undertake different tasks and products (Clemmensen et al 1954; Dybdahl & Dübeck 1983, Karmark 1989; Juul 2013; Bøndergaard 2014; Parby 2015).

Sporadic accounts and receipts from the seventeenth and eighteenth centuries provide evidence that joiners and cabinetmakers usually supplied strainers (Friis 1872-78:213 note 3; Eller 1971:139; Elling 1958:192; Elling 1945:42) (Fig. 6.13). Philipp Otto Runge mentions in a letter from 1803 that he could order a strainer (*blendrahmen*) from his joiner from one day to the next (Möckel and Castro 2013). Eckersberg mentions frequently in his diary that he acquired strainers from carpenters (Villadsen 2009: for instance 2 October 1816, 28 April 1817). No specific information on any purchases of strainers by Juel have so far been found, but there appear to have been plenty of woodworking craftsmen in Copenhagen that could have supplied strainers for Juel's studio. In *Stats- og Handelsspejlet* from 1780, one of the earliest directories of trades and addresses, are listed 146 masters of joinery and 22 masters of carpentry in Copenhagen, as well as 15 turners (*drejere*), 15 chair makers (*stolemagere*), 18 coachbuilders (*hjulmænd/Karetmænd*) and other masters of less common woodworking crafts, such as organ builders (Holck 1780:69-72). Cabinetmakers are not listed separately from joiners. Depending on demand, the different specialised tasks were often taken on by the same craftsmen, while in other cases such as coachbuilding, the work was done in collaboration between multiple crafts (Dybdahl & Dübeck 1983:132). In addition to masters were journeymen and apprentices, who are not listed in the directory, but there were generally one to two times as many of these as the masters (Parby 2015:158).

The increase in economy during the latter half of the eighteenth century gave rise to many crafts. The woodworking sector was one of the most advanced in Copenhagen as many joiners and cabinetmakers fitted out interiors and supplied furniture to the wealthy aristocracy and the upwardly mobile bourgeoisie in the construction and decoration of castles, estates, mansions, houses, churches and so on (Elling 1958; Langen 2008:31-34; Parby 2015:42). It was a trend, as seen in the rest of Europe towards the end of the eighteenth century, which reached a climax in Paris, where an explosion of luxury, taste and fashion had taken place by 1780, with furniture becoming the most important object of luxury and expense (Stürmer 1979:479; Farr 1997). By the middle of the eighteenth century, stores

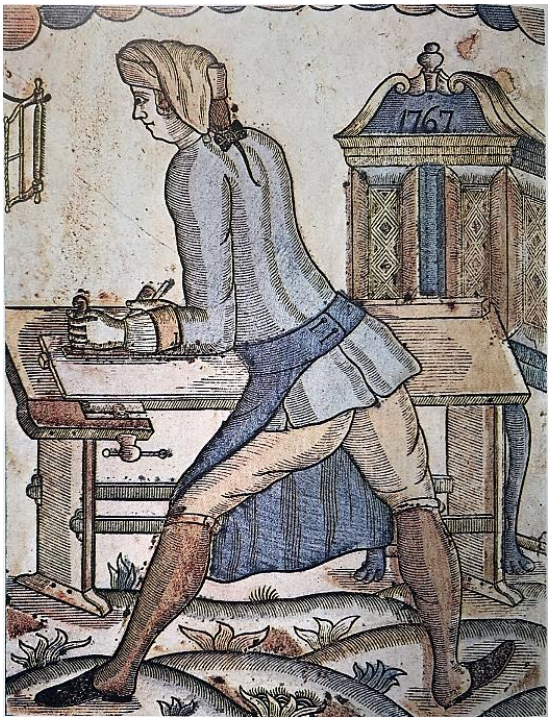

Fig. 6.13 Thomas Larsen Borup, *Cabinetmaker at his workbench*, 1767. Woodcut.

where one could buy ready-made furniture rather than by commission started to appear in Copenhagen. Joiners were the first to practice this type of commerce in Copenhagen, although other professions soon followed (Dybdahl & Dübeck 1983:20). The joiner and Cabinetmaker Mathias Ortmann (c. 1692-1757) had great success opening a store in *Gothersgade* in the 1740s. He ran advertisements in the newspaper *Kiøbenhavnske Danske Post-Tidender* (see for instance 15 December 1749 and 26 June 1758) and provided his furniture with a signature and an engraved label: "At Mr M. Ortmann located in Gotters Gaden [street] are all sorts of cabinets and joiner work manufactured for a very civil price in Copenhagen"[22] (Bruun Rasmussen). Similarly, a bit later in the century the joiner Jens Brøtterup (1752-1832) added labels to his furniture, signed "English, joiner and chairmaker."[23] He had worked for six years in England and, after he had turned in a dresser for review at the art academy he was granted royal permission to "Manufacture all kinds of joiner work and the associated turning, sculpting and chairmaking work"[24] as well as to employ journeymen and educate apprentices (Clemmensen et al 1954:235). Several joiners and cabinetmakers went into collaboration and founded furniture stores. The very first at *Børsen* did not have great success, but by the turn of the century, about a dozen such stores existed (Dybdahl & Dübeck 1983:20). The furniture displayed a high level of craftsmanship and an approach with fine drawings and the use of geometry to create intricate shapes of furniture (Chippendale 1754); this level of precision would not have been required for the construction of strainers. There seem to have been plenty of woodworking craftsmen with skills to have supplied strainers for Juel's studio, as the strainers were basic structures with simple half-lap joints. Making strainers was likely considered slightly coarser woodworking. No matter the status and specialisation involved in making cabinets and luxurious furniture, records show that joiners at times produced both finer and coarser woodwork (Elling 1958). This information provides insight into the developments and demands of different trades in Copenhagen in the latter half of the eighteenth century.

6.3 Availability of Expandable Stretchers in Denmark

None of the preserved auxiliary supports in either Juel's or Abildgaard's paintings present as keyable stretchers, only as strainers. Juel's self-portrait with his wife in the studio from 1791 (Fig. 2.6), shows the reverse of a painting on the easel, exhibiting the auxiliary support as a strainer. This, in accordance with the preserved original strainers in both Juel's and Abildgaard's paintings, suggests that keyable stretchers were not yet in use in Denmark by the end of the eighteenth century or even into the early nineteenth century. The earliest known mention of the invention of keyable stretchers is by Pernety in his treaty *Dictionnaire portatif de peinture, sculpture et gravure …* (1757:xc).[25] How quickly this invention spread and how widely it was used and available in

[22] "Hos Sr M. Orthmann boende udi Gotters Gaden bliver alle Sorter Cabinet og Snedker Arbeide forfærdiget for en Civil Pris i Kiöbenhavn."
[23] "Engelsk, Snedker og Stolemager"
[24] "forfærdige alle Slags Snedker Arbeyde og det dertil behørende Dreyer, Billedhugger og Stoelemager Arbeyde"
[25] "On a inventé depuis peu une maniere de faire des chassis qu'on appelle chassis à clefs; ils sont preferable en tout aux anciens chassis parce qu'au moyen des clefs, on tend la toile plus fortement, &

Europe after this time is unclear, but it seems they were not widely used until the late eighteenth century (Buckley 2012:150). Stretchers with keys are at times depicted in artists' self-portraits from the studio, such as Adélaïde Labille-Guiard's *Self-Portrait with Two Pupils* from 1785 (Fig. 6.14). However, a strainer without keys sits in the background. This indicates that it was available in France at this time, but not universally used.

Fig. 6.14 Adélaïde Labille-Guiard, *Self-Portrait with Two Pupils*, 1785. The Metropolitan Museum of Art, oil on canvas, 210.8 x 151.1 cm. Detail (right) displaying the stretcher with keys.

It is unknown when keyable stretches became available in Denmark; however, paintings from other artists' studios give an indication. Several depictions during the 1820s and 1830s, by Danish Golden Age painters, show the reverse of paintings displaying the auxiliary supports (Fig. 6.15-6.18). However, only one of these displays the auxiliary support as a keyable stretcher, that of Wilhelm Bendz from 1826 depicting Ditlev Blunck (Fig. 6.16). The artist is holding a small, stretched canvas painting, which includes keys. However, the painting in the background of the depicted image shows a large painting stretched onto a strainer. This suggests that they were available at least from the mid 1820s, but may not have been widely used until later.

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toutes les fois que la sécheresse la relâche. Ces clefs se mettent dans tous les coins d'assemblage & aux bouts de chaque traverse."

Fig. 6.15 Ditlev Blunck, *The Battle-painter Jørgen Sonne in his Studio*, 1823. National Gallery of Art (SMK) (KMS57), oil on canvas, 121.5 x 101 cm.

Fig. 6.16 Wilhelm Bendz, *A Young Artist (Ditlev Blunck) Examining a Sketch in a Mirror*, 1826. National Gallery of Art (SMK) (KMS280), oil on canvas, 98 x 85 cm.

Fig. 6.17 Wilhelm Bendz, *The Raffenberg Family*, 1830. National Gallery of Art (SMK) (KMS7594), oil on canvas, 44.9 x 39.7 cm.

Fig. 6.18 Constantin Hansen, *Three Young Girls. The Artist's sisters Alvilde, Ida and Henriette*, 1827. National Gallery of Art (SMK) (KMS125), oil on canvas, 62.5 x 81 cm.

6.4 Original Strainers and State of Preservation

The preserved strainers, although simple in their construction, still appear structurally sound and continue to provide support for the paintings. In the Svenstrup paintings, the canvas appears slightly slack and displays minor local bulging, but not to a degree that obscures the images, poses a high risk of losses and cracking, or otherwise compromises the physical or aesthetic integrity of the paintings. Actually, the risks involved in re-mounting and stretching are likely to cause the

paintings more damage than if kept in their current state. As the paintings have been stored and displayed in the same location over a long time, it is likely that equilibrium has developed with their environment (Keck 1969:25; Michalski 2014; Bratasz et al 2020). Thus, in their current state, much of the tension stress that originally initiated cracking in the paintings has been relieved (Mecklenburg 1982; Karpowich 1990). If such paintings are stretched, keyed or remounted, it may introduce new tensions into the structure that can result in damages when re-installed in their normal environment. The wooden strainer or stretcher can also render a painting more taut or loose over the course of days or weeks depending on diffusion rate and dimensions (Andersen et al 2019). Removing a painting from its auxiliary support always involves risks of losses of ground and paint layers along the tacking margins and the fold-over edges (Scharff 2012:402; Hackney 2020:208). Furthermore, the short tacking margins often require the addition of edge lining (also known as *strip lining*) to reinforce and extend the tacking margins. This introduces new materials to the painting structure, which may induce new tensions. Thus, careful consideration should be made for such paintings before deciding to remove them from the original strainer.

6.5 Chapter Summary and Conclusions

While replacement of the original strainers with expandable stretchers has taken place on the majority of paintings by Juel from SMK, a few, as well as the paintings from Svenstrup, retain the original strainer. This provides rare evidence of shape, construction, availability and format of strainers in the late eighteenth century. The strainers are similar basic constructions with half-lap joints and are made of softwood (pine). The surfaces of the wood exhibit tool marks corresponding to eighteenth-century developments. Contrary to common belief for the era, the strainers exhibit slight beading and bevelling, suggesting this was utilised to some extent from an early time; however, this was not enough to avoid strainer-bar related cracking. Woodworking craftsmen, likely joiners or cabinetmakers, made the strainers for Juel's paintings produced in Denmark. Only one of the paintings from abroad, *Hauch KMS349*, painted in Paris, appears to remain with its original strainer. This is seemingly similar to other French strainers from this period. Expandable stretchers were available in France from the mid-eighteenth century, although they were likely not widely used until the end of the century. Expandable stretchers were probably not available in Denmark before the 1820s. Where retained, the original strainers remain sound and stable and provide sufficient support for the paintings. Paintings that remain on their original mounting have likely reached an equilibrium with their surroundings over a long time, and careful consideration of this aspect should be made before performing treatments that may introduce new tensions in the painting structure.

7 Canvas Support

Canvas characteristics, such as weave density, type of fibre or spinning direction, when assessed with other features of the support such as tacking margins, loom widths and the presence or absence of cusping, may answer questions regarding the origin, preparation, history, format and composition, canvas-roll matches, dating and authenticity of the paintings.

There is general consensus that the properties of the canvas have a continuous impact on the preservation of the paintings, as they influence the physical behaviour of the canvas support in response to environmental fluctuations over time (Mecklenburg 1982; Russell and Berger 1982; Hedley 1988). Various structural characteristics, such as fibre type, direction of the weave, density of fabric, how the threads are spun and thread irregularities, can influence the sometimes-unpredictable behaviour of canvasses. However, it can be troublesome to identify which of the characteristics are the cause of potential or existing damage as they are often are complex and intertwined (Hedley 1988; Rouba 1992; Hedley 1993; Bilson 1996; Andersen et al 2009; Vila et al 2019).

This chapter characterises the canvasses used by Juel throughout his career and in different geographical locations to obtain a better understanding of variations in market conditions and the artist's choices in fabric support, as well as to investigate patterns in the characteristics of the canvasses, which may have influenced degradation patterns, especially crack formation and contractions. Furthermore, investigation is carried out into how the canvasses were prepared for painting, whether some of the paintings originate from the same canvas roll and how this may have an effect on the art-historical dating of the portraits.

7.1 Characteristics of Juel's Canvasses

A total of thirty paintings on canvas by Juel have been studied. Eight of the paintings were examined in a previous study and only a selection of characteristics from these are recorded (Table 7.1) (Slotsgaard 2013; 2015). The canvas analyses included visual examination, microscopy, X-radiography and computer-assisted automated thread counting and weave mapping. The results of the canvas analyses are summarised in Table 7.2 and Table 7.3.

The canvasses used by Juel to a large extent have features in common that fit the market conditions and manufacture of canvas at the time. All of the canvas supports used for the examined paintings, whether produced in Denmark or abroad, are plain-weave canvas made from bast fibre, either flax or hemp, hand-spun and hand-woven. Bast fibres can be difficult to distinguish from one another and typically have a rounded polygonal outer shape with a narrow, round or oval lumen and V or X dislocations (nodes) when viewed under the microscope

(Ilvassalo-Pfäffli 1995:336-339; Bergfjord & Holst 2010). In six of the paintings, from the previous study, are the fibres identified specifically as flax (linen) (Slotsgaard 2013).

Fibres used for canvasses

That Juel's canvasses consist of bast fibres follows the customs of the era. In Europe in the eighteenth century, the fibres used for painting canvasses were mainly flax and hemp (Dalgaard 1980). Jute, originating from India, was not introduced in Europe until around 1795. Due to the coarse fibres, jute was not in common use until mechanisation of the production was initiated in the nineteenth century (Villers 1981). Cotton was introduced in Europe in the Middle Ages, but until the invention of the spinning machine in the late eighteenth century it was not possible to produce cotton yarns strong and fine enough to be used as warp threads in the weave. For this reason, early cotton canvas only consists of cotton in the weft direction, while the warp was still flax or hemp (Bro Jørgensen 1943:99; Villers 1981:7-8; Dalgaard 1980:20; Young 2012:122). The canvasses used for paintings were seemingly the same as those manufactured for other purposes such as household goods, clothing and sailcloth. Flax was the most widely used fibre for household products, closely followed by hemp, which was prepared in the same manner. Hemp fibres are slightly thicker than flax and thus a bit stronger (Villers 1981:6). This seems to be known among painters as well. The Swiss painter Pierre-Louis Bouvier (1765-1836) reported: "Canvasses made of hemp are the best, because they are stronger, and can endure to be stretched very tight without breaking. Linen canvasses are less strong; furthermore, they are prone to becoming slack. Cotton canvas is useless for this purpose" [26] (Bouvier 1827:544). Whether one type of bast fibre was used over another varies over the centuries and between geographical locations. Vanderlip de Carbonnel reported in her study that French eighteenth-century artists used hemp canvasses in plain weave, but, in contrast to Bouviers' comment, by the turn of the century a change towards flax canvas occurred, which has since become dominant (Vanderlip de Carbonnel 1980). Whether the fibres used for Juel's paintings produced abroad, at least while in France, were hemp rather than flax, as suggested by Vanderlip de Carbonnel, unfortunately at this point, remains undetermined.

Thread count and thread thickness

All the examined paintings display variation in thread count and thread thickness in the individual canvas, which strongly indicates that the threads are hand-spun and the fabric hand-woven (see Table 7.2) (Bilson 1996). This correlates with the industrial advancement of the time, since the spinning wheel and the mechanical loom were not commonly used for flax, hemp and jute until well into the early nineteenth century (Villers 1981:8-9; Young 2012:120-124). The spinning machines, initially used for cotton, were introduced in Denmark in the 1780s with some reluctance, as was the mechanical loom, which was not in use until the last half of the nineteenth

[26] "Les toiles de chanvre sont les meilleures, parce qu'elles sont plus fortes, et qu'elles peuvent supporter d'être très-fortement tendues sans se rompre. Les toiles de lin sont moins fortes; d'ailleurs elles sont sujettes à se détendre. Les toiles det coton ne valent rien pour cet usage."

century (Rawert 1844; Bro Jørgensen 1943; Andersen et al 2009). During the early mechanisation in the nineteenth century, an evenness and regularity of threads, often linked with mechanically produced canvasses, is sometimes seen in the transition period as hand-spinning skills improved (and vice versa) making it hard to distinguish between hand- or machine-spun fabrics (Rouba 1992; Young 2012:121). However, until that stage, threads and canvasses of flax and hemp remained hand-spun and hand-woven, which is probably also the case for Juel's canvasses no matter the geographical place of production.

All threads, regardless of geographical origin, were spun in a Z-twist, mainly at a medium angle, between 10 and 25 degrees, but those produced in Denmark at times display medium to tight spinning, with angles up to 30 or 35 degrees.[27] Generally, the threads of canvasses of paintings produced in Denmark show a higher average spinning degree and appear slightly more tightly spun than those produced abroad.

The weave density of each canvas varies with thread thickness and thread counts. Variations in thread thickness in the same direction of the individual canvas can vary up to 0.7 millimetres between threads – usually from 0.3 millimetres up to 1 millimetre. Minimum and maximum thread thickness as well as average, measured on eight to eighteen threads in each direction, are displayed in Table 7.2. The smallest thread thicknesses are found in the canvasses from paintings produced in Paris and Switzerland with threads down to 0.2 millimetres in thickness and with a smaller range of variation. These canvasses are thus slightly finer in quality than those commonly used in Denmark.

Table 7.1 Canvas support of eight portraits by Juel examined in a previous study (Slotsgaard 2015), see Appendix 26. The portraits are numbered 1-8 according to their dating. All the canvasses are plain-weave and all threads are Z-spun at an approximately 25-degree angle.

Painting number	1	2	3	4	5	6	7	8
Year	1766	1768	1769	1769	1786	1789	1790	1792
Fibre identification	Linen	Presumably linen (not analysed)	Linen	Linen	Linen	Presumably linen (not analysed)	Linen	Linen
Selvedge	Upper edge	Upper and lower edge	–	–	–	–	–	–
Direction								
Warp	Horizontal	Horizontal	–	–	–	–	–	–
Weft	Vertical	Vertical	–	–	–	–	–	–
Thread count								
Horizontal	15/cm	11–12/cm	11/cm	10/cm	14/cm	14/cm	13–14/cm	14–15/cm
Vertical	12/cm	9/cm	9–10/cm	11/cm	14–15/cm	9–10/cm	13/cm	14–15/cm
Thread thickness								
Horizontal	0.3–0.7 mm	0.4–1.0 mm	0.3–0.8 mm	0.3–1.0 mm	0.4–0.8 mm	–	0.4–0.8 mm	0.4–0.8 mm
Vertical	0.35 mm	0.4 mm	0.4–0.7 mm	0.3–1.0 mm	0.4–0.8 mm	–	0.3–0.7 mm	0.3–0.5 mm
Lining	Glue-paste	Glue-paste	Wax	None	None	Wax	Glue-paste	Glue-paste

[27] 0-10°=loose, 10-25°=medium, 25-45°=tight

The thread counts of the canvasses are divided into low, medium and higher ranges (Table 7.2 and Fig. 7.1). The lowest thread count, and most coarse canvas, is found in the self-portrait from Dresden, *Self-Portrait KMS3275*, from 1773 to 74. It displays a thread count of nine threads per centimetre in the horizontal direction and as low as seven threads per centimetre in the vertical direction. All the paintings produced in the early period of 1765 to 1772 also display low thread counts varying between eight to eleven threads per centimetre. Two exceptions are the *Self-Portrait KS93(1)* in the studio from 1766 and *Self-Portrait KMS3990*, from Hamburg, which both have slightly higher thread counts and fall within the medium range (between nine and fifteen threads per centimetre). The two paintings from Switzerland, *Prangins KMS4801* and *Tronchin KMS6151*, as well as two of the paintings from the later period, *H.Gerner KMS1444* and *J.P.B. Neergaard SV4*, display a finer quality and the highest thread count between thirteen and nineteen threads per centimetre. All additional paintings fall within the medium range. Similar trends in variation are seen in the previous study of eight paintings (Table 7.1). Detail images of the canvas of the examined paintings are presented in Appendix 27.

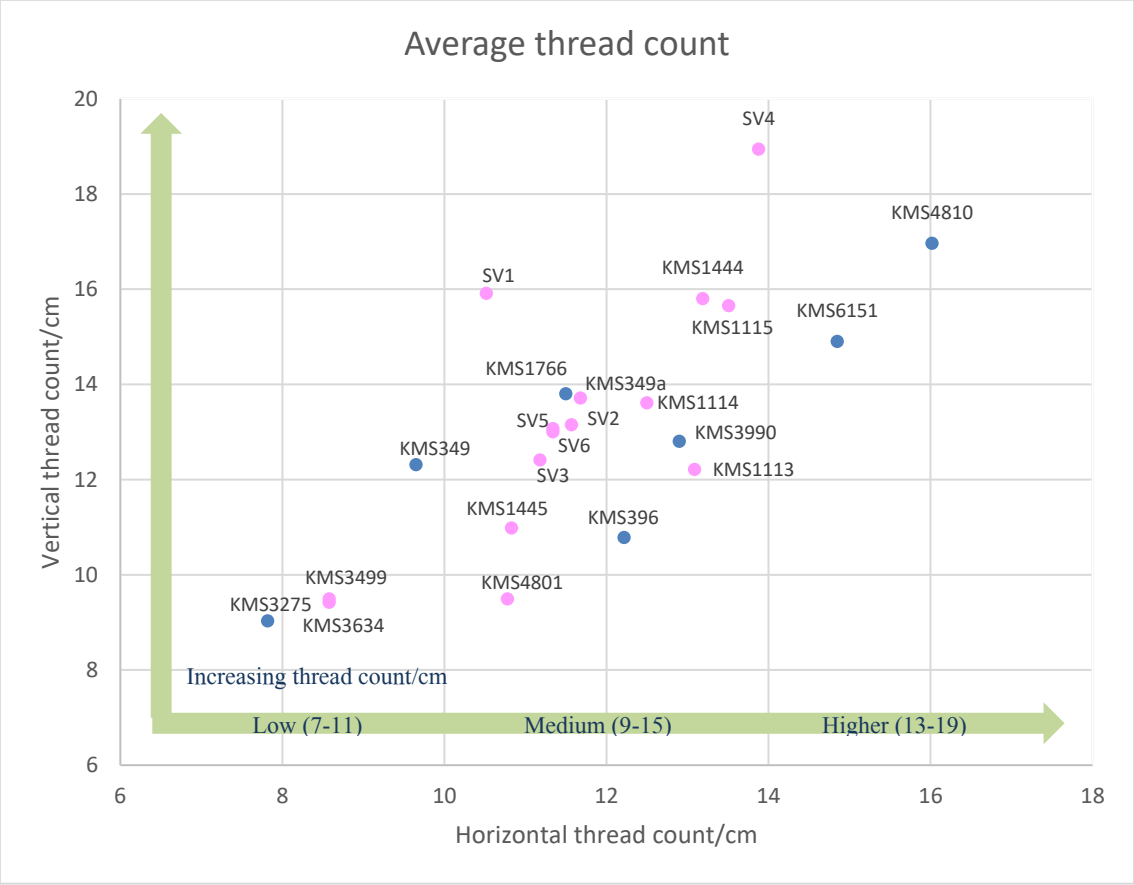

Fig. 7.1 Relative average thread counts of the twenty-two paintings in the current study. Pink markers signify paintings produced in Denmark, and blue markers the paintings produced abroad. The average values are derived from computer-assisted weave mapping.

As the numbers show (Fig. 7.1), the thread counts vary both between and within geographical regions as well as over time, making it complicated to make a proper relation between geographical location and quality of the canvas. The thread counts of paintings produced in Paris

fit with the observations made by Vanderlip de Carbonnel (1980) of an average of twelve to thirteen threads per centimetre for French eighteenth-century canvasses, suggesting they could have been purchased locally. The paintings produced in Switzerland have average thread counts within the higher range, but a similar high thread count is occasionally found in the paintings produced in Denmark during the later period of Juel's career. Looking at the paintings produced in Denmark, there is a general tendency for the canvasses to increase in thread count from the earlier to the later period of Juel's career. Either this had to do with a conscious choice, weighing quality against economy by Juel, who may have chosen cheaper or coarser canvasses in his early years, or it may show that a general trend toward development in quality in the local production and availability took place over the years (Dalgaard 1980). Canvasses used while in Denmark by Juel's contemporary Abildgaard, display similar medium-range thread counts of between ten to fourteen threads per centimetre, with no obvious development towards finer or coarser canvas in his production, although in his later years (d. 1809) canvasses of slightly finer quality were used in a few paintings (Filtenborg 2014:3-12; 2015:129). Research on canvasses used by artists in the Netherlands in the seventeenth century revealed that the thread density towards the eighteenth century changed from an average of ten to twenty threads per centimetre to ten to fifteen threads per centimetre (Van de Wetering, E. 1997:98-99). Given this trend continued in the Netherlands throughout the eighteenth century, the Netherlandish canvasses as well as both the French, as reported by Vanderlip de Carbonel, and Danish canvasses have thread counts that fall within the medium range. It could appear that this range in density of threads was quite common for artists' canvasses throughout Europe at this time, including in Denmark, whether locally produced or imported. More elaborate and structuralised studies of artists' canvasses in the future may provide a better impression of differences between eras, locations and the artists' choices as these are only rarely mentioned in written sources (Stols-Witlox 2017:118).

Local production and canvas quality

Juel probably acquired his canvasses locally, whether in Denmark or abroad. Several authors suggest that pragmatism and price likely reflected the choice of canvas for artists (Villers 1981:6; Van de Wetering 1997:95; Young 2012:116). There is no logical reason that Juel would have transported canvasses purchased in Denmark with him for eight years during his travels around Europe. However, whether he transported primed canvasses between locations around Europe, as he did with finished paintings in some cases, is unknown (see Section 2.4, anecdote on portrait of *Clemens KMS396*).

In general, it is problematic to determine whether the canvasses were of local production or imported, and this is also the case for the paintings produced in Denmark. No information on any acquisitions of canvasses by Juel exists. All of the examined canvasses used by Juel, regardless of the place of production, are plain-weave canvasses. Plain-weave linen (flax) canvasses were the most abundant in Denmark and produced in large quantity. They could be obtained in various qualities from finely woven to more coarse canvasses. As in other countries, the quality of the

canvas depended on both the thickness and density of the threads, how evenly the threads were spun, and bleaching and other treatments (Bruun Juul 1807:v.2,176). It is possible that the canvasses acquired in Denmark were of local production. The ruling mercantilism at the time sought to promote the production of flax in Denmark and to limit the import of linen products from other European countries, which were often cheaper and of better quality. However, imported goods – raw flax and hemp, as well as manufactured linen canvas – were still available and in demand, partly due to domestic production falling short of high demand and the fact that a great deal of smuggling occurred (Rawert 1844:9,23; Bro Jørgensen 1943; Olsen 1962; Dalgaard 1980:18-24; Johansen 1983; Paludan 2003; *Øresunds Toldkammer* 1773-1802). Bruun Juul reported in one of the first Danish product encyclopaedias, from 1807, that no matter how good the manufacture of canvasses was in Denmark, they could not live up the quality imported from other countries in Europe (1807:v.2,178). According to the French author Pernety, canvasses were labelled with regard to quality as *toile d'Italie*, *toile de Flandre/Flamande* and *toile Françoise* (Pernety 1757:534-35). The Italian grade was the coarsest, while the French canvas was of the finest grade. Netherlandish canvasses were, according to records, seemingly widely imported and available in Denmark (*Øresunds Toldkammer* 1773-1802; Dalgaard 1980). Furthermore, Danish-manufactured linen of different grades aimed to imitate foreign qualities and was often named after the famous import locations (Dalgaard 1980:22). Thus, the country of origin cannot be securely identified by the name of the canvas quality. No records on the specific thread density of the different types of fabric, nor of their price differences, have been found which could establish comparisons between Juel's canvasses and the common products. Archival research may reveal more information on these matters.

Weave orientation

As with fabric density and spinning method, an important structural component of fabric is the direction or orientation of the weave in the loom. The warp threads that run lengthwise through the loom may differ from the transverse weft threads and the directions may react differently to environmental changes (Hedley 1988; Young 1999; Franken 2017). The direction of the weave can be identified by the presence of a selvedge and, in some cases, other features such as thread irregularity, crimp and differences in number of threads in each direction (Rouba 1992). For the majority of the paintings examined, the weft threads appear in the vertical direction. Selvedge is identified in seven paintings and is generally recognised along the upper edge of the paintings (Fig. 7.2). Warp threads usually display the higher thread count, although this distinction cannot always be used with complete confidence (Rouba 1992; Van de Wetering 1997:301). In the cases when selvedge is identified, a higher

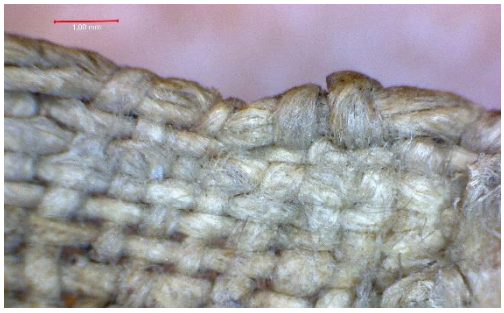

Fig. 7.2 Micrograph of preserved selvedge on *A.M.B.Neergaard SV2.* The edge displays the turning of every other weft thread around the last warp thread.

thread count is indeed observed in the horizontal-direction warp. The overall tendency in Juel's canvasses shows, with few exceptions, that the horizontal direction has a higher average of threads per centimetre than the vertical direction. This suggests that the weft primarily appears in the vertical direction of Juel's paintings.

Table 7.2 Summary of canvas analyses. Blue = produced abroad, pink = higher number of threads in the vertical direction. Numbers are listed with the horizontal direction over the vertical direction.

Painting id.	Year	Selvedge	Weave Direction	Threads (/cm) Range	Threads (/cm) Average*	Thread thickness (mm) Range	Thread thickness (mm) Average*	Spinning Degree (z)	Crimp 0-2**
KMS3990	c. 1764	-	Weft	11-13	12.8	0.3-0.7	0.45	15-30	2
			Warp	13-14	12.9	0.25-0.75	0.46	15-25	2
KMS3499	1770	Upper + lower	Warp	10	9.42	0.4-0.7	0.57	20-35	1
			Weft	8-9	8.52	0.4-0.8	0.64	20-37	2
KMS3634	1771	-	?	9-10	9.49	-	-	-	-
				9-11	10.78				
KMS4801	1772	-	?	8-9	8.46	-	-	-	-
				9-10	9.01				
KMS3275	1773-74	-	Warp?	9-10	9.03	0.25-0.7	0.4	15-25	1
			Weft?	7-8	7.82	0.3-1.0	0.66	15-25	0
KMS349	1776	-	Warp?	12-13	12.31	0.3-0.5	0.39	10-25	1
			Weft?	9-10	9.65	0.3-0.6	0.39	10-25	2
KMS396	1776	Proper right	Weft	10-11	10.78	0.3-0.6	0.45	15-25	0
			Warp	12-13	12.22	0.16-0.8	0.50	15-25	1
KMS1766	1778-79	-	Warp?	13-15	13.80	0.2-0.5	0.37	15-25	-
			Weft?	11-13	11.5	0.25-0.5	0.38	15-25	
KMS4810	1778-79	-	Warp?	15-18	16.96	0.2-0.5	0.33	-	-
			Weft?	16-17	16.02	0.25-0.6	0.42		
KMS6151	1779	-	Warp?	15-16	14.9	0.25-0.5	0.33	-	-
			Weft?	14-15	14.85	0.25-0.6	0.44		
KMS349a	1780	-	Warp?	14-17	13.71	0.35-0.75	0.50	20-30	2
			Weft?	12-13	11.68	0.3-0.6	0.43	15-25	1
KMS1444	1785	-	Warp?	15-18	15.80	0.35-0.8	0.56	15-30	2
			Weft?	13-14	13.19	0.25-0.5	0.38	15-30	1
KMS1445	1785	-	Warp?	10-14	10.98	0.4-0.6	0.51	20-25	2
			Weft?	11-12	10.83	0.25-0.5	0.37	20-25	2
KMS1113	1799-1800	-	?	12	12.21	0.4-0.7	0.56	15-30	1
				13-15	13.09	0.35-0.8	0.52	15-30	2
KMS1114	1799-1800	-	Warp?	14-16	13.61	-	-	-	1
			Weft?	12-13	12.5				2
KMS1115	1799-1800	-	Warp	15-16	15.65	0.4-0.7	0.54	15-25	2
			Weft	13-14	13.51	0.4-0.65	0.50	15-25	1
SV1	1788	Upper + lower	Warp	15-16	15.91	0.4-0.7	0.55	15-30	2
			Weft	11-12	10.52	0.4-0.8	0.6	15-40	1
SV2	1788	Upper	Warp	12-13	13.15	0.3-0.8	0.50	15-35	1
			Weft	12-13	11.57	0.3-0.9	0.49	20-35	2
SV3	1780s	-	Warp?	12-13	12.41	0.5-0.9	0.68	15-35	2
			Weft?	11-12	11.18	0.3-0.8	0.46	15-25	1
SV4	1790	-	Warp?	17-19	18.94	0.3-0.95	0.42	15-30	1
			Weft?	14-16	13.88	0.3-0.7	0.52	15-35	2
SV5	1797	-	Warp	12-13	13.07	0.3-0.8	0.57	15-35	1
			Weft	12-13	11.34	0.3-0.9	0.59	15-35	2
SV6	1797	Upper edge	Warp	12-13	13.00	0.3-0.8	0.51	15-35	1
			Weft	12-13	11.34	0.3-0.9	0.59	20-35	2

*Average thread counts are derived from computer-assisted weave mapping and average thread thickness is measured from 8-18 threads over 1-2 cm in each direction.
**Crimp by comparison of one thread from each direction. 0 = no significant crimp, 1 = some crimp, 2 = significant crimp.

In *Clemens KMS396*, in contrast to above, the selvedge appears along the proper-right edge identifying the weft as running horizontally. The canvas displays a higher number of threads in the vertical direction, supporting that this is the warp direction. Another instance where the higher number of threads is found in the vertical direction is in *Self-Portrait KMS3990,* from Hamburg; this suggests that the weft runs horizontally in this canvas as well. This canvas also exhibits irregular threads with thickenings in the horizontal direction. When a difference is noticeable in the quality of the threads between the two directions of the canvas, the warp direction tends to show regular spun threads, while irregular threads with thickenings are found in the weft (Rouba 1992; Van de Wetering 1997:99). Like *Clemens KMS396,* the weave orientation of *Self-Portrait KMS3990* may be different from the average of those observed. Except for *Self-Portrait KMS3990*, only minor differences in thread quality between directions are noticeable. In a few instances, the thread-folding test on a single thread from each direction, showed the weft to be less strong than warp threads (Table 7.3). This corresponds with the warp threads generally being stronger in the weave (Dalgaard 1980). However, this does not appear to be the case in *Self-Portrait KMS3990* or *Clemens KMS396*.

Based on the appearance of a single thread from each direction, several of Juel's paintings seem to have more crimp in the weft direction; however, others display more crimp in the warp or no distinguishable difference (Table 7.2). Generally, in machine-woven canvasses, the warp threads usually display the most crimp, while in hand-woven canvasses crimp is often transferred to the weft (Young & Hibberd 1999; Hackney 2020:72-73), with some authors suggesting the weft displays the most crimp (Rouba 1992). This makes the distinction between warp and weft based on crimp ratio troublesome. In conclusion, this examination shows that neither crimp, strength characteristics nor number of threads display a consistent-enough pattern to allow differentiation between weave directions based on these features alone, and that only a combination of these features can provide a basis for determination.

Cover factor

In addition to the above characteristics, the cover factor is calculated (Table 7.3). Cover factor is a number that indicates the extent to which the area of a fabric is covered by one set of threads. For any woven fabric, there are two cover factors: one for each direction of the weave (C1 = Horizontal, C2 = Vertical). These combined give the total cover factor, which represents the density of a fabric (Rouba 1992; Gabrijelčič & Dimitrovski 2004; Mathur & Seyam 2011). The cover factor is calculated as a percentage, based on the average number of threads per centimetre in each direction (by computer-assisted weave mapping, Appendices 1.3-22.3) and the average thickness of threads in each direction (Table 7.2). The average thread thickness is measured on a limited amount of threads in each direction (eight to eighteen) due to restricted access to the original canvas in most cases. The random and limited measurement of threads with variations in number, thickness and spacing between threads in hand-spun and hand-woven canvas can be problematic and may not provide an accurate statistical result unless a higher number of threads

across a larger section of a canvas is measured (Bilson 1996). The three Svenstrup paintings *A.M.B.Neergaard SV2*, *J.Moltke SV5* and *E.Moltke SV6* for instance, which in the following sections are proposed to originate from the same canvas roll, have a calculated total cover factor varying up to seven percent between them. This shows that cover factor calculations are very sensitive to small variations in measurements between thread-number averages and thread-thickness averages. Thus, the cover factor can act as an indication of fabric density for comparison between canvasses, but should not be considered an absolute certainty.

7.1.1 Correlation between Canvas Characteristics and Craquelure

One of the reasons for identifying direction in the weave is to identify the direction that might be most prone to swelling and contraction. In the characterisation of cracking and craquelure patterns in Chapter 5, based on Bucklow's eight descriptive distinctions, *iii* represents a dominance of craquelure in one direction (Table 5.3 and Table 7.3). In about half of the paintings, no dominant direction could be determined, which may in part be due to a strong flattening during lining treatment, making it hard to distinguish visibly. However, in the other half of the examined paintings, a small tendency towards a dominant direction is evident. The slight dominance in the direction of craquelure correlates with minor contraction (Fig 5.12). The contraction in the most cases coincides with the direction opposite to the largest thread density or cover factor, meaning when the horizontal direction displays a higher cover factor, contraction occurs in the vertical direction (Table 7.3). This pattern seems equally present whether there is a small or larger difference between cover factors of opposite directions. However, this is not the case for two of the Svenstrup paintings, which may be due to uncertainties relative to the low amount of threads measured. A high cover factor has, in other cases, proven prone to develop more stress and cracking than other paintings with less dense fabric, and this mechanism is often intensified in combination with the presence of animal glue (Bilson 1996; Fuster-López et al 2017; Vila et al 2017). It is worth noting that the largest cover factor does not always correspond with the direction which has the most threads, as the density of the fabric is dependent on both the number of threads and the thread thickness. This shows that the number of threads alone cannot determine fabric density. No other characteristics between the two weave directions seem to display a consistent pattern towards a dominant direction of craquelure.

The perpendicular contraction to the direction with higher density likely coincides with the model suggested by Bilson (1996) that swelling of the threads in woven fabric results in contraction because the undulating path the thread has to follow becomes longer around each swollen thread in the perpendicular direction. The extent of shrinkage depends on the tightness of the weave as one of the factors. However, in none of the examined paintings by Juel do we see – nor do we expect to see – the same dramatic response to moisture, of contraction and tenting as the type of canvasses known as "shrinkers", which appeared towards the mid-1800s. Shrinkers were often made from tightly machine-spun yarns and more dense fabrics (Rawert 1944; Hedley 1988; Bilson 1996; Andersen et al 2009).

Table 7.3 Cover factor relative to the dominant direction of cracks/contraction, and thread strength test.
Red = direction with highest cover factor, blue = horizontal dominance, green = vertical dominance.

Id. No	Year	Cover factor* %			Dominant direction	Thread folding test 0-10**	
		C1 Horizontal	C2 Vertical	Total	of cracks (iii)	Horizontal	Vertical
KMS3990	c. 1764	58	59	83	2.5 Horizontal	4	2
KMS3499	1770	54	55	79	3	10	10
KMS3634	1771	-		-	3	-	-
KMS4801	1772	-		-	3	-	-
KMS3275	1773-74	36	52	69	3	10	10
KMS349	1776	48	38	68	3	10	10
KMS396	1776	49	38	79	3	10	2
KMS1766	1778-79	51	44	72	3	0	-
KMS4810	1778-79	56	67	86	3	-	-
KMS6151	1779	49	62	81	3	-	-
KMS349a	1780	69	50	84	3	10	2
KMS1444	1785	88	50	94	3.5 Vertical	9	6
KMS1445	1785	56	40	74	3.5 Vertical	9	5
KMS1113	1799-1800	68	68	90	3	7	9
KMS1114	1799-1800	-		-	3.5 Vertical	10	9
KMS1115	1799-1800	85	68	95	3.5 Vertical	9	6
SV1	1788	88	63	95	3.5 Vertical	2	-
SV2	1788	66	57	85	2.5 Horizontal	10	5
SV3	1780s	84	51	92	3.5 Vertical	10	10
SV4	1790	80	72	94	4 Vertical	10	10
SV5	1797	74	67	92	2.5 Horizontal	10	9
SV6	1797	66	67	89	2.5 Horizontal	10	7

*Cover factor is calculated based on average thread counts (derived from computer-assisted weave mapping) and average thread thickness from 8-18 threads over 1-2 cm in each direction.
**0-1.5 = extremely brittle, 1.5-4 = fragile to tension stress, 4-7 = slightly fragile, 7.5-10 = Good condition (Oriola et al 2001).

The main differences in characteristics between the canvasses of the paintings produced in Denmark and those produced abroad, which might explain differences in the global crack pattern, are an overall slightly lower cover factor, slightly lower spinning degree and thinner threads in the paintings produced abroad. Minor exceptions are present and the differences are not very prominent. Denser canvasses, as well as thicker and more tightly spun threads, are more prone to swelling and contraction (Bilson 1996; Fuster-López et al 2017; Vila et al 2017). However, these variations alone are not responsible for the different formation and appearance of the global crack patterns between the two groups of paintings as described in Chapter 5. The initiation and

formation of cracks introduced by reactions in the canvas rely on the structure and strength of other layers, especially the ground layers. The interaction between layers is discussed in the main discussion, Section 11.3.

7.2 Formats and Canvas Roll Width

The width of the canvas roll, as well as the format of the paintings, may indicate the place of production or provide information on available materials and the choices made by the artist. In many European countries, fabric was produced in a range of standard loom widths based on the *ell*. The precise dimensions of the ell, however, varied slightly from country to country and city to city (Kirby 1999; Young 2012).[28] Canvasses in Rembrandt's (1606-1669) paintings, for instance, show that widths of about 70 centimetres (1 ell), about 85 centimetres (1.25 ell), about 140 centimetres (2 ell), about 175 centimetres (2.5 ell) and about 210 centimetres (3 ell) all occur (Van de Wetering 1997:124). Wider strips were usually more expensive than the standard width (Van de Wetering 1997:124). The prevailing loom width of Danish eighteenth-century linen canvas was 70 to 80 centimetres (c. 1.125-1.25 ell), whereas wider canvas is seen less frequently, but does appear (Bro Jørgensen 1943:40; Dalgaard 1980; Filtenborg 2015).

In three instances, selvedge identified along both the upper and lower edges of the painting indicates the use of the full width of the canvas roll. On the portrait of *Schimmelmann KMS3865 (2)* from 1768, the width of the canvas roll (height plus tacking margins) adds up to about 82 to 83 centimetres. The portrait *Rahr KMS3499* from 1770 has very narrow tacking margins and the width of the canvas adds up to about 80 centimetres. On the almost two-decade-later-produced *J.B.Neergaard SV1,* the total width adds up to 80 to 81 centimetres. This shows that the used standard width remained similar over the decades.

On a general scale, the majority of Juel's paintings have dimensions fitting or close to the prevailing domestic loom width in at least one direction (Poulsen 1991). Paintings by Juel's colleague Abildgaard display a similar trend in dimension (Filtenborg 2015:136). Juel's use of canvas for a standard-sized portrait sometimes, however, appears to be at the widest and, in some instances, perhaps somewhat above the prevailing domestic loom width. This could suggest either that Juel in some cases used imported canvas or that by the second half of the century slightly wider canvas strips of Danish production were more commonly available.

The portraits *Battier KMS3634* and *Saly KMS4801* measure 79 and 83 centimetres in height respectively, not including the tacking margins (as these are cut). While cusping along the upper and lower edges may suggest the weft runs vertically, a marginally higher thread count in the

[28] The Netherlandish ell seems to have been about 70 centimetres, an English ell measured 114 centimetres (Young 2012:123) and the Danish ell measured 62.77 centimetres.

vertical direction, could suggest that this is in fact the warp direction. This might explain the height dimension exceeding the standard roll width in these two cases.

Larger-scale paintings and canvasses

All the examined portraits by Juel are painted on canvas that consists of a single piece without seams. However, seams have been identified in paintings by Juel that are not part of this study, showing Juel at times made use of joining canvasses for larger-scale paintings above the norm. For instance, two larger-scale portraits, currently in storage at SMK, display seams showing that two strips of canvas were sewn together to make up the chosen dimension. The portrait of coffee merchant Christen Ravn (KMS6980) from 1770 measures 125 by 99.5 centimetres. It displays a seam running horizontally across the painting at a height of approximately 50 centimetres, while the widest strip measures at least 75 to 80 centimetres, which corresponds to the prevailing loom width. The portrait of Countess Danneskiold-Laurvig (KMS941) from 1790 to 1791, on the other hand, measures 149.5 by 120 centimetres and displays a vertically oriented seam approximately 18 centimetres from the proper-left edge, leaving more than 100 centimetres for the widest strip of canvas making up the majority of the painting, which is wider than the prevailing loom width. The seam running parallel with the selvedge shows that the warp direction is vertically oriented in this painting.

Fig. 7.3 Jens Juel, *Niels Ryberg with his Son Johan Christian and Daughter-in-law Engelke, née Falbe.*, National Gallery of Denmark (SMK) (KMS6251), oil on canvas, 253 x 336.5 cm. The largest painting in Juel's production.

A handful of fabric manufacturers established in Denmark during the second half of the eighteenth century seem to have been able to provide canvasses of larger width, at least in some instances. The largest painting by Juel is that of the tradesman Niels Ryberg (1725-1804) and family from 1797 (Fig. 7.3), where Ryberg is depicted in nature, accompanied by his son and daughter-in-law, with the estate Frederiksgave (now Hagenskov) in the background. This painting measures 253 by 336.5 centimetres and consists of a single piece of canvas. This dimension is much larger than the common domestic canvas width, but was possible of national production. Ryberg owned a linen factory at *Køng* that was established during the late 1770s (Rasch 1964; Paludan 2003). By the mid 1780s the factory was well advanced and probably the best-developed fabric manufacture in Denmark (Bro Jørgensen 1943:33). Ryberg received permission to import both flax and tools from abroad. Records show that an equal amount of flax grown on the land and flax imported from abroad was used in the linen production (Paludan 2003; Schovsbo et al 2012). The large canvas for the painting was likely produced at Ryberg's manufacture. At least from 1785, the factory possessed a *fløjskyttelvæv* (flying shuttle), which was likely the first of its kind in the country, capable of making strips up to 3 or 3.5 ell (about 220 centimetres), and two wide looms requiring handling by to people capable of producing up to 5-ell-wide strips (about 315 centimetres) (Bro Jørgensen 1943:33; Paludan 2003:80-81). In a letter, Ryberg's son, Johan Chr. Ryberg, seems to downplay the large-scale portrait from vanity to pragmatism:

> A painting is being created in this time at Juel's of 4 ell in height and 5 ell wide, which depicts my father sitting in one of Fr[ederiks]gaves fields in a conversation with my wife and me, who stands in front of him, while in the background a piece of the very beautiful view of Fr[ederiks]gave manor and garden; my own conviction absolves both my father and me that no vanity has taken part in the decision making for having a thus costly portrait of ourselves, but solely the desire to give Juel the opportunity by such a piece to display his leading talent in portraiture and landscape painting, my father decided to make this great expense, which in any other case would have been a folly by a private man.[29]
>
> (14 November 1797, cited in Heiberg 2003).

The fact that the family provided Juel with the opportunity to produce such a large painting may imply that, besides placing the commission, they also delivered the canvas; moreover, perhaps they were the only linen manufacture in Denmark capable of producing such large-scale canvasses.

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[29] "Et Malerie forfærdiges i denne Tiid hos Juul af 4 Al. Høyde og 5 Al. Bredde som forstiller min Fader siddende i en af Fr[ederiks]gaves Marker i en Samtale med min Kone og mig, som staar for ham, samt i Baggrundpen af Stykket en meget smuk Udsigt over Fr[edereks]gaves Gaard og Hauge; min egen Overbeviisning frikiender baade min Fader og mig selv at ingen Forfængelighed har Deel i den Beslutnings Tagelse at bekoste saa dyrt et Portræt af os selv, men allene Lyst at kunde give Juul Lejlighed til ved et saadant Stykke at vise sin førende Kunst i Portræt og Landskabsmaleriet bestemte min Fader til at giøre denne store Bekostning som i anden fald vilde have været en stor Daarlighed af en Privatmand."

Standard formats

Standard-sized panels, canvasses and frames were available in the Netherlands from the early-seventeenth century (Young 2012:132). In France and England, standardised strainers for paintings, depending on subjects, appeared by the mid-eighteenth century. Pernety lists fifteen standard sizes, while portraiture in England usually conformed to five standard sizes (Pernety 1757:353; Kirby-Talley 1986:58; Gent et al 2014; Hoenigswald 2008:137). The dimensions of Juel's portraits in the early Copenhagen period are close to the English three-quarter, or bust-size, for portraits (about 76 by 63 centimetres), varying a few centimetres in each direction. While the standard oval portrait format (about 68.5 to 70.5 by 53.5 to 55 centimetres) seen in Juel's later production meets no particular conformity from abroad (Poulsen 1991). It has been argued that the dimensions of paintings for many painters may have been purely practical, and that the width of the available canvas roll pre-determined the size of paintings, rather than a standard format for paintings or strainers, as suggested by Pernety and others (Hoenigswald 2008). In this way, the width of the canvas roll would dictate the largest dimension in one direction for the majority of standard commissioned portraits, while the other direction was ruled by the ratio of static symmetry (Simon 2013). In Abildgaard's case, several paintings are cut from larger pre-primed canvasses; some in a small format that allowed for two paintings to be cut from the width of one standard canvas roll (Filtenborg 2014). As with Abildgaard, Juel in most cases used canvasses cut from large pre-primed formats where the width of the roll was fully utilised. This is discussed in the following section. This approach would have given the best cost-benefit and usage of materials and, likely, the standard width of the available canvas roll in most cases dictated a seemingly standard dimension in many of Juel's portraits.

7.3 Mounting and Preparation for Painting

For the paintings produced in Denmark, the canvasses appear cut from larger pre-primed canvasses. This is evidenced by the presence or absence of primary cusping, as well as the presence of the ground layer on the tacking margins. Primary cusping relates to the deformations caused by the initial stretching of the canvas and its positions along the edges, that become fixed in the canvas by the application of the ground and may gradually extend up to 25 centimetres into the canvas (Van de Wetering 1995:14-15). When the supports are prepared from a larger pre-primed canvas, primary cusping is usually only seen along either one edge, some edges or none at all, depending on the placement and the size of the pre-primed canvas (Fig. 7.4). This primary cusping does not correspond with the fixing during the mounting on the auxiliary support. After the priming of the canvas on a larger stretching frame, the support is cut for each painting and mounted on the strainer. This subsequent action can at times create a secondary cusping.

As described in the previous section, preserved selvedge along both the upper and lower edges of some of the canvasses signifies that the entire width of the canvas was regularly used for a portrait. Primary cusping along these edges, but without selvedge, may indicate a proximity to the cut former selvedge. Sometimes cusping is identified along one of the vertical sides as well,

indicating the end of the long stretched pre-primed canvas strip. Other times, the absence of cusping along the vertical sides suggests its placement from a central position on a long strip of pre-primed canvas (see reconstruction suggestion Fig. 7.9 and Fig. 7.10). The extent of cusping in Juel's paintings is displayed in X-radiographs and weave-angle maps in Appendices 1.3 to 22.3.

Fig. 7.4 Vincent Laurensz van der Vinne (II) (1686-1742), *A Painter in his Studio*, 1758. Rijksmuseum, Netherlands, etching, 101 x 125 mm. The cusping along the edges of the canvas is visible in the large paintings in the background. The canvasses are mounted by the use of a string. If such a canvas was primed and then cut, for instance into quarters, cusping would remain locked in and visible only on two sides.

Pencil lines along the fold-over edge, just below the paint application edge detected in a few of the Svenstrup paintings demonstrate how the plan for cutting multiple canvasses from a long strip was likely laid out (Fig. 7.5). This was possibly done by placing the strainer and tracing its shape onto the primed canvas. This is a practical way to see how many canvasses would fit and where to cut it, and to ensure optimal use of the primed canvas strip.

Fig. 7.5 The tacking margin of *J.Moltke SV5*. A pencil line barely detectable is present along the edge of the paint layer. It was possibly used as a mark-up of the size of the painting when cutting from the larger pre-primed canvas and positioning during mounting on the strainer.

When selvedge is present, the application edge of the ground layer is usually seen, leaving a small amount of bare canvas visible (Fig. 7.6), while the cut edges usually display ground layer extending all the way to edge of the canvas (Fig. 7.5). If a canvas was primed after being mounted individually on the auxiliary support, it is usually evident based on the fact that the ground layer extends only to the folded edge, with un-primed canvas visible along the tacking margin on all

sides. This is not the case in any of the paintings examined in this study. However, the paint layer in the majority of paintings by Juel extends only to the fold-over edge, showing that, although the preparatory layers were generally pre-applied to larger-format sections of canvas, the paint application took place following mounting of the pre-primed canvas on the strainer of equivalent format (Fig. 7.5 and Fig. 7.6).

Fig. 7.6 Upper edge and tacking margin of *J.B.Neergaard SV1* displaying selvedge and application edge of the ground layer. A longitudinal hole (approximately 1.5 cm) seen in the canvas both on the upper and lower tacking margins, is likely from the initial mounting while priming the large canvas.

Primary cusping usually originates from the canvas initially being stretched in a frame while priming. This was traditionally done with a string, as demonstrated in Figure 7.4. In *J.B.Neergaard SV1*, an approximate 1.5-centimetre longitudinal hole is present in the bare canvas, located between the selvedge and the application line of the ground layer, on both the upper and lower tacking margins, which could originate from the initial mounting during priming (Fig. 7.6). As described by de Mayerne, the ground layer was often applied with a large knife or spatula (1620:5r). Movements from such a spatula or similar object are frequently detected by curved ridges of ground that show up lighter in the X-radiographs (Witlox & Carlyle 2005:527; Noble and Verslype 2017:§2.5.2). Such ridges are only detectable in a few of the examined paintings, most obviously in *Prangins KMS4810* (Fig. 7.7) and more vaguely in just a few other examined paintings such as *M.Moltke KMS2084(5)* from 1786 (Slotsgaard 2013:80). While it is discussed in Section 9.3 that *Prangins KMS4810*, along with other paintings produced abroad, may have been purchased from a supplier pre-primed, a similar indication in those produced in Denmark suggests related methods of preparation. A technique for the application of ground layers was expressed in a magazine for artists and craftsmen in 1838; this

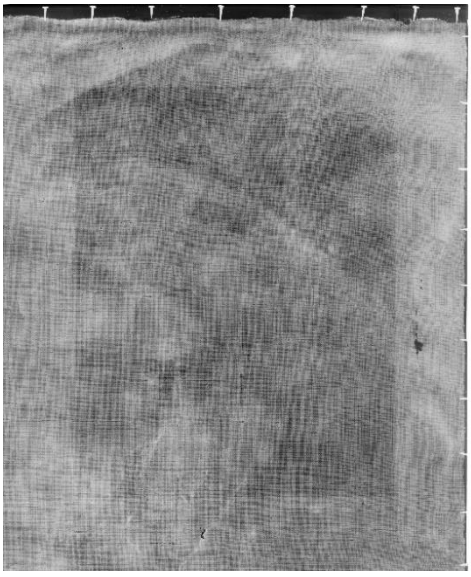

Fig. 7.7 X-radiograph of *Prangins KMS4810* (upper proper-left quadrant) shower curved lines likely deriving from the application of ground with a large knife or spatula.

describes the priming of a canvas stretched in a 470- to 565-centimetre-long frame using metal hooks and violin screws, using a spatula as long as the entire width of the canvas for spreading the ground material from one end to the other (Ursin & Hummel 1838:261). This method is likely more industrial than the method used for Juel's paintings.

Mounting tools and hand forged nails

Only the Svenstrup paintings indicate the original mounting of the canvas to the strainer. They retain original hand-forged nails along the tacking margins.[30] Longitudinal indentations on the reverse of the strainer adjacent to most tacks suggest the use of a mounting tool or stretching pliers (Fig. 6.7). Although canvas pliers are not mentioned in sources on painting practice until the end of the nineteenth century, the artist would have needed pliers or similar to hold on to the edges securely in order to stretch the stiff pre-primed canvas (Gettens & Stout 1966:284; Buckley 2012:153). Diderot and d'Alembert's *Encyclopedia*, although not specific to the painter's practice, shows examples of different types of pliers of the era from other crafts that would have been useful for this purpose (1763 vol.3: Chest and trunk making pl. 1; Shoe and boot making pl.1; 1771 vol. 9: Upholstery pl. 4, Fig.2; Hodkinson & Child 1995).

Individually prepared paintings?

While the paintings produced in Denmark appear prepared from a larger canvas in the manner described above, a few of the paintings produced abroad seem to fall outside the norm and may have been individually prepared. Both *Hauch KMS349* and *Clemens KMS396* display cusping along all four sides, suggesting they may have been individually stretched and primed. In *Hauch KMS349*, no selvedge is present and the darker paint layer of the background extends to the cut edge of the tacking margins covering the white ground layer, suggesting some paint application occurred before mounting on the oval strainer. However, the paint layer of the green jacket only extends to and follows the oval fold-over edge, hence the painting was planned or finalised in an oval format (Fig. 7.8). In *Clemens KMS396*, selvedge is present along the proper-right tacking margin. The application edge of the ground layer is present along this margin and covered by paint layer as well. Along the additional three sides, the ground and paint layer composition extends to the cut edge of the tacking margins. This suggests it may have been altered slightly in size, but this could correspond to the history of the painting being transported un-stretched across Europe and perhaps re-mounted several times, as reported in Section 2.4 and Section 6.1.

Prangins KMS4810 and *Tronchin KMS6151* display cusping along all four sides, however, it is unclear whether this cusping is primary or secondary. The absence of tacking margins makes it

[30] The tack heads are hand-hammered and most display 2-4 facets. A multifaceted head usually characterises hand-forged nails in combination with a square shank that tapers to a point. Multiple blows from a hammer form the facets, while the red-hot nail rod is held in a heading tool. Machines for cutting nails were not invented until the 1790s and hand-wrought nails continued to be used well into the nineteenth century (Visser 1997:24, Buckley 2012:153).

impossible to see whether the canvasses were prepared differently than the other examined paintings in terms of the appearance of the ground layer along the edges. This demonstrates that removing the tacking margins eliminates a large proportion of the visual characteristics for determining practices of the initial preparation of the painting.

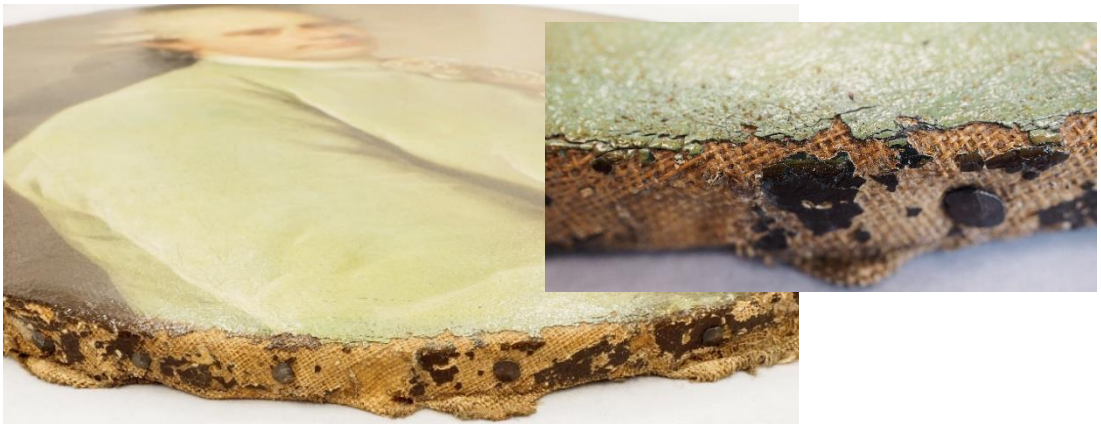

Fig. 7.8 The lower tacking margin and fold-over edge of *Hauch KMS349*. The dark paint layer of the background extends to the cut edge of the tacking margins covering the white ground layer, while the green paint of the jacket extends only to the fold-over edge.

7.4 Matching Canvasses

When thread density and other characteristics of the canvas, as well as the character of the ground layer and visual appearance of the tacking margins, can be identified as comparable, there is a valid chance that the painting support originates from the same canvas roll and possibly from the same pre-primed canvas. By using computer-assisted weave mapping of the X-radiographs, the examination of Juel's paintings provides evidence that two sets of paintings can originate from the same canvas roll. In addition, they were indeed prepared in the same manner and cut from the same larger pre-primed canvas. This is found to be the case for three of the paintings from Svenstrup: *A.M.B.Neergaard SV2*, *J.Moltke SV5* and *E.Moltke SV6,* and for *Bagge KMS1115*, which was found to match *Berner KMS1544(8)* from the previous study.

Matching canvasses from Svenstrup

The three Svenstrup paintings are all unlined and mounted on their original strainers with their tacking margins preserved. The canvas supports have similar characteristics and the ground layer is present on the tacking margins, exhibiting a similar pink colour. Matching compounds with regard to binders, pigments and fillers are identified in the ground layer of all three (Chapter 9) and they all display similar crack patterns (Chapter 5). The weave maps allow for a reconstruction of how the three paintings were positioned on a larger pre-primed canvas relative to each other. Figure 7.9 displays the proposed layout of the canvasses on the pre-primed canvas, showing: (a) images of the finished paintings; (b) the calculated weave maps of characteristics in the warp-direction threads, which are unique for a particular canvas roll, tracing the lines in the same position throughout the three canvasses (Johnson 2017); (c) and (d) the angle maps of the threads,

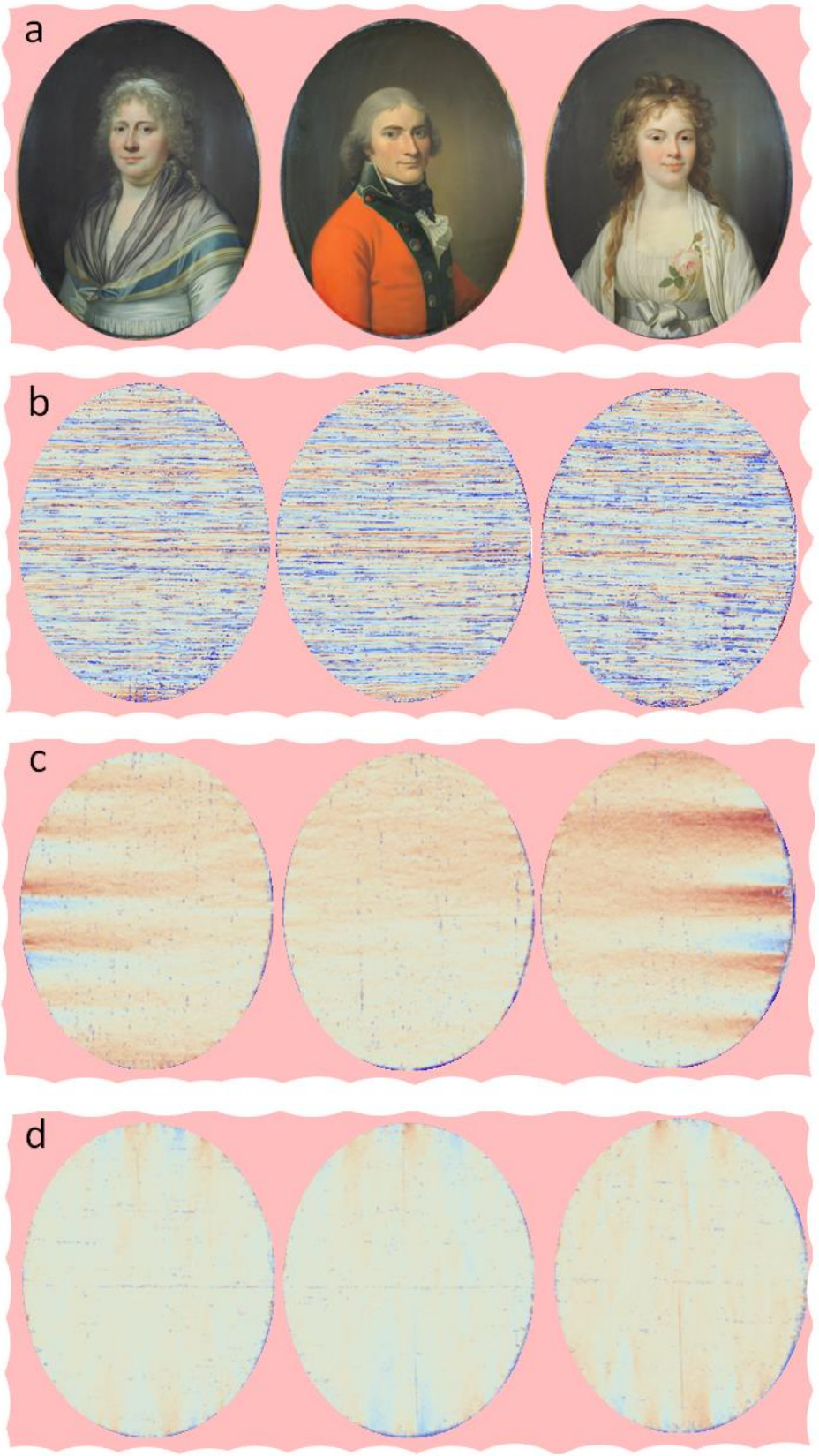

Fig. 7.9 Reconstructive suggestion of the positions of the individual supports of *A.M.B.Neergaard SV2*, *J.Moltke SV5* and *E.Moltke SV6* on a larger pre-primed canvas: (a) finished paintings, (b) calculated weave maps, (c) horizontal angle maps and (d) vertical angle maps.

which represent variations in the local orientation of the threads, signifying the extent of primary cusping, horizontally and vertically respectively. The horizontal angle map (c) also displays minor secondary cusping, related to the present mounting, where some distortion in the weave has occurred due to contraction of the canvas towards the centre over time, while being fixed in the same position. Preserved selvedge along the upper edges of both *A.M.B.Neergaard SV2* and *E.Moltke SV6*, as well as primary cusping along both the upper and lower edges of all three paintings, suggests that close to the full width of the canvas roll was used in the vertical direction. The application edge of the ground can be seen along the upper and lower edges, both where selvedge is present and absent (similar to Fig. 7.6). Cusping on the vertical sides of *A.M.B.Neergaard SV2* and *E.Moltke SV6* corresponds with them being positioned at opposite ends of a prepared canvas, while *J.Moltke SV5*, which does not present any cusping on the vertical sides, fits in the centre between the other two, as illustrated. The fixing points of the primary cusping along the vertical sides of *A.M.B.Neergaard SV2* and *E.Moltke SV6* are measured having been placed about 12 to 14 centimetres apart. The total width of the canvas strip is about 75 centimetres and the total length of a pre-primed canvas accommodating three such paintings adds up to at least 175 centimetres. Naturally, we cannot see whether the canvas length would have been even longer if additional paintings were cut from the centre. To do so, another portrait with a similar ground and canvas characteristics must be identified and matched based on characteristics and position related to cusping.

Matching canvasses of Bagge and Berner

In the selection of paintings for the examination, the portrait *Bagge KMS1115* was selected as presumed pendant to *P.J.Schouw KMS1113* and *A.C.Schouw KMS1114*, as they depict Poul Johan Schouw, his mother and mother-in-law, and their portraits are dated to the same years (1799-1800). However, none of the paintings is signed or dated by Juel and during examination it was found that none of the three paintings shares similar canvas characteristics or ground layers (Section 7.1 and Chapter 9). Instead, it is found that the portrait of *Bagge KMS1115* seems to match one of the portraits previously investigated depicting the sister of *P.J.Schouw KMS1113*, Maria Ulrika Berner née Schouw, *Berner KMS1544(8)* (Appendix 26). Both portraits are painted on an off-white double ground and appear to originate from the same roll of pre-primed canvas (Fig. 7.10). Both paintings present with visible cusping both along the upper and lower edges, suggesting that the entire width of the canvas roll was used, although the selvedge has been cut and is not present. Neither of the paintings display cusping along the vertical edges, suggesting that they, like *J.Moltke SV5*, were cut from the central area of a larger primed canvas. As with the above, there is currently no way of telling how long the prepared piece of canvas was or how many paintings it would have covered. If it accommodated four paintings, which is the likely minimum as neither of the aforementioned paintings seem to have come from the ends of the pre-primed canvas, it would have been at least 250 centimetres long. This length is equivalent to 4 ell, a length of pre-primed canvas occasionally purchased from 1816 by Eckersberg, as described in his diaries (Villadsen 2009:26.8.1816, see Section 9.3).

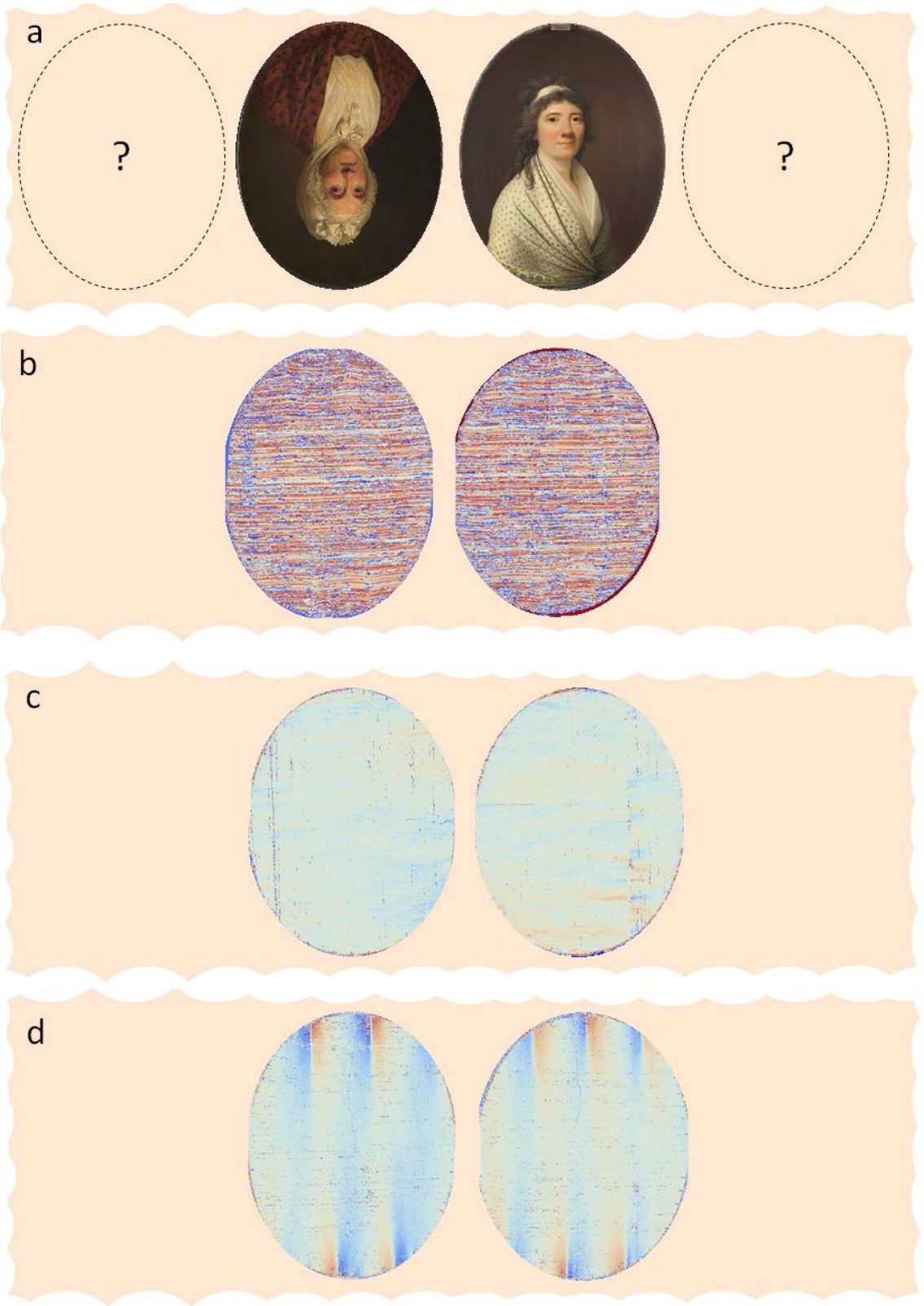

Fig. 7.10 Reconstructive suggestion of the position of the individual supports of *Bagge KMS1115* and *Berner KMS1544(8)* on a larger pre-primed canvas: (a) finished paintings, (b) calculated weave maps, (c) horizontal angle maps and (d) vertical angle maps.

This approach for the preparation for painting was rather common practice and several examples from other painters, both from Denmark and abroad, exist where paintings can be traced to originate from the same canvas bolt or pre-primed canvas (Van de Wetering 1997:100-107; Van Tilborgh et al 2012; Filtenborg 2014; Noble 2014; Filtenborg & Andersen 2017; Johnson 2017). In recent years, this type of comparative study has become more approachable with access to computer-assisted weave mapping. A question that remains unanswered is whether the priming, or preparation, was an act that took place in the studio or whether pre-primed canvasses were purchased ready-made from a supplier. This discussion, as well as an account of Juel's use of grounds, their colour and characteristics, will follow in the next chapter.

7.5 Matching and Dating

The identified matches in two sets of paintings may affect the dating of the portraits. As the majority of Juel's paintings are not signed and dated, they are dated art historically, based on documentary sources, style and events in the sitter's life. This is the case for all of the Svenstrup paintings. *A.M.B.Neergaard SV2* has been dated to 1788, while *J.Moltke SV5* and *E.Moltke SV6* have been dated to 1797. *A.M.B.Neergaard SV2* was dated as a pendent to *J.B.Neergaard SV1*, which portrays the husband around the time of his death. The daughter and son-in-law are dated to 1797, which corresponds with the event of their marriage and a delivery from Juel. As mentioned in Section 3.2, the dating of the portraits largely relies on receipts and letters found in the archives of the estate. In these records, the sitter's name is not mentioned and the attribution is based on Andrup, the author's, qualified guesses relative to the sitter's life (Wedell-Neergaard 1921). While the current dating suggests the portraits were executed about nine years apart, the matching canvasses of *A.M.B.Neergaard SV2* and the Moltke-couple, suggest that *A.M.B.Neergaard SV2* was painted later than the portrait of the husband, and likely in the same acquisition as the newly-wed Moltke couple. The records have not been reviewed as a part of this project; possibly the attribution between receipts and sitters ought to be differently allocated altogether. Juel's estate auction lists only two prepared mounted canvasses, a roll of prepared canvas and eleven strainers, suggesting that his storage was limited but adequate. The likelihood that Juel kept two matching, prepared canvasses for the same family for nine years seems not very plausible (Fugl 1803). Naturally, we cannot know for sure; however, Juel's prolific production and his seemingly inconsistent use of grounds speaks against this argument (for ground layers see Chapter 9).

Similar questions of dating arise in regard to *Bagge KMS1115* and *Berner KMS1544* upon the identification of matching canvasses. According to received wisdom, the portrait of *Berner KMS1544* was painted upon request of her children after her return to Denmark from India in 1792, after her husband's death (Bie 1938:213; Poulsen 1991:165). Her brother, who also lived in India, was in Denmark for a brief visit from October 1799 until May 1800. Thus, his portrait, *P.J.Berner KMS1113,* is assumed to have been painted during this time. Poul Johan Berner had married Cecilie Maria Schouw, née Bagge, in the early 1790s. The portraits of both his and her

mother, *A.C.Schouw KMS1114* and *Bagge KMS1115*, have previously been dated, following his portrait, to 1799 to 1800 (see family tree in Fig. 7.11). The match between *Berner KMS1544* and *Bagge KMS1115* suggests that the portraits of the two mothers should perhaps instead be dated, following the sister's portrait, to 1792; or, that the sister's portrait may have been painted later than previously thought, at the same time as her brother's portrait. The scarf depicted on both *Berner KMS1544* and her mother *A.C.Schouw KMS1114* bears a striking resemblance, suggesting these two portraits are contemporary. Again, the coincidence that a matching prepared canvas was kept for eight or nine years and used for a portrait of a family relation seems unlikely.

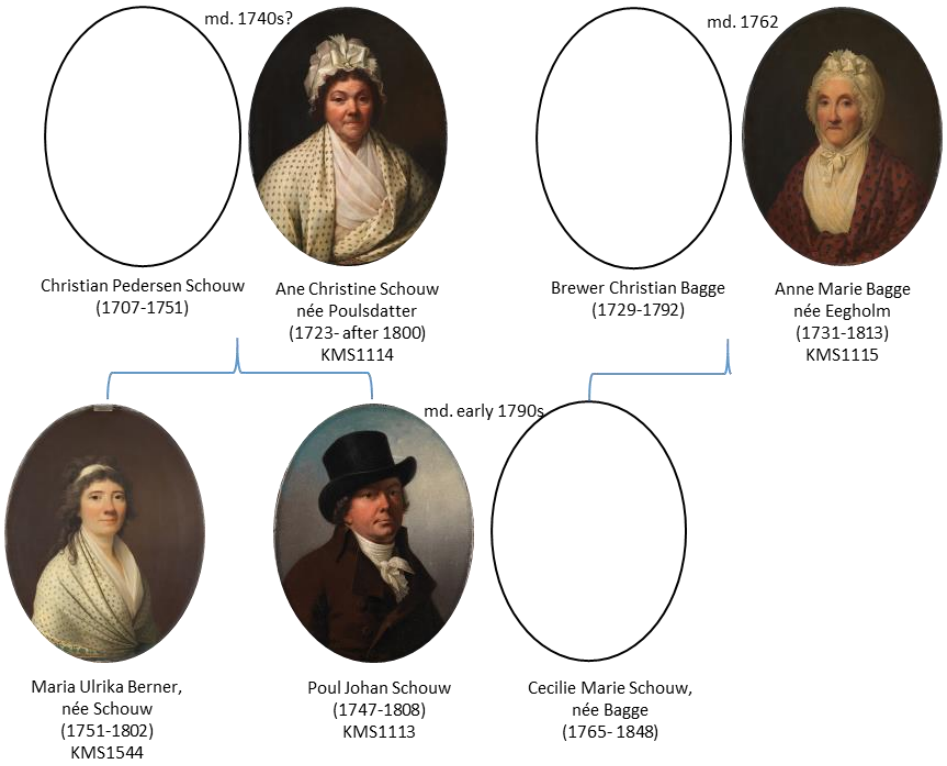

Fig. 7.11 Family relations between Schouw and Bagge.

The case of *J.B.Neergaard SV1* and *A.M.B.Neergaard SV2* raises questions as to whether it was always the case that couples were painted at the same time. In this vein, *H.Gerner KMS1444* is signed and dated 1785; *C.S.Gerner KMS1445* is not signed and dated by Juel, and is art-historically dated in ordinance with the husband, as expected pendants. While differences in ground layers between these two portraits may be strictly practical (Chapter 9), it could also be an indication that they were not painted at the same time.

No adjustment has been made to the dates listed in this thesis for the mentioned portraits on the background of these findings. More elaborate studies of Juel's paintings concerning weave mapping and ground application may reveal more about the work processes of Juel's studio. Ideally, this could aid in the establishment of a new timeline for Juel's production, although this would require examination and X-radiography of a very large number of paintings.

7.6 Chapter Summary and Conclusions

Juel likely acquired his canvasses locally, whether in Denmark or abroad. It is not evident whether the canvasses used in Denmark were all of domestic production. Although this was promoted by the ruling mercantilism, records show that a large variety of foreign linen products was available and that they were often cheaper and better than those manufactured in Denmark.

All the canvasses used in the examined paintings by Juel fit the market conditions and manufacture of canvas in Europe at the time. They are hand-woven plain-weave canvasses, with threads consisting of bast fibres, hand-spun in Z-twist mainly between 10 and 25 degrees, while those produced in Denmark at times display medium-to-tight spinning of 30 and 35 degrees. All canvasses display variations in thread count and thread thickness. The coarsest canvasses are found in the early period, while the finest canvasses are found in the paintings from Switzerland, but also in a few produced in Denmark in the later years. Most canvasses of paintings produced in Denmark and abroad have thread counts within a medium range of 9 to 15 threads per centimetre, making the establishment of a relationship between geographical location and quality of the canvas troublesome, and it could appear this type of canvas was a common choice for artists in this era, no matter the geographical place of production. No pattern is found as to which direction consistently had the most crimp. Those paintings which display contraction and dominant cracks in one direction were usually found to have a higher cover factor in the opposite direction, which could be one of the parameters for contraction occurring.

The paintings produced in Denmark have more dense canvasses as well as thicker and more tightly spun threads compared to those produced in France and Switzerland. Such canvasses are more prone to swelling and contraction. However, these variations alone are not responsible for the different formation and appearance of the global crack patterns between the two groups of paintings. The initiation and formation of cracks introduced by reactions in the canvas rely on the structure and strength of other layers, especially the ground layers. These effects are discussed in the following chapters.

The presence of selvedge, along with some additional characteristics, shows that the weft direction is most commonly vertically orientated and that Juel made use of the full width of the size of the available canvas roll for standard portraits. Only in a couple of paintings produced abroad, and in paintings beyond standard format, is the weft found to be horizontally orientated. In the paintings produced in Denmark, the canvasses are usually cut from larger pre-primed canvasses, while those produced abroad display signs of individual preparation in a few instances. Two sets of paintings are found to most likely originate from the same rolls of pre-primed canvas. This may affect the art-historical dating of the portraits and the timeline of Juel's production.

8 Sizing

This chapter investigates the use of sizing in Juel's paintings. Juel's era of practice took place in a time of transition; earlier, a more traditional approach was common and size layers appear to have been used more generally, whereas later on there was a seemingly common tendency to omit the layer. The presence or absence of the sizing layer in paintings throughout Juel's career, and in those with different locations of origin, may indicate differences in his practice in various countries or time periods (his early versus later career). Furthermore, consideration is given to whether the presence or absence of a sizing layer may relate to differences in craquelure patterns.

In historical recipes, the size layers are frequently mentioned as an integral part of the preparation for painting (Stols-Witlox 2017). The general idea was that sizing would protect the canvas from the degrading effect of the oil and prevent the ground from sinking and seeping through to the reverse of the canvas (Watin 1776:116-117; Merrifield 1849:728; Massing 1998:349-350; Witlox & Carlyle 2005:520-522; Carlyle et al 2008:113; Stols-Witlox 2017:73). Giovanni Battista Volpato (1633-1706) describes the technical problems pertaining to the absence of a sizing layer in his manuscript from about 1670: "When the canvas has no glue to defend it from the oil, it loses its strength, for the oil dries, so that it becomes like the bark of a tree, and when the canvas is taken off the stretching frame it cracks and splits" (Volpato in Merrifield 1849: 728).

Several authors describe that the sizing will lay down the small fibres of the canvas threads and prevent the ground from passing through the holes and creating protrusions on the reverse of the canvas (Félibien 1676:407; De Mayerne 1620-44:98v; Watin 1776:116-117; John Barrow 1754, cited in Carlyle et al 2008). Not only is extrusion to the reverse a loss of valuable material, when a primed canvas is rolled, an imprint of any protruding material on either side, may be formed in the otherwise smooth surface. To avoid this, the back of the canvas should be scraped (Carlyle et al 2008:112). This implies both that despite sizing, protrusions on the reverse of the canvas were a common issue, and that in a practical aspect, that primed canvases were frequently rolled or the paintings removed from the auxiliary support for transport and subsequently re-mounted.

The most common sizing material used in traditional painting is animal glue, followed by flour and starch paste. In some recipes for flour-paste size layers, additions of oil, glue and/or honey are mentioned (Stols-Witlox 2017:80-88). If the size was rather liquid it could be applied with a brush, while a more gel-like consistency was usually applied using a knife (De Mayerne 1620:5r). To avoid impurities and knots, the surface was polished with a pumice stone before the application of the ground (Stols-Witlox 2017). In the sixteenth and seventeenth centuries size layers were nearly always mentioned in recipes for painting preparation on canvas, but by the middle of the eighteenth century concerns regarding its use arose (Stols-Witlox 2017:80). Pernety explains that some artists omit the sizing layer because humidity will swell the animal glue making the painting prone to flaking, and that in these cases the ground should be applied directly to the bare canvas

(Pernety 1757:xci).[31] In his lecture from 1752, the French academy director Jean Baptiste Oudry (1689-1755), referred to the Flemish approach as being to use canvasses without glue, which results in the canvasses being more flexible "than ours" [French paintings] and the paintings less prone to flaking (1752/2008:7).

The majority of recipes from the nineteenth century do not mention a size layer, however sizing remained in use to some extent as it appears in recipes for commercial canvas preparation during the nineteenth century (Stols-Witlox 2017:56,71).

In Danish sources, size is mentioned in *Nye og fuldstændig Maler og Forgylderbog …* with a description and reasoning identical to the sources above (Anonymous 1794:115). As the book is largely a compilation of other European treatises (see Chapter 2), it reflects previous practice, and may not be completely up to date on the then-contemporary local changes in practice. A Danish description of how to prepare a canvas for oil painting given in a contemporary magazine for artists and craftsmen from 1838, does not mention sizing (Ursin and Hummel 1838:261). Research on paintings by Danish Golden Age painters shows no indications of sizing having been applied, nor has any mentioning of sizing by the Danish Golden Age painters or the local colourmen, which had emerged by then, been found in diaries or recipes (Andersen 2013:26-28; Filtenborg & Andersen 2017). This indicates that the practice of sizing the canvas in Denmark had reduced at least by the early nineteenth century. The question is whether this practice was omitted already at Juel's time of production.

From the sources, it appears that the change in the practice of applying glue sizing was to a large extent due to an increasing awareness of moisture sensitivity resulting in flaking and paint loss. This is consistent with present-day knowledge. Animal-skin glue is a very hygroscopic material that reacts to fluctuations in humidity by swelling and contracting and is recognised as being responsible for inducing stress in the painting structure due to its high response to changes in relative humidity, possibly leading to cracking and fracture (Mecklenburg 1982; Hedley 1988; Karpowich 1989; 1990; Mecklenburg & Fuster-López 2006). In low relative humidity, glue sizing can induce high forces in the structure while excessive moisture can result in loss of adhesive strength (Ackroyd & Young 1999; Mecklenburg & Fuster-López 2006). It has been concluded that the absence of a glue layer results in a lower response to relative-humidity fluctuation in paintings (Mecklenburg1982; Mecklenburg 2005; Andersen 2013; Andersen et al 2017:10). The presence or absence of a sizing layer in Juel's paintings may therefore affect both the current state of degradation and the long-term stability of the paintings. Investigations into the use of sizing in Juel's paintings are described and discussed in the following section.

[31] "Plusieurs Peintres ne veulent pas qu'on encolle leurs toiles, parce que l'humidité détrempe la colle, & rend la Peinture sujette à s'écailler."

8.1 Sizing in Juel's Paintings

Sizing layers can be troublesome to detect, as they are often thin layers, hard to sample and analyse (Billinge et al 1997:23; Stols-Witlox 2017:173). In paintings that are lined, or have undergone other conservation treatments, reliable identification and differentiation between an original sizing layer and the lining adhesive can be difficult, if not impossible. Conservation treatments such as consolidation or lining use similar materials as may have been used as sizing, such as glue or starch.

Several methods of analysis are applied to investigate the use of a sizing layer in Juel's paintings such as visual analyses of the reverse of the canvas, microscopy, cross-sections, UV fluorescence, X-radiographs and ATR-FTIR. None of these methods provide enough evidence to give an assertive conclusion as to whether a sizing layer was applied or not. However, some paintings display a strong indication that they have no sizing, while others remain uncertain or inconclusive. The results and observations are described below and summarised in Table 8.1.

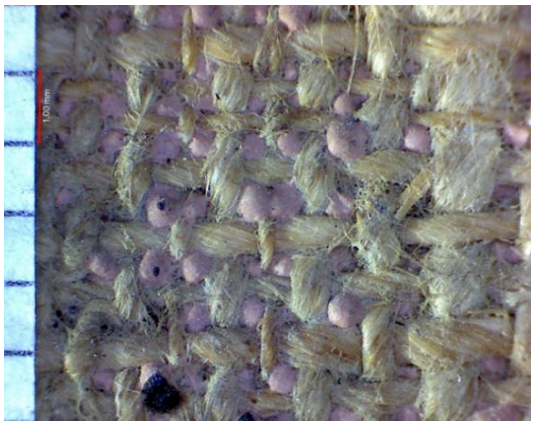

Fig. 8.1 Detail image of the reverse of the canvas of *A.M.B.Neergaard SV2* displaying extensive presence of protruding pink ground material.

Fig. 8.2 Detail image of the reverse of the tacking margin of the canvas of *Self-portrait KMS3990* displaying protruding ground material consisting of the lower grey layer of the double ground.

Protrusions on the reverse

Protrusions on the reverse of the canvas are visible in the majority of the paintings studied, whether lined or not lined. The majority of the paintings display a general presence of protrusions (Fig 8.1 and Fig 8.2), while other paintings display occasional presence or simply a rare sporadic presence (Table 8.1). The extent of protrusions is further investigated in the X-radiographs. In the lined paintings with little or no visible access to the reverse of the canvas, this method allows for identification of protrusions or thickened points of ground material. As the ground is thicker in the points protruding to the reverse these appear in the X-radiographs as small circular shapes between the canvas threads. This provides an indication of the extent of protrusions throughout the painting (Table 8.1). Appendix 27 presents detailed images of the canvasses with the presence of protrusions on the reverse and the representative perception in details of the X-radiographs.

Table 8.1 Summary of results and observations regarding sizing layers the examined paintings by Juel. Where marked in blue, paintings were produced while abroad. For canvas and X-radiography detail images see Appendix 27.

Painting id.	Year	Protrusions visible on the reverse	Protrusions or thickenings perceptible in X-radiograph	Organic or fluorescent layer in cross-section	Evaluation of sizing	Lining
KMS3990	c. 1764	Yes	Yes	No	None evident	G-P
KMS3499	1770	Yes	Yes	Slight indication of organic layer, sectional fluorescence	Perhaps *or lining adhesive	G-P W-R
KMS3634	1771	n/a	Yes	Slight indication of organic layer, no particular fluorescence	?*	G-P W-R
KMS4801	1772	n/a	Yes	Fluorescent layer below ground and in cleavage	?*	G-P W-R
KMS3275	1773-74	Occasional	Occasional	Yes, fluorescent layer	Perhaps*	G-P
KMS349	1776	n/a	Rarely	No	Perhaps*	G-P
KMS396	1776	Yes	Yes	Yes, fluorescent layer	Perhaps*	G-P
KMS1766	1778-79	None visible	Occasional?	No	?	G-P W-R
KMS4810	1778-79	n/a	Occasional	Yes, no particular fluorescence	?	G-P
KMS6151	1779	n/a	Yes	No	?	G-P
KMS349a	1780	No	Occasional to rarely	Yes	Perhaps*	G-P
KMS1444	1785	No	Seemingly, yes	Yes, slight fluorescence	?*	G-P W-R
KMS1445	1785	Yes	Yes	Yes, slight fluorescence	?*	G-P
KMS1113	1799-1800	?	Occasional	Yes, slight fluorescence	?*	G-P W-R
KMS1114	1799-1800	n/a	Yes, occasional	Yes, no particular fluorescence	?*	G-P W-R
KMS1115	1799-1800	Yes	Yes	No	None evident	G-P
SV1	1788	No	Occasional	Single point fluorescence	Perhaps	No
SV2	1788	Yes	Yes	No	Likely none	No
SV3	1780s	Rarely	Occasional?	Yes, organic layer present	Perhaps*	G-P
SV4	1790	Yes	Yes	Possibly	Likely none	No
SV5	1797	Yes	Yes	Yes, but due to fibres	Likely none	No
SV6	1797	Yes	Yes	Yes, but due to fibres	Likely none	No

A traditional indicator, as expressed in the recipes, is that if ground material that has protruded through to the back of the canvas is evident, little or no sizing was applied (Villers 1981:6; Carlyle et al 2008). The presence or absence of protrusions alone, however, is not substantial evidence of a size layer having been applied or not. The extent of protrusion of ground material on the reverse, whether a canvas has been sized or not, certainly depends on the viscosity of the ground layers

themselves and how closed or open the weave of the canvas is. The way the ground sits on the surface of the canvas may, in addition to absent protrusions, indicate the use of a sizing layer. Although occasional protrusions are visible on the reverse, in at least three instances *Self-Portrait KMS3275*, *Hauch KMS349* and *Clemens KMS396* the ground is also observed to sit flat over the open interstices of the canvas (Fig. 8.3). This indicates that either a film-like sizing layer prohibited the extrusion into the interstices, or that the ground material was so viscous that it did not extrude into the interstices during application. This is also observed in a fragment of ground and paint layer, which came off the tacking margin of *Hauch KMS349* during handling (Fig. 8.4). The white ground layer sits very plane on the canvas, as the areas covering the interstices are rather level and flat. In the image, yellowed glue from consolidation or lining can be observed on the top right and in some of the indentations from the canvas threads. This signifies how the lining adhesive can penetrate the structure and give a false-positive indication of an original sizing layer.

Fig. 8.3 Detail image of the reverse of the canvas of *Clemens KMS396*. The red ground layer sits flat over the interstices in the canvas, suggesting either a film-like sizing layer prohibited extrusion or that the ground material was very viscous when applied.

Fig. 8.4 A fragment of paint and ground layer from *Hauch KMS349*. The white ground is rather level and sits flat over the interstices of the canvas suggesting either a film like sizing layer prohibited extrusion or that the ground material was very viscous when applied.

Furthermore, reconstructions of the application of glue-size found that the visibility and coverage of the size layer depends on the method of application as well as the type and the viscosity of the sizing material (Stols-Witlox 2017:173-186; Carlyle 2012:34; Hendrickx et al 2016). A hot animal-glue size, being rather liquid, will be absorbed into the canvas and may not provide a film covering the interstices of the canvas, but rather give an even distribution in relation to the canvas fibres and thus not be visible as a separate layer. If the size is applied cold, as a gel, it is not absorbed as strongly into the canvas and it is more likely to appear as a distinct fluorescent or organic layer between canvas and ground layers in the cross-section (Carlyle 2012:34; Hendrickx et al 2016). Besides, gel consistency of a glue size differs depending on the glue origin and temperature. Hendrickx et al (2016) found that a difference in the temperature of a glue size layer of only five degrees, from 20°C to 15°C, increased the level of absorption into the canvas threads. In *Nye og fuldstændig Maler og Forgylderbog …* (Anonymous 1794:115), the author explains that the consistency should be that of *vælling* (gruel), referring to a thinner version of porridge, and it should be applied evenly until the reverse shows visible saturation (“har trukket sig ind”).

The author explains that it should be so thick that it fills the interstices, but does not protrude to the reverse. Residual glue not absorbed in the canvas should subsequently be removed. Thus, consistency may have varied in the practical application, as do descriptions of consistency in the recipes (Stols-Witlox 2017:181-182). At times pinholes are formed in the film over the gaps in the canvas, through which the ground layer will protrude after all (Carlyle et al 2008:113; Stols-Witlox 2017:184). Other times, if the knife extruded the gel-like material through the canvas, the glue can be detected in the interstices when examined from the reverse. This variety makes it troublesome to conclude on the presence of a sizing layer, based on the visual appearance and protrusions.

Fluorescent layer in cross-sections

The visual detection of an organic or fluorescent layer in the cross-section can provide evidence that a sizing layer was applied. However, in paintings that have been impregnated with adhesive or lined, the cross-section may display such a layer as well. The non-original adhesives could have seeped into the gaps between the canvas and ground layer making it problematic to distinguish between an original sizing layer and a lining or consolidation adhesive. An organic or fluorescent layer below the ground layer is observed in several instances in the cross-sections from Juel's paintings. Some show an evenly distributed layer all through the cross-section while others display a stippled or sectional appearance (Table 8.1 and Appendix 29). All the paintings from SMK included in this study have been lined with glue-paste, and a number of these subsequently lined with wax-resin (see Chapter 5). Figure 8.5 shows an ultraviolet fluorescence image of a cross-section of *Hielmstierne KMS349a*, displaying a distinct fluorescent layer between the canvas and ground layer. This could indicate the use of a sizing layer, but as the painting has been glue-paste lined, the presence of the fluorescent layer cannot be identified as an original sizing layer for sure.

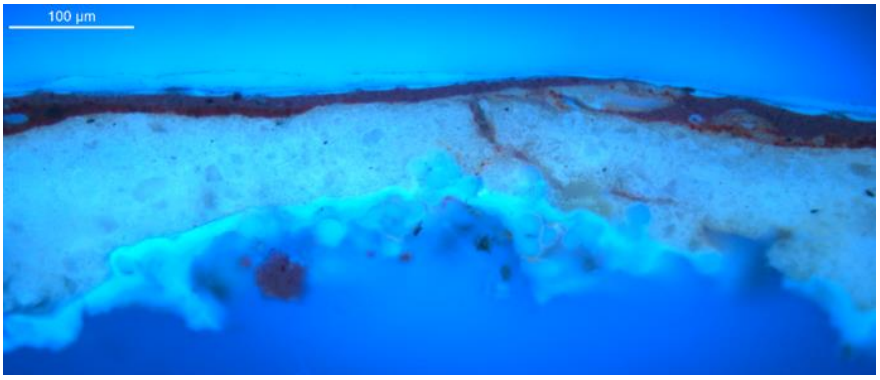

Fig. 8.5 UVa image presenting a fluorescent layer between canvas and ground layer in the cross-section of *Hielmstierne KMS349a* indicating the use of a sizing layer. However, as the painting is glue-paste lined, it cannot be distinguished between an original sizing and the glue-paste adhesive for sure.

Another risk of a false-positive identification of a sizing layer in cross-sections is found in the fibres of the canvas. In all the examined paintings, the canvas fibres display fluorescence under

ultraviolet radiation. The fluorescence present below the ground layer in cross-section of *J.Moltke SV5* and *E.Moltke SV6* for instance, are due to fibres (Fig. 8.6). For this reason it can be difficult to differentiate between the sectional presence of fibres adhered to the ground layer and a possible size layer in the cross-section. The reason for fluorescence is unclear, but could be due to either the treatment process the canvas went through during manufacture or binding-media saturation (Bruun Juul 1807:v2,176; Ursin & Hummel 1838:16; Lyle 1982:342). In comparison, a contemporary pure linen sample, also displays ultraviolet fluorescence (Fig. 8.7).

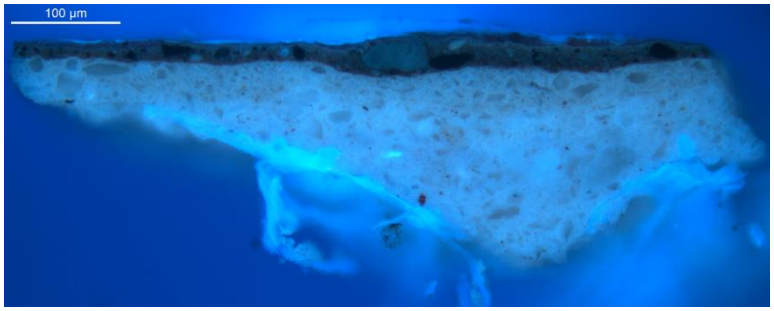

Fig. 8.6 UVa image presenting fluorescence beneath the ground layer in the cross-section of *J.Moltke SV5* seeming, on first look, to indicate the use of a sizing layer. However, the fluorescence is due to the canvas fibres.

Fig. 8.7 UV image of modern 100% pure linen fibres displaying fluorescence.

Further investigations included examination of the canvas threads under microscope. For the lined paintings, it was evident that adhesive compounds were present. However, as in the cross-sections, it was not possible to differentiate between lining adhesive and a possible size layer. No distinguishable layer that could apply to sizing was detected in the unlined paintings under microscope either. However, the presence of a crystalline grainy substance and small black particles could be observed on and around the fibres; this could be due to degraded varnish, dirt and grime or starch from the manufacture process of the canvas, or may relate to possible sizing material. When observing the reverse of the canvas macroscopically, extensive amounts of insect droppings were present as well.

Material analysis

Material analysis directly on the canvas was carried out on threads sampled from three paintings, *Holm KMS1766*, *J.B.Neergard SV1* and *A.M.B.Neergaard SV2* using ATR-FTIR to test if the method could be applied to detect the presence of a sizing layer (Appendix 33). Besides a strong presence of cellulose related to the canvas, the method generally provided rather noisy and weak or inconsistent spectra. This could likely be due to the various contaminating compounds observed under microscope. It was concluded that this method for detection of sizing was not reliable and that there was too much uncertainty around whether the compounds detected could relate to a sizing layer or not.

As discussed in Section 9.3, the GC/MS analyses provide no further evidence of a sizing layer having been applied. Only in samples from *Saly KMS4801* and *P.J.Schouw KMS1113* was

protein detected; however, as the paintings are both glue-paste lined, the protein likely derives from the lining adhesive.

Further investigation

Further steps in the detection of a sizing layer could be to perform fluorescent comparison between known glue-paste lining material and the possible size layers as they may display different fluorescence (De la Rie 1986; Rozlucka & Arszynska 2000). Furthermore, it may be useful to prepare small samples that include canvas as cross-sections and use a fluorescent staining method (Johnson & Packard 1971; Martin 1977; Wolbers & Landrey 1987; Berrie 1994). This might reveal whether a sizing layer was used and, if so, the distribution of the material, whether as a distinct layer or absorbed into the canvas threads. In recent years, a new ruthenium-complex-based stain available under the commercial name of SYPRO® Ruby is proposed (Sandu et al 2011; Dallongeville et al 2016:4). This is also the fluorescent stain used for detection in the reconstructions of sizing layers mentioned above (Carlyle 2012; Hendrickx et al 2016). Material evidence of a sizing layer, by appropriate method, ought to be more identifiable in un-lined paintings. However, it was decided not to proceed with further analyses of the sizing layer within the time frame of this study.

Results of assessment

As is described and discussed in this chapter, results of this assessment of whether sizing layers were used in Juel's paintings are largely inconclusive, but there are some interesting points to note (Table 8.1). The lack of protrusions in some instances, in combination with the flat appearance of the ground layers, suggests the possible use of a sizing layer. These instances are primarily the paintings produced while abroad. It is possible that the practice of sizing was still maintained, for instance, in France, as expressed by Oudry. In other paintings, it is not possible to securely differentiate between a possible sizing layer and the lining adhesive. In several of the paintings produced in Denmark from the later period of Juel's career, the general appearance, including protrusions and no visible indication of a sizing layer, suggests that either no sizing was applied, or it was applied rather liquid and absorbed evenly into the threads.

Differences in the use of sizing may have been based on location and could have depended on whether the canvasses were prepared in the studio or purchased pre-primed. The strong indication of lack of sizing in paintings from the later period of Juel's career suggests that the practice of omitting the sizing layer was not uncommon in Denmark by the last quarter of the eighteenth century.

The limited losses of ground and paint layers in Juel's paintings suggest either that no sizing layer is present or that it has not actively influenced the painting structure in a degrading manner. Karpowich (1989; 1990) suggest that sizing contributes to a common pattern of craquelure. This type of craquelure is only seen in a few local instances and most extensively in *Self-Portrait KMS3275*, but this may as well be a result of reactions caused by the glue-paste lining. These cracks are mainly perpendicular to the edges and visible in the corners and over the stretcher bars,

and correspond to cracks that result from restrained shrinkage of the painting structure (Mecklenburg 1982; Karpowich 1989; 1990). These often occur related to the presence of glue size, but can also occur due to shrinkage from climate fluctuations (Mecklenburg 1982; Karpowich 1989; 1990). It is unclear how and if the presence of a glue-sizing layer would otherwise have visually influenced the morphology of the overall crack patterns between the two groups of paintings.

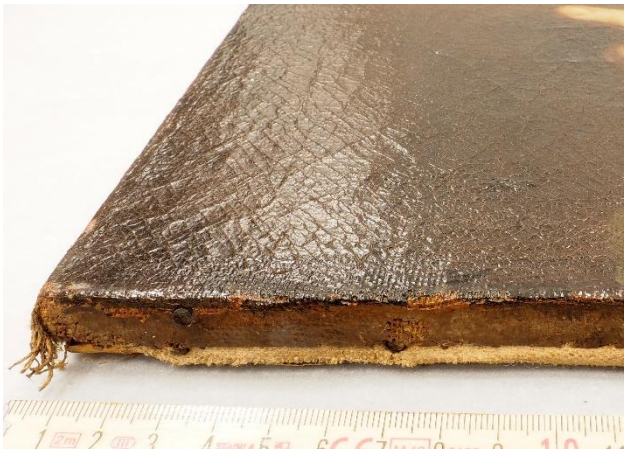

Fig. 8.8 Detail image of the lower proper-right corner of *Self-Portrait KMS3275* displaying cracks perpendicular to the corner and stretcher bars, commonly associated with restrained shrinkage related to the presence of glue, high RH or low temperatures.

8.2 Chapter Summary and Conclusions

Juel's career took place at a time when artistic practices were changing, particularly with regard to sizing layers. In the years before Juel was working, a traditional approach that made use of sizing as an important part of the preparatory process was common; in the years after Juel's death there was an increasing tendency to omit the sizing layer altogether. Several methods of analysis were applied to investigate the use of sizing layers in Juel's paintings. The issue of whether any sizing layer was used in Juel's paintings remains largely inconclusive. This is especially the case in the paintings that are lined, or have undergone other conservation treatments, because the secure identification and differentiation between original sizing and the lining or consolidation adhesive can be difficult. These conservation treatments use similar materials to a sizing, such as glue or starch.

The lack of protrusions on the verso of some paintings, in combination with the flat appearance of the ground layers, seems to suggest the possible use of a sizing layer. Interestingly, these instances occur primarily in the paintings produced while abroad. However, as mentioned before, in these and other paintings it is not possible to make a confident differentiation between a possible sizing layer and the non-original adhesive from lining or consolidation, so these observations must be treated with caution. In several of the paintings produced in Denmark from the later period, the general appearance – ground protrusions on the verso of the canvas and the absence of a visible sizing layer – suggests that either no sizing is applied or that it was applied rather liquid and absorbed evenly into the threads.

Differences in the use of sizing may have occurred depending on where paintings were made and whether the canvases were prepared in the studio or purchased pre-primed. Nonetheless, the strong indication of the absence of sizing in paintings from the later period of Juel's career suggests that the practice of omitting the sizing layer was not uncommon in Denmark by the last quarter of the eighteenth century. The state of degradation of the majority of Juel's paintings suggest either that no sizing layer is present or that it has not actively influenced the painting structure. It is unclear how and if the presence of a glue-sizing layer could visually influenced the morphology of the overall crack patterns between the two groups of paintings.

During the investigation of sizing layers, it was observed that the presence of other materials could be misleading in the identification of an original sizing layer, and that it is necessary to combine analyses to make a conclusion. Material evidence of a sizing layer, by appropriate method, ought to be more identifiable in un-lined paintings.

9 Ground Layers

Although mostly an unseen layer, the ground can have a great influence on the visual expression of a painting. The colour, texture, thickness and degree of absorption relate to painting technique, and the properties of the ground layer, as well as the paint layers, depend on the type of pigments, fillers and binders it contains (Stols-Witlox 2012:162; Mecklenburg et al 2005; Mecklenburg et al 2013). The ground layers, in their position between the support and paint layers, play an important role in the structural stability and long-term preservation of a painting. If the ground fails to adhere to the canvas, losses of both ground and paint layer will occur, while a ground that does not adhere well with the overlying paint layers may cause cleaving or flaking paint.

Historical sources and technical examinations show that a great number of recipes and compositions are found for ground layers on canvas dating from the seventeenth to the nineteenth centuries. Although some general trends exist in materials used in Europe in this era, recipes and research into ground layers show that no uniform way of making grounds existed (O'Donoghue et al 1998; Witlox & Carlyle 2005; Groen 2005; Stols-Witlox 2017). The colour, structure and use of pigments and fillers often depended on local practices and the materials available. The binding medium was in most cases drying oil, although occasionally emulsion grounds were used (Merrifield 1849:820; Baier et al 1992; Van Mander & Miedema 1994:257v; Van de Wetering 1997; Massing 1998; Van Hout 1998; Stols-Witlox 2017). Even artworks by the same artist often display variations in grounds (Kirby 1999; Groen 2005; Filtenborg 2014; Filtenborg & Andersen 2017; Stols-Witlox 2017; Haack Christensen et al (eds.) 2020).

During the seventeenth and eighteenth centuries, the use of coloured grounds on canvas was common in European painting tradition (De Mayerne 1620-44; Félibien 1676:407-8; Duval 1992; Stols-Witlox 2017). The ground could, depending on tone, be included in the composition of the painting as shadow areas or mid-tones. Double grounds consisting of a reddish underlayer followed by a thin grey top layer were widely used (De Mayerne 1620-44; Félibien 1676; Watin 1776:117; Groen 2005; Massing 1998; Phenix et al 2009; O'Donogue et al 1998; Van Hout 1998; Stols-Witlox 2017). The mid-eighteenth century onwards sees a tendency to transition towards a more elaborate use of lighter grounds, and by the mid-nineteenth century, light or white grounds were preferred (Witlox & Carlyle 2005; Stols-Witlox 2017:123).

Reasons for variations in employment of different ground layers may be due to artists purchasing pre-primed canvasses. Commercial priming of canvasses emerged in Europe in the seventeenth century and by the early nineteenth century this practice was a firmly established line of business in most countries (De Mayerne 1620:5r; Haaf 1987; Van de Wetering 1997:22; Van Hout 1998; Witlox & Carlyle 2005, Villadsen 2009; Stols-Witlox 2017:141). The earliest sources originate from the Netherlands, Italy, France and England, with one anonymous British source from 1668 (92) claiming: "I could teach you how to prime it [the canvas], but it is a moiling work, and

besides, it may be bought ready primed cheaper and better than you can do it your self. Few painters (though all can do it) prime it themselves, but buy it ready done." Despite this, some painters continued to prepare their own grounds and it is unclear to what extent this practice of purchasing ready-made, pre-primed canvasses was used and available to painters of different countries, regions and cities throughout the period (Kirby 1999; Witlox & Carlyle 2005; Stols-Witlox 2017). In Denmark, no documentary evidence has been found supporting that Danish painters had access to commercially primed canvasses before the early nineteenth century (Andersen et al 2009; Villadsen 2009; Filtenborg 2014:6).

This chapter investigates Juel's use of ground layers throughout his career. Firstly, this is considered with regard to the colour and number of layers in different paintings; as variations are found to occur, it is considered how these reflect a certain time, practical influence or pattern in practice. Secondly, the results of analyses of the composition of pigments and fillers as well as the binding media, are presented and discussed. Additionally, consideration is given to how the materials correlate to the state of preservation, especially differing crack patterns between locations, which may explain expected differences between ground layers in paintings produced in or outside of Denmark. Finally, based on the observations and results of analyses of the ground layer composition, it is assessed whether the canvasses may have been prepared in Juel's studio or purchased pre-primed from a supplier.

9.1 Colour and Structure of Juel's Ground Layers

The colour and structure of Juel's ground layers were examined using visual analyses and cross-sections. The preliminary examination of eight paintings by Juel suggested a consistent use of reddish-brown (orange) ground layers during his early career in Copenhagen (Appendix 26) (Slotsgaard 2013; 2015). Following his return to Copenhagen after years abroad, four paintings of the period displayed a more varied use of grounds, both with regard to colours and number of layers; a transition to the use of lighter grounds is evident towards the later part of his career (Slotsgaard 2013; 2015). The preliminary examination generated at least three questions concerning colour: Were the similar grounds in the early career influenced by Juel's education during his apprenticeship with the painter Michael Gehrmann in Hamburg? Did he become influenced to use white or lighter grounds during his years abroad? Are there any patterns in the variance of colour use and layer structure of different portraits? Consideration of these questions is included in this chapter section.

Juel's use of ground colour overall reflects the general tradition of coloured ground layers as well as a transition from coloured to lighter or white grounds towards the nineteenth century. This current investigation supports the use of similar ground layers in paintings produced during Juel's early career in Copenhagen from 1765 to 1772, while he was attending the art academy, as found in the preliminary study. The eight years Juel was travelling abroad mark a shift in his use of colour for the ground layers. This, in combination with the results of material analyses presented

in the following, confirms the hypothesis that Juel used different materials during these years, suggesting differences in either technical approach or in the availability of materials. Both the use of a traditional double ground consisting of a white or grey layer over a red ground layer, and the emergence of white and light grounds in his practice are evident in paintings from the travelling years. The preliminary study suggested some consistency in the transition from coloured grounds towards the use of lighter and white grounds in the later part of Juel's career (Slotsgaard 2013; 2015). However, the current study shows the employment of both white and coloured grounds throughout the entire period after his return to Denmark, in a manner that at times appears very inconsistent and with a larger variation in both colour and number of layers than first anticipated. Ground layers that are similar to those used in the early years reappear, along with occasional white ground layers, and pink, red and brown layers. Figure 9.1 displays all known cross-sections to-date from paintings by Juel in chronological order and exhibits the transition and diversity of ground layers throughout his career. The variation is further described later in this section, with attention to possible sources of influence. Examination of the grounds of Juel's contemporary colleague, Abildgaard, similarly reveal a large diversity and no apparent systematic use of ground layers (Filtenborg 2014:17).

Based on the previous study, it was proposed that the application of underpainting seen in two of the portraits, *M.Moltke KMS2084(5) and Hennings 290/60(7)* (Fig. 9.1 and Appendix 26), was used to modify the ground colour, respectively dark greyish brown and red, to establish a lighter base colour for the paint layers of the flesh (Slotsgaard 2013:87; 2015). However, no such underpainting was identified in the examination of paintings in the current study, through cross-sections or during microscopic examination of the cracked paint surface (only *P.J.Schouw KMS1113* and *Bagge KMS1115* had samples for cross-sections removed from the flesh tones).

Ground colour in the early years

All the examined paintings from Juel's early period in Copenhagen exhibit a reddish-brown ground, orange in tone, consisting of one or two applications of matching material. A similar colour is evident in other paintings from this period as well through visual observation and additional cross-sections (Fig. 9.1). A similar ground colour is also depicted in Juel's self-portrait from the studio from 1766 (Fig. 1.1). This suggests that Juel (his studio or a supplier) had a standard approach to the grounds at this time. Similarities could suggest that a larger batch of ground material was made up to prepare large or multiple canvasses. Minor differences in colour and mixtures from these years may be explained by the fact that preparing the same colour ground with different batches of pigments and mixing by volume is challenging (Carlyle & Witlox 2005; 2007). Based on the identification of a similar ground colour in one of Abildgaard's paintings from the same years, *The Israelites Gathering Manna in the Desert*, 1766, Filtenborg considered this type of ground to be a standard ground used at the academy. However, other paintings by Abildgaard, such as *David Anointed by Samuel*, 1767, show a cream-coloured ground, which may suggest otherwise (Filtenborg 2014:20).

Fig. 9.1. Timeline representing the development and variation of ground layers in known cross-sections from portraits by Jens Juel (based on dating in the Catalogue Raisonné (Poulsen 1991)). All cross-sections can be found in the SMK/CATS database or the School of Conservation cross-section archives. Pink and blue line represents paintings produced in or outside of Denmark respectively. Cross-sections are not displayed to the same scale and magnification.

As stated in Section 7.3, all Juel's paintings produced in Denmark appear cut from larger pre-primed canvasses. While matches are determined between paintings originating from the same pre-primed canvas during the latter part of Juel's career, it remains to identify matches between pre-primed canvasses of paintings produced in the earlier period. Matches between various artists attending the academy could even support the notion of a standard ground used there, as suggested by Filtenborg.

Juel's *Self-Portrait KMS3990,* painted in Hamburg in 1764, displays a double ground consisting of a lighter grey layer on top of a darker grey layer. This means that, based on this painting, there is not evidence of a direct influence from the apprentice years to the use of grounds in the early Copenhagen years. Analyses of further paintings from Juel's apprentice years may reveal whether there was any direct influence on the grounds used in the early Copenhagen years from his training in Hamburg, or whether it was rather a matter of local or timely practice.

Emergence of white grounds

In the chronology of the paintings studied, a shift occurred in Juel's production while working and travelling around Europe. For instance, white grounds appear in his practice in the mid 1770s. The earliest examined painting determined to have a white ground was painted in Paris in 1776 (*Hauch KMS349*). The *Self-Portrait KMS3275,* supposedly painted in Dresden in 1773 to 1774, possibly influenced by Graff (see Section 5.4), has the traditional double ground layer consisting of a thicker red layer followed by a very thin light grey layer. Were it not for its presence on the tacking margins, the thin light-grey layer could have been mistaken for a layer of underpaint (Appendix 5.2). Technical examination of Graff's paintings shows that Graff remained in the tradition of coloured grounds until the end of the eighteenth century, after which white grounds started to appear in his paintings (Mösl 2013). This implies that a technical influence on Juel with regard to the use of white grounds does not originate from Graff. Whether Graff's canvasses were primed in the studio or purchased ready-made remains to be investigated (Mösl 2013).

After Juel's stay in Dresden, he likely travelled to Vienna and thence to Italy, where he probably reached Rome in 1774 and stayed for about two years (Poulsen 1991:17-18). Very little is known about Juel's stay in Rome. Most of what is known about his stay in Rome comes from letters and travelogues written by Abildgaard, who was in Rome at the same time. As Juel did not become a member of the Accademia di San Luca, he was not allowed to practise any independent portrait business in the city and only a couple of paintings from this time exist (Poulsen 1991). Artists such as the German painter Anton Raphael Mengs (1728-1779) or Pompeo Batoni (1708-1787) may have influenced Danish painters such as Juel and Abildgaard to start using light or white grounds, or the impetus may have come from other painters with whom they were in contact with during this time. Poulsen suggests that Juel could have studied works by Mengs, who had worked in the city but had moved to Spain by the time Juel arrived in Rome (Poulsen 1991). Perhaps Juel worked in the studio of Batoni, who had an active workshop there (Poulsen 1991:18-19). While

it is reported that Batoni throughout his career frequently employed a smooth pink-red ground consisting of lead white, vermilion, quartz and natural ultramarine mixed in oil, it seems that this observation was based on a rather scarce number of paintings (Clark 1985:40; Bowron & Kerper 2007:168). Thus, further investigations of Batoni's paintings could reveal a more varied use of ground layers. Mengs encouraged the use of light-coloured or white grounds in his treatise *Lezioni pratiche di pittura* from 1780 and some paintings by Mengs show that he used light coloured grounds in his paintings much earlier than this (Mengs 1780:258; Filtenborg & Andersen 2017:49). As expressed in other treatises at the time, the transition from coloured to lighter grounds was based on concerns that the transparency of the paint layers over time may cause the paint layers to "sink into the ground", leading to contrasts, colours and shadow areas diminishing or becoming difficult to make out (Mengs 1780:258; Oudry 1752/2008:6; Carlyle & Witlox 2005:525-257). Abildgaard, whose ground layers, like Juel's, display various colours throughout his career, made use of white and light-coloured grounds during his years in Rome (Filtenborg 2014:17). There appear to be only two known surviving paintings by Juel from his time in Rome. One of these, *The Roman Dwarf Francesco Ravai, called Bajocco* (KMS370), is painted on a medium-toned grey ground layer on a coarse and open-weave canvas. This type of canvas corresponds with the coarse canvasses commonly used by Abildgaard in Rome (Filtenborg 2014:3), however the ground is perhaps darker than would be anticipated in comparison to Abildgaard's light grounds at this time. It has not been confirmed (due to lack of access) whether the other painting by Juel from Rome, *Portrait of Nicolai Dajon* (Museum of National History, A707), has a white or light ground. A third painting, a portrait depicting Abildgaard, was lost in the fire of Christiansborg Castle in 1884 (Poulsen 1991:65).

If the influence towards the use of lighter grounds did not originate in Rome, it may have been in Paris, Juel's next destination, as the portrait of *Hauch KMS349* displays a white ground layer. As in Rome, little is known about Juel's stay in Paris or on possible sources of inspiration (Poulsen 1991; Christensen 1996). The portrait of *Clemens KMS396*, similar to the *Self-Portrait KMS3275* from Dresden, displays the traditional double ground with a red underlayer followed by a white or light grey layer: a type of ground elaborately used by French painters (Duval 1992; O'Donoghue et al 1998). This type of double ground does not re-appear in any of the examined paintings from Denmark, and is not found in any paintings by Abildgaard either (Filtenborg 2014:17).

Colour variation in the latter years

The paintings produced in Switzerland display light-coloured grounds in white or light pink as does *Hielmstierne KMS349a* painted the year Juel returned to Copenhagen. Light and white grounds are seen occasionally throughout the latter part of Juel's career, but he continued to employ different coloured grounds and compositions, even in his very last years (Fig. 9.1). For instance, the portrait *A Running Boy, Marcus Holst von Schmidten* (KMS3635) from 1802, the year of Juel's death, based on visual examination displays a dark reddish-brown ground along the

tacking margin. A similar degree of variation is seen in ground layers in Abildgaard's paintings. Except for the use of light-coloured grounds during the Roman years, Filtenborg states: "one is struck by the diversity of types and colours [of ground layers] that appear throughout his oeuvre" (2014:17). White grounds recur in Abildgaard's paintings occasionally throughout his career, but like Juel in the later years, the ground layers display a large diversity in types and colours, even within the same series of paintings (Filtenborg 2014:17-30). This demonstrates that neither Juel nor Abildgaard were unique in this diverse ground practice.

Number of layers and thickness of grounds

In addition to colour, the number of ground layers – whether one or two is applied, also varies. While some paintings display two distinct ground layers in two different colours, others suggest two applications of the same material. In some instances, it is troublesome to determine from the cross-section whether a ground layer consists of one or two applications.

The thickness of the ground layers depends on the location on the canvas, as they display a thinner layer over the intersection points of the threads and a thicker layer where the ground material has filled the voids of the canvas. Thus, the lower layer usually displays the most variation in thickness. The total thickness range is measured from as low as 20 µm to as high as 200µm, with a couple of instances up to 250 and 300 µm for the earliest paintings examined (*Self-Portrait KMS3990* and *Self-Portrait KS93(1)*: Appendix 26) (Fig. 9.2 and Table 9.1).

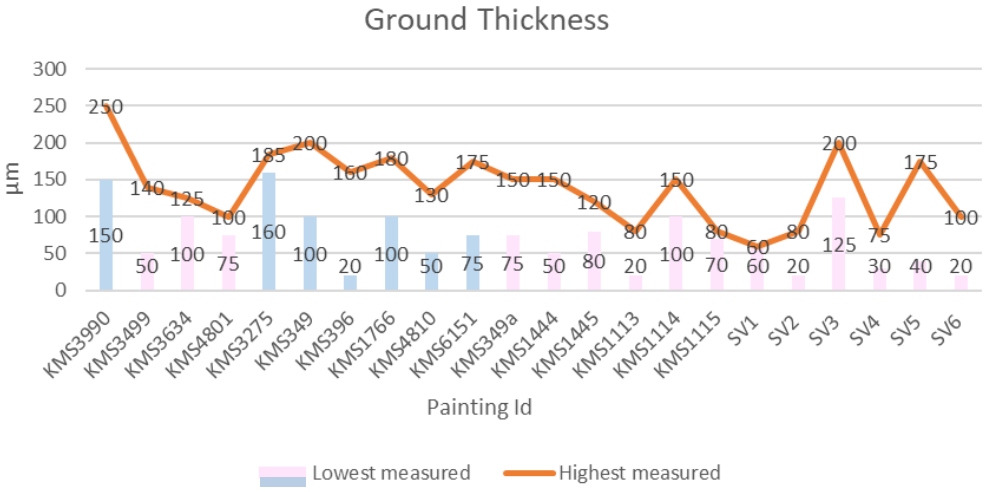

Fig. 9.2 Diagram of the lowest and highest measures of the total ground layer thickness in the cross-sections (see also Table 9.1). Blue = paintings produced abroad, pink = paintings produced in Denmark.

Relation of ground thickness to craquelure

The thickness of the ground layers is suggested as one of the factors determining the influence of the support on the craquelure (Keck 1969:18; Bucklow 1997; Flores 2017). However, in this study, no systematic relationship between the overall thickness of the ground layers and the two different crack patterns identified between the paintings produced in France and Switzerland and

those produced in Denmark could be determined (Fig. 9.2). Although some of the combined ground-layer thicknesses of paintings produced in France and Switzerland are higher than several of those produced in Denmark, measuring up to between 130 and 200 µm, this is not consistent. Some of the paintings produced in Denmark also have a combined ground thickness measuring up to 150 to 200 µm. Thus, thickness is not a consistent factor influencing craquelure morphology. The thicker the paint or ground layer, however, the wider the crack interval, or size of islands in the network is expected to be (Keck 1969:18; Flores 2017). This can be systematically checked in some, but not all, paintings by comparing the numerical representation of island size in Bucklow's categories (viii) from Section 5.3 to the thickness of the ground layers. The comparison between island size and thickness of ground layers in the two groups is presented in Figure 9.3.

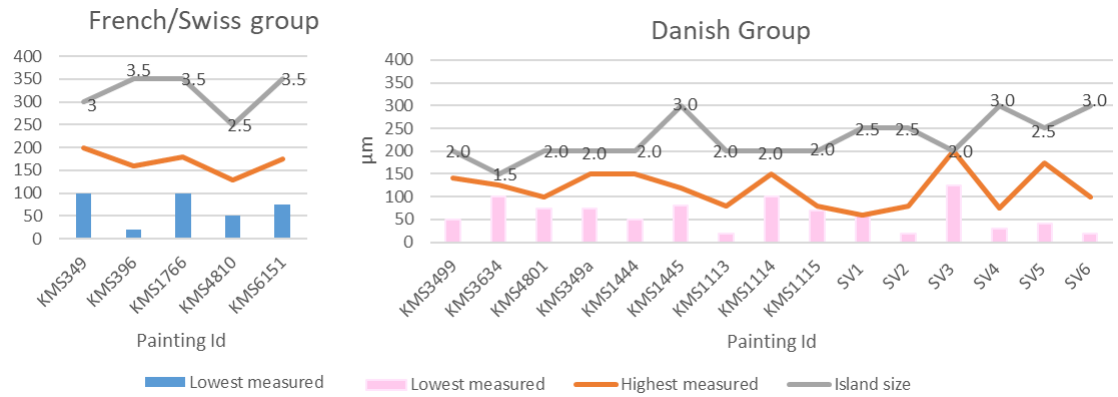

Fig. 9.3 The numerical representation of island size in the overall craquelure network from category viii (Table 5.3) compared to ground thickness in cross-sections (Fig. 9.1). While a correlation can be established in some paintings, no consistent pattern can be established as a factor influencing differences in craquelure morphology between the paintings produced in Denmark and those produced in France and Switzerland.

Reasons for variations in colour and structure

It is still unclear why some painters, and in this case Juel (and Abildgaard), employed such diversity in their ground colour and layers. Certainly, a reason for changes and variations in the use of ground colour by Juel and Abildgaard could suggest that the choice of colour was made for them. As is discussed below (Section 9.3), the reason for the shift in colour and structure of the ground layers may be due to purchasing pre-primed canvasses from local suppliers. In both Juel and Abildgaard's paintings, so far, no apparent systematic reasoning has appeared as to why one colour was chosen over another in different paintings. Groen suggests that the materials of the grounds may not have been of particular importance. It may have varied without much reflection and simply been a means of establishing a suitable surface for the paint layers as cheaply as possible (Groen 2005:322). In contrast, certain contemporary authors expressed that the colour of the ground was in no way irrelevant. Oudry stated in his lecture at the academy in 1752 that: "It is by no means a trivial matter which tone should be given to the ground …" While Oudry's concern related to the tonal degradation of paintings, the colour of the ground can also influence the execution and layering of the paintings, and some sources suggest the colour of the ground could be related to the subject of the painting (Stols-Witlox 2014:210; 2015; 2017:135-37).

Lairesse, in his treaty originally published in 1707, argued that the ground colour should reflect the personality of the sitter and the complexion of the skin to establish most likeness (1817:VII,13). Pendant portraits by some artists have shown that a lighter ground colour was used for the female portrait than for the male portrait, suggesting the artists employed different coloured grounds depending on the complexion of the person to be portrayed, as suggested by Lairesse (Noble 2004:331; Stols-Witlox 2014:210). However, no such systematic approach in ground colour related to the sitter is identified in Juel's portraits during this study. Several of the assumed pendants do display differences in ground colour, such as *H.Gerner KMS1444,* which has a light-brown ground, while the portrait of his wife, *C.S.Gerner KMS1445,* presents a reddish-brown ground colour. Pendants such as *J.Moltke SV5* and *E.Moltke SV6*, however, display the same pink ground colour. Thus, no specific pattern in ground colour related to subject or gender emerges from the examination of these pendants, nor does Juel's execution or paint layering seems particularly influenced by the ground colour (cf. Chapter 10).

9.2 Pigments and Fillers

The pigments and fillers making up the colour and composition of the ground layers in the examined paintings have been analysed using cross-sections (Appendix 29), SEM-EDX (Appendix 31), ATR-FTIR and Raman spectroscopy (Appendix 32), and additionally for the SMK paintings, XRF and FORS were undertaken (Appendix 35). A summary of the analyses of pigments and fillers in the ground layers is listed in Table 9.1.

The range of pigments and fillers used in Juel's ground layers are limited. Lead white, hematite or red earth (iron oxides),[32] carbon-based black and vermilion are identified in different quantities. In singular instances, an occasional presence of synthetic arsenic sulphides, bone black, massicot or goethite are identified (Table 9.1). The fillers identified in the different ground layers are calcium carbonate (likely chalk), kaolin and gypsum, as well as occasional quartz and silicate (Table 9.1). The most abundant pigment and filler are lead white and calcium carbonate respectively, in different distribution. This is exemplified in Figure 9.4, showing the difference in distribution of lead white and calcium carbonate in the cross-sections of *Hauch KMS349* and *Battier KMS3634.* In Figure 9.5 the grounds are divided into four types and sub-categories, primarily relating to the proportional distribution of the two compounds: Type I contains mainly lead white and hardly any calcium; Type II contains close to equal amounts of lead white and calcium; Type III contains mainly calcium and hardly any lead white and Type IV represents mixed compositions. The pattern that emerges in the ground layer composition is that the ground layers of paintings produced in Denmark all contain calcium carbonate, while the paintings produced during the travel years in the 1770s contain no, or very little, calcium carbonate (Table 9.1 and Fig 9.5). In contrast, the Danish paintings contain little or hardly any lead white in the

[32] Hematite likely in the form of red ochre, while the red earth identified seem to derive from a more natural clay source (see for instance Helwig 2007; Eastaugh et al 2008).

grounds, except for *A.M.B.Neergaard SV2*, *J.Moltke SV5* and *E.Moltke SV6* (Type II), which contain about equal amounts of lead white and calcium carbonate. The grounds of *Hauch KMS349, Holm KMS1766, Prangins KMS4810* and *Tronchin KMS6151* (Type 1), consist mainly of lead white, with sporadic presence of other pigment particles and other fillers. The two additional paintings from the travel years, *Self-Portrait KMS3275* and *Clemens KMS396,* have a deep-red ground colour consisting of red earth as the first ground layer. Of the two, only the red ground of *Clemens KMS396* displays random particles of lead and calcium. Both red ground layers are followed by a thin white or light-grey layer, which similarly to the other light grounds from the travel years, appears to contain mainly lead white, with no particular trace of calcium carbonate.

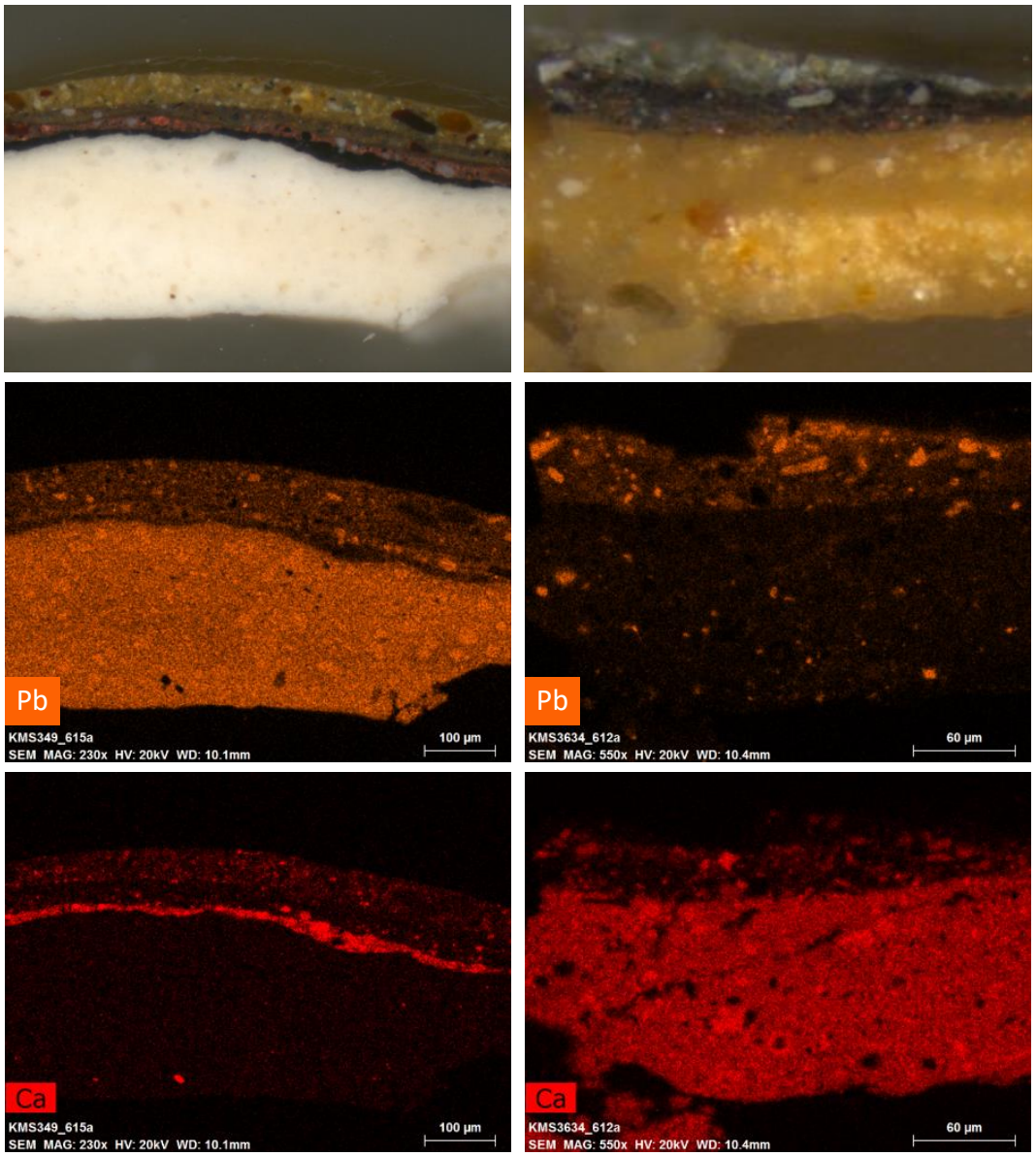

Fig. 9.4 Cross-sections and SEM-EDX images of lead and calcium distribution in the cross-section from *Hauch KMS349* (left), showing a large proportion of lead white and no calcium carbonate in the ground layer, compared to *Battier KMS3634* (right) showing little lead and much calcium carbonate in the ground layer (See also Appendix 31).

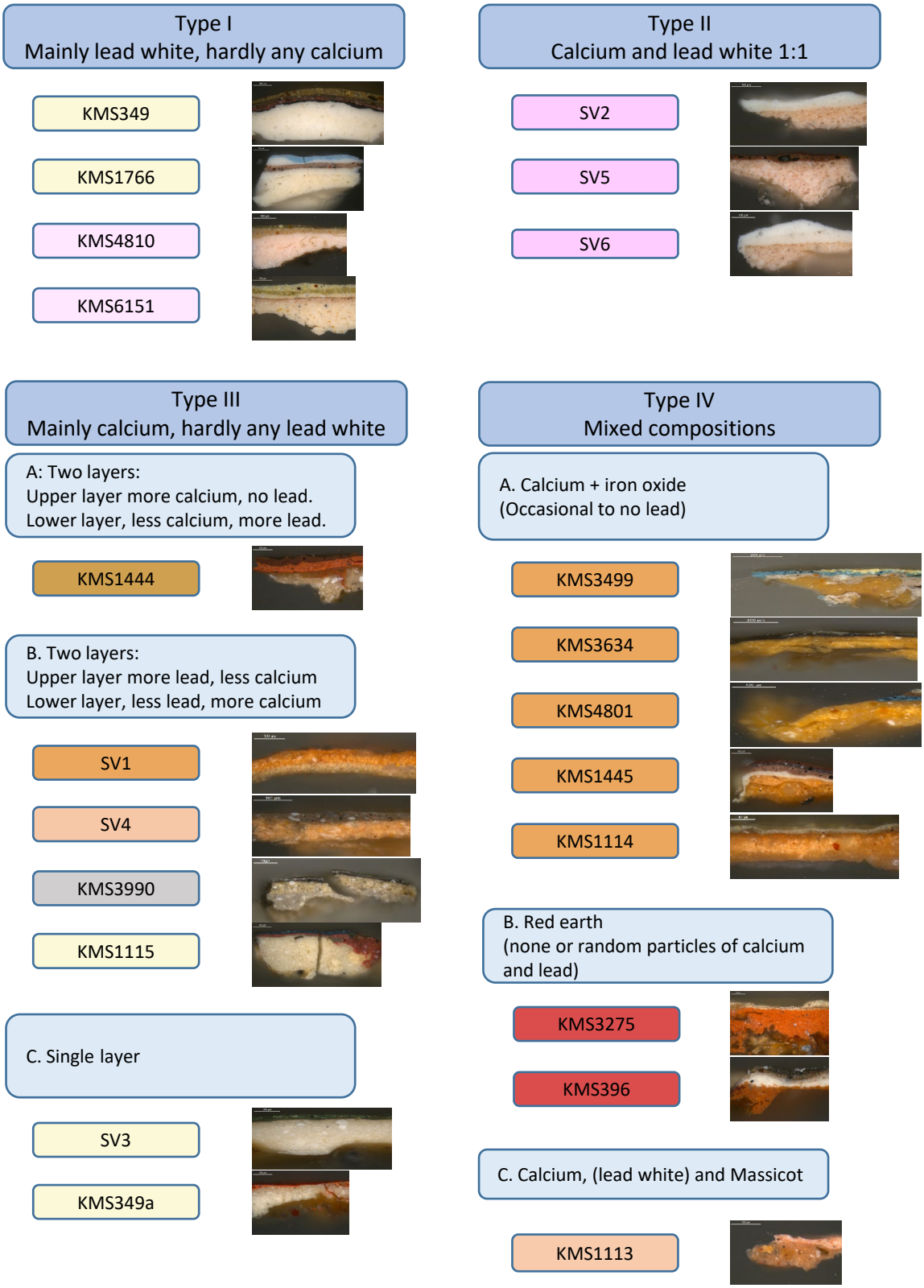

Fig. 9.5 Division of ground layers into four types and sub-categories, mainly regarding the proportional distribution of lead white and calcium carbonate (larger images of cross-sections are displayed in Appendix 29).

Table 9.1 Overview of pigments, fillers and elements identified in ground layers by ATR-FTIR, Raman, SEM-EDX, XRF and FORS. Blue = Paintings produced abroad.

Painting id.	Year	Ground layer	Ground colour	Thickness µm (Total)	ATR-FTIR and Raman Pigments							
					Lead white	Hematite/ red earth	Synthetic arsenic sulphides	Carbon-based black	Bone black	Vermilion	Massicot	Goethite
KMS3990	c. 1764	0	Light grey	100	x							
		00	Grey	50-150 (150-250)	x							
KMS3499	1770	0	Orange	50-140	x	Prob.						
KMS3634	1771	0	Orange	100-125	x	x				Poss.		
		00(?)	Orange		x	x				Poss.		
KMS4801	1772	0	Orange	75-100	x	Prob.						Prob.
		00(?)	Orange		x	Prob.						
KMS3275	1773-74	0	Light grey	10								
			Red	150-175		x						
KMS349	1776	0	White	30-70	x							
		00	White	40-160 (100-200)								
KMS396	1776	0	White	10-45	x			x				
		00	Red	10-120 (20-160)	x	x						
KMS1766	1778-79	0	White	30-40	x							
		00	White	75-150 (100-180)	x							
KMS4810	1778-79	0	Light pink	50-130	x							
KMS6151	1779	0	Light pink	75-175	x			x				
KMS349a	1780	0	White	75-150	x							
KMS1444	1785	0	Brown	25-30								
		00	Light brown	25-125 (50-150)	x							
KMS1445	1785	0	Orange	20-40								
		00	Orange	60-100 (80-120)		x		x				
KMS1113	1799-1800	0	Brown	20-80	x	x		x		x	x	
KMS1114	1799-1800	0	Orange	100-150		x						
KMS1115	1799-1800	0	White	30-40	x							
		00	White	30-40 (70-80)	x							
SV1	1788	0	Dark orange	30	x	Poss.						
		00	Light orange	30 (60)		x	x	x	Occas.	x		
SV2	1788	0	Pink	20-80	x	x		x				
SV3	Mid-1780s	0	White	125-200	x							
SV4	1790	0	Light orange	25-50	x	x		x		Poss.		
		00	Light orange	20-30 (30-75)	x	Poss.		x		x		
SV5	1797	0	Pink	40-175	x	x		Poss.				
SV6	1797	0	Pink	20-100	x	x		Poss.				

Table 9.1 (continued from previous page)
Occas. = Occasional, Prob. = Probably, Poss. = Possibly

Painting id.	Ground layer	Ground colour	ATR-FTIR and Raman					SEM-EDX	XRF	FORS
			Fillers					Elements in order of abundance		
			Calcium carbonate	Gypsum	Kaolin	Quartz	Silicate			
KMS3990	0	Light grey	x		Poss.	x		Pb, Ca (Si, Al, Fe, K, Mg, Na)	Pb, Fe, Ca, Sr, Zn, Zr, Cu, Cd, Mn, Ti, Sn	
	00	Grey	x					Ca, Pb (Al)		
KMS3499	0	Orange	x				Occas.	Ca (Pb, Fe, Si, Al, P)	Pb, Ca, Fe, Zn, Sr, Cu, Mn, Ti, Sn	Probably ochre
KMS3634	0	Orange	x				Occas.	Ca (Pb, Fe, Si, Al)	Pb, Ca, Fe, Sr, Zn, Cu, Mn, Sn	Ochre, perhaps red ochre
	00(?)	Orange	x							
KMS4801	0	Orange	x				Occas.	Ca (Pb, Fe, Si, Al, Mg, K, Na)	Pb, Fe, Ca, Zn, Sr, Zr, Mn, Cu, Sn, Ti	Red earth?
	00(?)	Orange	x					Ca, Pb (Fe, Si, Al, Mg, K, Na)		
KMS3275	0	Light grey						n/a		
		Red			x	x		Si, Al (Pb, Ca, Fe, Ti, Mg, Na)	Pb, Fe, Zr, Sr, Ti, Ca, K, Zn, Cu, Mn, Si, Cr, Sn	Red earth
KMS349	0	White				Occas.	Occas.	Pb (Al, Ca, Si)	Pb, Fe, Hg, Ca, Cu, Sn	
	00	White						Pb (Al, Ca, Si)		
KMS396	0	White						Pb (Ca, Al, Si)		
	00	Red	x		x	x		Si, Ca, Al, Fe (Pb, K, Mn, Mg, Na)	Pb, Fe, Ca, Zn, Cu, Mn, Cd, Sn	
KMS1766	0	White					Occas.	Pb (Ca, Al)		
	00	White					Occas.	Pb, Ca (Al)		
KMS4810	0	Light pink				x	Occas.	Pb (Al, Ca)		
KMS6151	0	Light pink			Occas.	Occas.	Poss.	Pb (Si, Al, Fe, Ca)		
KMS349a	0	White	x			Occas.	Occas.	Ca, Pb (Si, Al, Zn)	Pb, Ca, Zn, Fe, Sr, Mn	Lead white (mixed with calcium carbonate)
KMS1444	0	Brown	x					Ca (Pb, Al, Si, Fe, Mg)	Pb, Ca, Fe, Hg, Sr, Zn, Cu, Mn, Sn	
	00	Light brown	x				Occas.	Ca, Pb (Al, Fe, Si, K, Mg, P)		
KMS1445	0	Orange	x	x				Ca, Pb (Al)	Pb, Fe, Ca, Sr, Zn, Cu, Mn, Sn	Lead white and earth pigment
	00	Orange	x			Occas.	Occas.	Ca (Pb, Si, Fe, Al, K)		
KMS1113	0	Brown	x				x	Ca (Pb, Si, Fe, Al, Mg, K)	Pb, Ca, Fe, Zn, Cu, Mn, Sn, Ti	Lead white, Sienna?
KMS1114	0	Orange	x				Occas.	Ca (Pb, Fe, Si, Al)	Ca, Pb, Fe, Sr, Zn, Cu, Mn	Lead white and ochre
KMS1115	0	White	x			Occas.	Occas.	Ca (Pb, Si, Fe, Al, Mg)	Pb, Ca, Fe, Sr, Zn, Cu, Cd, Sn	Lead white
	00	White	x			x	x	Ca (Pb, Si, Al, Mg)		
SV1	0	Dark orange	x					Ca, Pb (Mg, Al, Si)		
	00	Light orange	x					Ca, (Si, Fe, Al, Pb, Mg, Na, P?)		
SV2	0	Pink	x		Poss?	x		Ca, Pb (Al, Mg, Fe, Si)		
SV3	0	White	x					Ca, Pb (K, Al, Fe?Mg?)		
SV4	0	Light orange	x	x	x			Ca, Pb (Si, Al, Fe, P, Mg)		n/a
	00	Light orange	x		Poss.	Occas.				
SV5	0	Pink	x			Occas.		Pb, Ca (Si, Al, Mg, Fe)		
SV6	0	Pink	x				x	Pb, Ca (Al, Mg, Fe)		

Relation to recipes

The combination of chalk and oil with some lead white or earth pigments in the ground layers from paintings produced in Denmark is quite pervasive throughout Juel's career. As is discussed below (Section 9.3), the binding medium for Juel's grounds appears to consist exclusively of drying oil. This use of pigments found in Juel's ground layers is largely in agreement with historical recipes for preparatory layers, where earth pigments and lead white are of the pigments most frequently mentioned (Stols-Witlox 2017:90). Lead white also acts as a siccative in oil; this and other pigments were often added for their drying capabilities (Van Hout 1998:214; Van Eikema-Hommes 1997). Ground layers in paintings by Abildgaard also contain chalk as a filler (Filtenborg 2014:17-18), as do the ground layers of paintings by other artists of the Danish Golden Age (Andersen et al 2017), suggesting that this was quite common practice in Denmark. A substantial amount of analysis on ground layers from paintings by various European artists has found chalk contained as a filler in oil ground layers, supporting this was common practice in general (see for instance Duval 1992; Stevenson 1998; Kirby 1999; Cross & Brummitt 2011; Mösl 2013; Albrecht et al 2019; Noble & Verslype 2017:2.5.2). This suggests a discrepancy between recipes and the actual use of material combinations in ground layers in many instances, as according to Stols-Witlox, except for one late-eighteenth-century German recipe, no north-Western European recipes describe the mixture of chalk and oil before the early nineteenth century and, even after this time, it is rarely mentioned (2017:51-58). When chalk is mentioned in recipes as a filler, it is primarily in combination with animal glue for panel grounds or occasionally as a base layer for canvas (Stols-Witlox 2017:89). Some recipes do, however, mention the use of *ceruse* in oil grounds, which is a term used for a white pigment mixed with chalk containing compounds in various proportions (Dossie 1764:131; Watin 1776:18-19; Eastaugh et al 2008:97).

Generally, European trends in ground colours display a transition towards lighter grounds from the mid-eighteenth century onwards (Witlox & Carlyle 2005; Noble 2004:331; Stols-Witlox 2012:177). However, to what extent pure lead white grounds without calcium carbonate were used – relating to Juel's production of paintings in France and Switzerland – is less clear and requires further study. Duval suggests that the use of calcium carbonate decreased in French grounds by the mid eighteenth century but that the double ground remained in extensive use (1992). O'Donoghue et al (1998) similarly found that the majority of French eighteenth-century paintings in the collection at the Getty and LACMA has double grounds, with a red lower layer composed of iron oxides, silicates, calcite and lead white, followed by an upper light-grey layer of lead white, calcite and charcoal. These appear very similar to the ground structure found in *Clemens KMS396*, painted in Paris.

9.2.1 Pigments and Fillers and their Correlation to Craquelure

The pattern of presence or absence of calcium carbonate and lead white in the ground layers found between the paintings produced in Denmark and those produced in France and Switzerland

corresponds to the two different types of craquelure found between these two groups of paintings as suggested in Section 5.3. This pattern appears to be one of the main factors for the development of one type of craquelure over another and has a great influence on the mechanical and chemical properties within the structure of the painting. This is supported by research into mechanical properties of ground layers, which has shown that the choice between a white-lead ground and a chalk- or earth-pigmented ground can result in significantly different degrees of degradation (Mecklenburg & Lopez 2006; Tumosa & Mecklenburg 2013; Mecklenburg et al 2013). Different pigments and fillers affect both the drying durability and the strength of the paint film and can produce grounds and paint layers that range from weak to strong and from flexible to stiff and brittle (Toussaint 1974; Zosel 1980; Mecklenburg 2005; Mecklenburg et al 2005; Mecklenburg & Fuster-Lopez 2006).

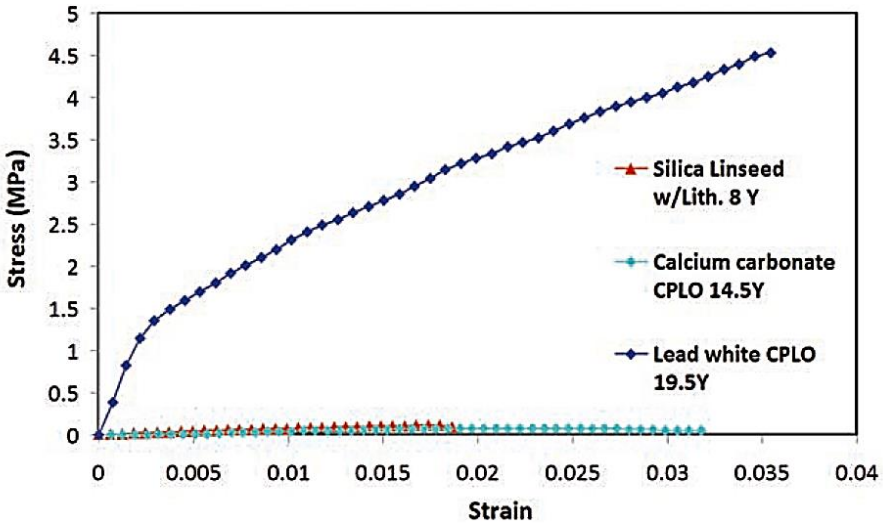

Fig. 9.6 Stress-strain plot of silica and calcium carbonate in cold-pressed linseed oil, compared to lead white in cold-pressed linseed oil. The lead white presents high strength compared to both silicate and calcium carbonate, which are weak (Tumosa & Mecklenburg 2013, courtesy of Marion F. Mecklenburg).

Chalk- and earth-pigment grounds are generally presumed to be more hygroscopic and less mechanically strong compared to grounds predominantly containing lead white (Mecklenburg 2007a). Oil grounds or paints containing lead white develop into strong and durable films that seem to increase in stiffness and strength over time (Mecklenburg et al 2013). Many other pigments, such as earth colours, form very weak films (Mecklenburg et al 2005; Mecklenburg et al 2013). Paint layers made with pigments such as earth colours appear to dry quickly. However, while these may become dry-to-touch quickly, over time they exhibit a severe loss of strength and stiffness. They become weak and sensitive to relative-humidity fluctuations and solvents (Mecklenburg 2007a; Mecklenburg et al 2013). A stiffer and stronger layer, such as a ground containing lead white, is much more resistant to relative-humidity fluctuations and solvents (Mecklenburg et al 2013). Various fillers, such as chalk, gypsum and silicates, do not affect the drying of the oil and, like pure drying oil or grounds containing earth colours, they also develop into weak grounds and paint films (Tumosa & Mecklenburg 2013). Figure 9.6 displays the

difference in stress-strain between paint films containing calcium carbonate and lead white. This corresponds with Bucklow's suggestion that the strength of the ground layers is a reason for the different morphologies of the two types of craquelure (see Section 5.3). The influence of the different types of grounds on the entire structure of the paintings and their state of preservation is further discussed in the main discussion, Section 11.3.

9.3. Binding Media

Samples from all twenty-two paintings included in this project were analysed by ATR-FTIR mapping and twenty-one of the samples by GC/MS, to identify the use of binding media in the ground layers. While ATR-FTIR mapping was performed on separate ground layers in most cases when two layers were present, GC/MS analyses included both ground layers analysed as a bulk. Therefore, possible differences between layers in double grounds are not considered.

The initial proposal for the binding media analyses was based on ATR-FTIR results from analyses of ground layers from six paintings during the previous study, which indicated the presence of both oil and protein (Appendix 26) (Slotsgaard 2013; 2015). Starch was present in four of these samples. This is consistent with all four paintings being glue-paste lined and the starch likely originating from the lining-treatment adhesive. Equally, the protein may originate from the glue used during conservation treatment in the four paintings that are lined. However, in the two paintings that are not lined, the indicated protein could originate either from the ground layer, a sizing layer or from consolidation during a conservation treatment (Slotsgaard 2013).

The focus for the binding media analyses for this study was to identify the type of drying oil and if the ground layers indicated any presence of protein, to investigate whether Juel made use of pure oil grounds or emulsion grounds. ATR-FTIR mapping on the cross-sections from paintings included in the current study all gave a positive or possible identification of a drying oil, while only one of the samples, *J.B.Neergaard SV1,* presented a possible indication of a protein being present (Table 9.2; Appendix 32).

The presence of drying oil corresponds to historic recipes and the technical tradition of the time, as the binding medium used for ground layers for oil paintings on canvas in the eighteenth century was usually oil (Van de Wetering 1997; Van Hout 1998; Stols-Witlox 2017). The type of drying oils that have found most usage in European painting practice are linseed, walnut and poppy-seed oil (Mills & White 1994:36; Colombini & Modugno 2009; Stols-Witlox 2017). Occasionally, emulsion grounds are found in analyses or described in recipes, where the oil binder is mixed with egg, glue or other additions such as varnishes or honey (Merrifield 1849:820; Massing 1998, Van Hout 1998; Baier et al 1992; Van Mander & Miedema 1994:257v; Stols-Witlox 2017). Emulsion grounds are generally considered to dry faster and be more absorbent than pure oil grounds (Jirat-Wasiutynski & Newton 1998; Stols-Witlox 2017:179-81). For most, if not all, of Juel's paintings produced in Denmark, the ground layers have a rather matt appearance, suggesting they could be

at least semi-absorbent (Appendices 1.2-22.2). Analyses of samples from the ground layers of Danish Golden Age paintings (c. 1810-1850) identified the possible presence of egg as a binder in combination with drying (linseed) oil (Andersen 2013:35; Andersen et al 2017). As Juel is supposed to have been a great influence on the Golden Age painters, especially Eckersberg, it would be interesting to establish whether such a technical trend originated in Juel's era. However, as is described below, no such tendency could be confirmed as the presence of egg was not detected.

GC/MS

GC/MS confirmed the presence of drying oil as a binder in all the samples analysed. In addition to drying oil, some further compounds - amino acids, waxy components, starch and resins – were detected (Table 9.2). These compounds are likely contamination from conservation treatments or other layers, rather than an addition to the ground-layer mixture by the artist. The presence of additional compounds (peaks) remain inconclusive or unidentified. Some of these are likely to be contamination products from the derivatisation and sample preparation procedure, as they seem to correspond with these compounds (Appendix 36). The identification of various compounds by GC/MS are elaborated in the following passages. A summary of results and substances from the different fractions and organic compounds are displayed in Table 9.2. Interpretation comments and chromatograms are presented in Appendix 37.

Drying oil

Drying oil as a binder was identified and confirmed by GC/MS in all the samples analysed, by the presence of azelaic (di-C9), palmitic (C16) and stearic acid (C18) in the chromatograms (Fig. 9.7) (Appendix 37) (Mills & White 1994:33,171). Possible identification of the type of drying oil is discussed in the following subsection (9.3.1).

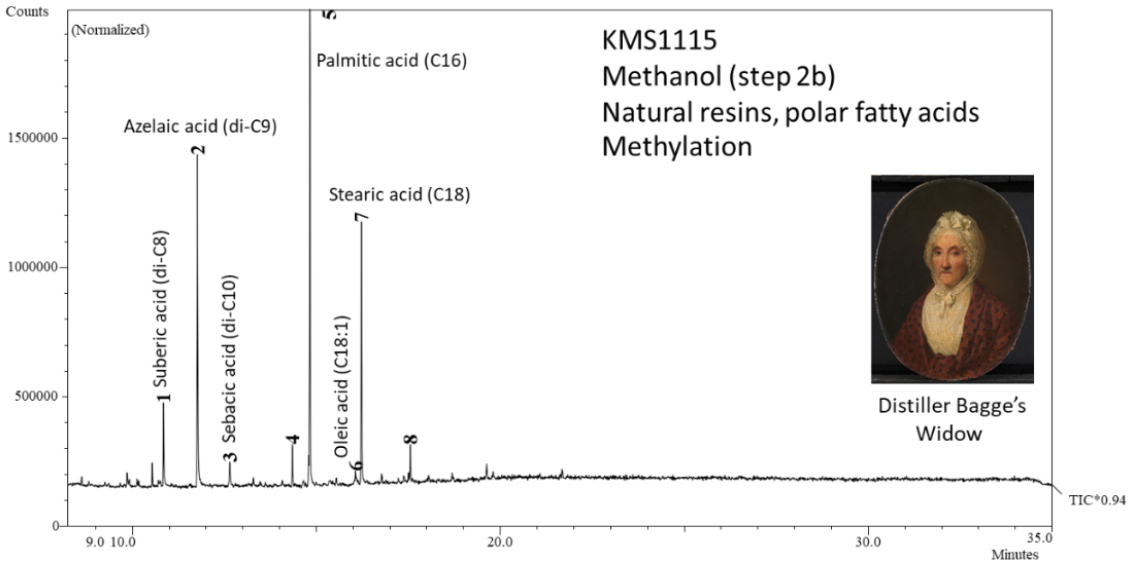

Fig. 9.7 Chromatogram of step 2b of GC/MS analyses of *Bagge KMS1115*. The most common fatty acids (methyl esters) are present. Drying oil is identified by the presence of azelaic, palmitic and stearic acid.

Table 9.2 Overall interpretation of organic substances in ground layers from paintings by Juel analysed by ATR-FTIR and GC/MS. Chromatograms are displayed in Appendix 37. Blue = Paintings produced while abroad.

		ATR-FTIR		GC/MS					
Painting id.	**Year**	**Lipid (drying oil)**	**Protein**	**Lipid**	**Protein**	**Waxes**	**Resins**	**Poly-saccharides**	**Lining**
KMS3990	c. 1764	Yes		Drying oil				Starch	G-P*
KMS3499	1770	Possibly		Drying oil		Wax?		Starch?	G-P W-R*
KMS3634	1771	Possibly		Drying oil		Wax	Diterpenoid Sandarac?	-	G-P W-R
KMS4801	1772	Possibly		Drying oil	Animal glue?	Wax		-	G-P W-R
KMS3275	1773-74	Possibly		Drying oil				Starch?	G-P
KMS349	1776	Yes		Drying oil				-	G-P
KMS396	1776	Possibly		Drying oil				-	G-P
KMS1766	1778-79	Yes		Drying oil		Wax		-	G-P W-R
KMS4810	1778-79	Yes		Drying oil				Starch	G-P
KMS6151	1779	Yes		Drying oil				Starch	G-P
KMS349a	1780	Possibly		Drying oil				Starch?	G-P
KMS1444	1785	Possibly		Drying oil		Wax		Starch	G-P W-R
KMS1445	1785	Possibly		Drying oil				Starch	G-P
KMS1113	1799-1800	Possibly		Drying oil	Animal glue?	Beeswax	Dammar	Starch	G-P W-R
KMS1114	1799-1800	Possibly		Drying oil		Wax	Diterpenoid Sandarac?	Starch	G-P W-R
KMS1115	1799-1800	Yes		Drying oil				Starch	G-P
SV1	1788	Possibly	Possibly	Drying oil				-	None
SV2	1788	Possibly		Drying oil				-	None
SV3	1780s	Possibly		Drying oil				-	G-P
SV4	1790	Possibly		Drying oil				-	None
SV5	1797	Possibly		Drying oil				-	None
SV6	1797	Possibly		n/a					None

*G-P = Glue-Paste lined. W-R = Wax-Resin lined.

Proteins

The characterisation of the source of proteinaceous materials is based on the quantitative evaluation of the amino-acid profile obtained after hydrolyses and derivatisation (White 1984; Bonaduce et al 2009). Some amino acids could be detected in about half of the samples by GC/MS, but none seem to contain a full complement of amino acids that could definitively

identify them as belonging to a specific protein (Appendix 37: Table 37.2). Only samples from *Saly KMS4801* and *P.J.Schouw KMS1113* show protein by the presence of hydroxyproline in the soluble protein fraction (Step 5P), suggesting collagen (animal glue) is present (White 1984). As both paintings have been glue-paste lined and subsequently wax-resin lined, the prospect is that the glue derives from conservation treatments, rather than an addition to the ground-layer mixture or a sizing layer. If hydroxyproline is absent, collagen-based proteins can be ruled out (Colombini et al 2010). Except for animal glue containing hydroxyproline, the proteins expected to be found in organic painting media (casein, egg, animal glue/collagen) all contain the same amino acids; however, the quantity of each amino acid differs, thus enabling specific protein identification based on quantity (Mills & White 1994:85-86). The presence of egg or casein result in a certain level of aspartic and glutamic acid being present (Colombini 2010:722). These amino acids were only identified in the two samples also containing hydroxyproline and thus cannot be separately recognised as deriving from egg or casein. Neither could any presence of amino acids be confirmed in the sample from *J.B.Neergaard SV1,* which indicated the presence of protein during ATR-FTIR analyses. Occasional amino acids detected in the samples seem to correspond rather with derivatisation agents, and are likely due to contamination products from the sample-preparation procedure.

Waxes

Waxy components are identified in seven samples based on their chromatographic profile (Table 9.2) (Mills & White 1994; Andreotti et al 2006; Andreotti 2008; Colombini et al 2010). Only in *P.J.Schouw KMS1113* does the chromatographic profile propose beeswax specifically, while the remaining samples do not display a full identifiable profile. The presence of wax in the analysed samples corresponds particularly with paintings that are wax-resin lined.

Resins

Resins are identified by marker compounds, which are detected in three samples (Table 9.2) (Colombini et al 2000; Colombini et al 2010). Dammar was identified in *P.J.Schouw KMS1113* (Van der Doelen 1999), and two samples, from *Battier KMS3634* and *A.C.Schouw KMS1114,* suggest traces of a diterpenoid resin, possibly sandarac (Romero-Noguera et al 2014). The presence of both dammar and beeswax in *P.J.Schouw KMS1113* suggest that this is residue from the wax-resin lining (cf. Section 5.1). The possible trace of sandarac may originate from a previous varnish layer.

Starch

Starch is identified by the chromatographic profile in about half of the samples (Table 9.2) (Lluveras-Tenorio et al 2012). The presence of starch, similarly to the compounds above, correspond with paintings that are glue-paste lined.

In conclusion, the binding media in ground layers in Juel's paintings appear to primarily consisting of drying oil. Other substances cannot at present be confirmed as having been added to the ground mixture by the artist. Additional compounds are likely not present, or the amount is so low that it falls below the limit of detection. Identification of the specific type of drying oil is discussed in the subsection below.

9.3.1 Drying Oil Identification

For all of the samples analysed by GC/MS, the chromatograms identified the presence of drying oil in the ground layers. Due to the range of lipid materials likely used in traditional oil painting, it is sometimes possible to identify the source of lipids being a specific drying oil, either linseed, walnut or poppy-seed, or egg (Colombini et al 2010). This identification is generally based on the quantitative evaluation of mono- and dicarboxylic fatty acids, more specifically the ratio between different fatty acids, as well as the presence or absence of specific fatty acids (Mills & White 1994; Colombini et al 2002; Colombini et al 2010; Bonaduce 2015 and references therein). The determination of the source of drying oil is traditionally based on the ratio between the relative amounts of palmitic acid (C16) over stearic acid (C18), called the P/S ratio (Mills 1966; Mills & White 1994:171; Shilling & Khanjian 1996B; Colombini et al 2002; Bonaduce 2015; and references therein).

The P/S ratio for the samples analysed during this study is derived from the chromatograms (Appendix 37) and calculated along with a few additional fatty acid ratios commonly used in support of the P/S ratio: azelaic over palmitic acid (A/P) and oleic over stearic acid (O/S). These are described below and the ratios are listed in Table 9.4.[33] The ratios are calculated from fraction 2b as well as the summation of fraction 2b and 3b (cf. Section 4.15). The same volume of solvent for extraction is used in both fractions and it is evident from the chromatograms that not all methylated fatty acids are extracted in fraction 2b, and that they are further extracted in fraction 3b. The two fractions display different ratios in some cases and thus calculations from both are included in the table.

Type of drying oil

Typical values of the P/S ratio found in literature to determine drying oil source are 1 to 2.4 for linseed oil, 2 to 4.5 for walnut oil, 3 to 8 for poppy-seed oil and 2.5 to 3.5 for egg (Table 9.3) (Mills & White 1994:171; Colombini et al 2010). For most of Juel's paintings produced in Denmark and Germany, the ratios indicate the use of linseed or walnut oil (Table 9.4). The four paintings with a light ground, white or pink, produced in Paris and Switzerland, *Hauch KMS349, Holm KMS1766, Prangins KMS4810* and *Tronchin KMS6151,* have a relatively high P/S ratio

[33] In accordance with common practice the quantification of fatty acids are based on peak areas of the chromatograms after derivatisation and not by use of calibration curves otherwise recommended (Tsakalof et al 2006; Manzano et al 2011; Bonaduce et al 2015).

suggesting the use of walnut or possibly poppy-seed oil (Table 9.4). Because the parameters of walnut oil overlap those of linseed oil, poppy-seed oil and egg lipids, it can be troublesome to differentiate between pure oil and mixtures of different oils or egg lipids. The A/P ratio can support differentiation between drying oils and egg (Colombini et al 2002).[34] An A/P ratio lower than 0.3 suggests the presence of egg and an A/P ratio higher than 1 suggests the presence of just drying oil (Table 9.3). An intermediate value of the A/P ratio suggests a mixture of the two (Mills & White 1994:171; Tsakalof et al 2006, Andreotti et al 2008; Colombini & Modugno 2009). The A/P ratios of the majority of samples analysed in this study are close to or above 1, indicating the presence purely of a drying oil (Table 9.4). However, almost half of the samples have an A/P ratio in the intermediate range, between 0.26 and 0.97, normally suggesting an oil and egg mixture (Table 9.4); however, according to Colombini et al, the presence of egg must be confirmed by amino-acid analysis of the proteinaceous matter (2010). As discussed in the previous section, no amino-acid profile in the samples could be determined to originate from egg. As the presence of egg could not be confirmed by amino-acid presence, the P/S ratios suggests the use of just drying oil.

Linseed oil is traditionally the most commonly used drying oil in European painting technique (Hermens & Townsend 2012:210). This was also the case in Denmark, and linseed oil was produced locally; it is therefore not surprising that this was identified in the paintings produced in Denmark (Bregnhøi 2010:153). As it is explained in the contemporary Danish publication *Nye og fuldstændig Maler og Forgylderbog …*: "Painters mainly use linseed oil, which is the best. It does not have as much fat and thus dries faster; it is also the best buy. In France and Italy they use nut or poppy oil, but besides that they are more expensive here, they are also fatter and therefore more difficult to dry …" (Anonymous 1799:51-52).[35] The occasional higher P/S ratios found in the paintings produced in Denmark that suggest walnut oil are more surprising. Whether this result is reliable, or is subject to an insecurity in the method or the presence of other compounds, is uncertain. For instance, *A.M.B Neergaard SV2* and *J.Moltke SV5* show different P/S ratios. Analysis of *A.M.B Neergaard SV2* suggests linseed oil, while that of *J.Moltke SV5* suggests walnut oil. As previously discussed, these paintings appear to originate from the same pre-primed canvas, and the colour and composition of the ground layers correspond. Therefore, this difference suggests an uncertainty in the method. This uncertainty is further discussed below.

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[34] The A/P ratio is often used in combination with the total dicarboxylic acid content, ΣD (mainly suberic, azelaic and sebacic acid) (Colombini et al 2002). As all of the dicarboxylic acids could not be consistently detected and quantified in the chromatograms this content is not calculated. Similarly, other dicarboxylic acid ratios, such as azelaic over suberic (A/Sub) and azelaic over sebacic (A/Seb), previously believed to indicate pre-treatment of the oil (pre-heated or stand-oil) are therefore left out of the study. These ratios have been more recently revealed as an unsuited parameter for such determination (Mills & White 1982; Van den Berg et al 2002; Katsibiri & Boon 2004; Bonaduce et al 2012). Once pre-polymerised oil is applied to a surface, it could appear that it finishes drying like unheated oils (Erhardt et al 2000).

[35] "Malerne bruge i Særdeleshed Linolien, som den beste af alle. Den har ikke saa meget Fedt hos sig og tørres derfor lettere; den er ogsaa best kjøb. I Frankerige og Italien bruger man Nød- og Valmue Olie; men foruden at de hos os ere dyre, saa ere de tillige federe, og altsaa vanskeligere at tørre …"

According to sources, the indication of the use of walnut or poppy seed oil in the grounds of paintings produced in France and Switzerland may be less surprising (De Mayerne 1620-44:7; Massing 1998:342). Although the extent of their use – especially poppy-seed oil over linseed oil or walnut oil – is uncertain, according to recipes linseed and walnut were favoured, while poppy-seed oil may have been used to a lesser extent (Stols-Witlox 2017:95).

State of oxidation

The intermediate A/P ratios may indicate a lower state of oxidation rather than any presence of egg (Tsakalof et al 2006; Keune et al 2008; Columbini & Modugno 2009:199). The A/P ratio is dependent on the level of oxidation, degradation and polymerisation of the oil film (Colombini & Modugno 2009; Colombini et al 2010). The lowest A/P ratios were found in the paintings produced in France and Switzerland: *Clemens KMS396*, *Hauch KMS349, Holm KMS1766, Prangins KMS4810* and *Tronchin KMS6151*. This could suggest that the ground layers in these paintings are still not fully cured. This possible lower state of oxidation may be supported by a high O/S ratio in some instances (Table 9.4). Normally, the content of oleic acid in aged paintings is very low, with an O/S value around 0.1 to 0.2 (Colombini et al 2000; Colombini & Modugno 2009:196-99) (Table 9.3). Free oleic acid is typically completely converted by oxidation to azelaic acid in a fully cured paint films; thus, high oleic- and low azelaic-acid content in centuries-old oil paint is hard to explain (Maines et al 2010; Manzano et al 2011). The presence of more than a trace amount of oleic acid is interpreted as an indication that the paint film is either not yet fully cured or that something has interfered with the curing process preventing oxidation from occurring (Maines et al 2010). For instance, Maines et al (2010) have found that high O/S ratios in paint with the presence of zinc-containing pigments indicate the presence of zinc soaps as zinc oleates. XRF analysis of the ground layers in Juel's paintings do show a small presence of elemental zinc in some of the samples from the paintings produced in Denmark, however, limited visible access to the ground layers in some of the painting produced abroad did not allow XRF analysis to confirm such presence (Table 9.1). Although a zinc-containing pigment was not used directly in Juel's paintings, naturally occurring zinc-impurities can be present (O'Donogue et al 1998; Ricci et al 2004). However, the ground layers, which according to A/P ratio exhibit the lowest level of oxidation, are the grounds that contain the highest amount of lead white (those produced in Paris and Switzerland: *Hauch KMS349, Holm KMS1766, Prangins KMS4810* and *Tronchin KMS6151*). In general, paints containing catalytic dryers such as lead and manganese compounds tend to dry faster than those without, while zinc for instance is a slow dryer (Mecklenburg 2005; Tumosa & Mecklenburg 2013). The lead-white content of these grounds would likely increase drying time rather than prohibit drying. Therefore, it is unclear at this point, which factor could possibly have interfered in the curing process and resulting in a decreased state of oxidation.

Table 9.3 Mean values of fatty-acid ratios for lipid binders in the available literature.

	Linseed oil	Walnut oil	Poppy seed oil	Egg	Egg and oil mixture
P/S	<2-2.4	2-4.5	3-8	2.5-3.5	-
A/P	>1	>1	>1	<0.3	0.5-1 (or low oxidation?)
O/S	0.1-0.2 (expected level for fully cured paint films)				

Table 9.4 Characteristic parameters related to the identification of the source of lipid material in samples from ground layers in paintings by Jens Juel. P/S, A/P and O/S ratios for drying oil identification and state of oxidation are calculated for fraction 2b and fraction 2b plus 3b. Blue = paintings produced abroad.

Painting id.	Year	P/S (2b)	P/S (2b+3b)	A/P (2b)	A/P (2b+3b)	O/S (2b)	O/S (2b+3b)	Possible interpretation
KMS3990	c. 1764	2.68	2.56	0.81	0.75	0.44	0.24	Linseed or walnut?
KMS3499	1770	1.90	1.94	1.42	1.30	0.25	0.22	Linseed
KMS3634	1771	2.24	1.98	1.68	1.46	LLOQ*	LLOQ	Linseed or walnut
KMS4801	1772	2.80	2.22	1.03	0.96	0	0	Linseed or walnut
KMS3275	1773-74	1.72	1.71	1.27	1.34	0.13	LLOQ	Linseed
KMS349	1776	5.68	5.69	0.34	0.26	0.39	0.23	Poppy seed?
KMS396	1776	2.70	2.40	0.61	0.41	0.29	LLOQ	Walnut?
KMS1766	1778-79	5.72	5.14	0.33	0.28	0.94	0.58	Poppy seed?
KMS4810	1778-79	4.97	3.82	0.55	0.61	0.27	0.14	Walnut or poppy-seed?
KMS6151	1779	4.87	3.95	0.41	0.37	0	0.15	Walnut or poppy-seed?
KMS349a	1780	2.45	2.31	1.11	1.28	LLOQ	LLOQ	Linseed or walnut
KMS1444	1785	2.06	2.16	0.94	0.92	LLOQ	LLOQ	Linseed or walnut
KMS1445	1785	1.72	1.83	1.30	1.33	0.12	0.10	Linseed
KMS1113	1799-1800	2.82	3.34	0.97	0.70	0.17	0.24	Walnut?
KMS1114	1799-1800	1.95	2.84	1.75	1.34	LLOQ	0	Linseed or walnut
KMS1115	1799-1800	1.92	1.77	0.72	0.64	0.11	0.08	Linseed
SV1	1788	3.48	3.48	0.97	0.97	0.50	0.50	Walnut?
SV2	1788	1.32	1.32	0.89	0.89	0	0	Linseed
SV3	1780s	1.99	1.99	1.37	1.37	0	0	Linseed
SV4	1790	3.13	3.13	0.89	1.10	0.51	0.51	Walnut?
SV5	1797	3.19	3.19	1.03	1.03	0	0	Walnut?
SV6	1797	-		-		-		n/a

*below limit of quantification (LLOQ)

Correlation to drying cracks

As expressed in the literature, the relevant variables in the formation of an oil-paint film are very broad and the synergetic effects often unknown (Van den Berg et al 1999). However, according

to the calculated ratios in this study, there appears to be a general correlation between the use of pigment, possible type of drying oil and a lower state of oxidation – as well as the geographical origin of the ground layer. This is evident by the higher P/S ratios and lower A/P ratios for the ground layers in paintings produced in France and Switzerland (Table 9.4). Furthermore, this correlation corresponds to the exact paintings in which the initiation of ageing cracks appear to originate in the paint layers from pre-existing drying cracks. As described in Section 5.3, such drying cracks typically occur if paint layers are either leaner or are applied too soon on a ground, which has not sufficiently dried (Thompson 1915; Keck 1969; Van den Berg et al 1999; Van Loon 2012:225).

Linseed oil is generally, and has been for centuries, considered the fastest drying oil, followed by walnut oil and then poppy-seed oil, as the slowest dryer (Anonymous 1794; Mayer 1930:111; Hermens & Townsend 2012:210, Stols-Wiltox 2017:96). The use of a slower-drying oil, as the P/S ratios suggest, could have influenced the curing time of the ground layer. Since oxygen diffuses in from the surface, the top layer will become solid first and underlying layers will dry more slowly. Crack formation can result due to uneven contraction of the top and underlying layers (Van den Berg et al 1999; Erhardt et al 2000). The A/P ratios, which suggest low oxidation of these ground layers, further propose that something could have interfered with the curing process over a longer period, and perhaps still does. The portrait of *Clemens KMS396* also displays this type of drying cracks; however, analysis shows that its ground has a relatively low P/S ratio. This could be due to the two ground layers being analysed as a bulk. It is not possible to differentiate between the binding media of the lower red ground and the upper light white layer, and different binders could have been used in these layers or the layers could have cured at different rates.

The systematic difference in ratios for the ground layers in the paintings produced in France and Switzerland, as well as the presence of drying cracks, suggest a difference in materials, the drying process and the interaction between layers in these paintings. This, as well as the wrinkling seen in at least two portraits from the Dresden years, suggests that Juel not only used different materials while abroad, but that they responded differently than he was used to – or that, due to practicalities, he was rushed into painting on ground layers that had not sufficiently dried, which he may or may not have been aware of at the time. Some contemporary sources drew attention to the fact that oil-based grounds require long drying times, up to one year, before they should be painted upon (Stols-Witlox 2017:168).

Problems in the use of ratios for drying oil identification

The ratios calculated from the fatty-acid content displayed in the chromatograms from ground-layer samples in Juel's paintings provide some indications as to the type of drying oil and its state of oxidation; however, some discrepancies or inconsistencies between the ratios have also been found. These discrepancies and inconsistencies can currently not be explained.

It should be noted that the use of various ratios for the interpretation and determination of the type of drying oil is found increasingly problematic, according to literature. It has been generally concluded, that the P/S ratio should be carefully considered and used with caution during interpretation and determination of the type of drying oil (Tsakalof et al 2006; Keune 2005; Keune et al 2008; Colombini et al 2010; Bonaduce et al 2012; Bonaduce et al 2015). Despite this conclusion, the P/S ratio from GC/MS analysis remains in continuous use for oil binder interpretation, mainly due to the fact that at this point no other easy applicable interpretation method has been developed (see for instance Witkowski et al 2018).

The traditional use of P/S ratios for drying-oil determination is centred on the assumption that, since these two fatty acids have similar chemical reactivity, their relative ratio should remain fairly constant upon ageing (Mills 1966). It has since been demonstrated that evaporation of the organic medium in paint layers does take place during ageing and that the P/S ratio can decrease significantly over time with loss of palmitic over stearic acid (Schilling et al 1999). This decrease, however, is largely dependent on various factors such as preparation and sample age, the thickness of the paint film, the presence of overlying layers, the presence of pigments (metal ions) and other organic binders, as well as conservation treatment and storage history (Keune 2005; Colombini et al 2002; Colombini et al 2010; Bonaduce et al 2012). Furthermore, the determination of composition can be subject to experimental error and variation due to the use of different techniques (Mills 1966; Mills & White 1994:32). Some report that if materials, pigments or other binders are present, which form complexes or other chemical compounds with the fatty acids, such as lead carboxylates, then evaporation does not take place and the ratios should be somewhat more reliable (Bonaduce et al 2012; Bonaduce et al 2015). Therefore, the P/S ratio ought to be reliable in samples from old works of art (Blasco et al 2008). For these reasons the calculation of fatty-acid ratios is included in this study, and the results may act as a comparison with other drying-oil analyses of paintings outside this thesis. However, as recommended in the literature, possibly the ratios should be considered with some caution.

9.4 Preparation – Studio or Ready-Made?

The character and variation in ground layers as presented and discussed throughout this chapter add to the consideration as to whether the priming of Juel's canvasses took place in his studio or he purchased the canvas pre-primed from a supplier. Preparation and priming of Juel's canvasses are described and discussed in Section 7.3, where, except for a few paintings produced abroad, it is generally found that Juel's canvas supports were cut from larger pre-primed canvasses. As suggested in Chapter 7, Juel likely purchased his canvasses locally, but whether they were already primed upon purchase is less evident. So far, no documentary evidence that indicates that Danish painters had access to commercially primed canvasses before the early nineteenth century has been found (Andersen et al 2009, Villadsen 2009). Among the firms selling artists' tools and materials, one of the earliest was the Copenhagen firm of H.J. Bing & Son, established 1819, which was a supplier to several of the Danish Golden Age painters (Andersen et al 2009). From

Eckersberg's diaries, we can see that he purchased pre-primed canvas before this (1816); thus, other suppliers were available sometime before. Filtenborg claims that, indeed, commercially primed canvas was available before 1800, although no names or written evidence have survived. Filtenborg suggests, based on Mandelbergs estate auction from 1786, which lists both primed and un-primed canvas, that Mandelberg's studio practice included the act of priming as well as perhaps the employment of commercially primed canvasses (2014:6). However, it is still uncertain to what extent this could have been established practice and it would have depended on supply and demand. Juel was one of the most prolific artists in Copenhagen at the end of the eighteenth century, but other artists were often struggling to find commissions (Slotsgaard 2019). In Denmark, at least up until the beginning of the nineteenth century, most crafts were strongly controlled by the guilds (Bregnhøi 2010:157-59). The Copenhagen directory of 1780 lists forty coarse painters (*malere*) and forty-one cloth makers (*dugmagere*) (Holk 1780:70). One of these trades could have been of service to painters for priming canvasses.

Pre-primed canvasses in Denmark

The resemblance of the ground layers in Juel's paintings from the early Copenhagen years to one another suggests a very similar approach, and that perhaps the same person or studio made them. Juel was an up-and-coming, less-established painter in these years (see Chapter 2). Although he did well in portrait commissions and is known to have had an assistant (Christian Rafn: Poulsen 1991:24; Christensen 1996a:59), the production was far less than in his later, most busy years following his return to Copenhagen. In this sense, it may have been cheaper to prime the canvasses in the studio during the early years, carried out either by Juel himself or by the aid of an assistant.

In the later Copenhagen years, when Juel was busier with commissions, his grounds display a larger variety of structure and colour, making the matter less clear. As discussed above, the reason for using varied ground colours are several; it could be that they were not made by the same person, or that they were simply made with the appropriate material available in the studio at a certain time and that the colour was not of great importance. Also, in these years, Juel is known to have had assistants; Herman Kofoed is most frequently mentioned in sources, as well as academy students (Hansen 1907; Christensen 1996a:68). The practice of priming canvasses could have remained in the studio, likely performed by assistants rather than by Juel himself. The re-currence of some types of grounds, for instance, resembling those from the early years, could suggest that the canvasses were primed in the studio. It could be that the practice was not consequently one or the other, and that both studio-made and pre-primed canvass were used, as also suggested by Filtenborg. At this point is not possible to bring the question closer to a conclusion. Further investigation into contemporary painters' techniques as well as contemporary documentary sources may provide a better impression of common practices and availability of pre-primed canvasses for Danish painters in this era. Matches between canvasses between different artists could also provide evidence that they shared suppliers. That Juel at least considered purchasing pre-primed canvasses from Dresden just after the turn of the century, is

know from Runge. In 1802, the former student of Juel, wrote from Dresden to his brother in Hamburg stating that he was about to send a parcel with pastels to Juel, as Juel could not buy them in Copenhagen. Runge further commented that in the future Juel might also like to have some of the local Dresden canvas sent to him, which was considered very good (Runge 1840:2-155).[36] Unfortunately, Juel's sudden death the same year, likely did not allow this to happen.

An evaluation based on the findings in the current investigation compared to other studies and documentary sources, suggests that if Danish painters in the last half of the eighteenth century purchased pre-primed canvasses, they purchased lengths of canvas and strainers separately, and subsequently cut and stretched them in the studio. Examinations of both Juel and Abildgaard's paintings provide evidence that they were usually cut from larger pre-primed canvasses and, in the case of both artists, paintings have been found to originate from the same roll of primed canvas (Section 7.4; Filtenborg 2014:10). The estate auction following Juel's death, as well as that of Mandelberg, listed stretched canvasses as well as rolls of primed canvas; from Juel's studio eleven empty strainers were listed, further supporting that this practice occurred (Mandelberg 1786:60-61; Fugl 1803:29-30). It could appear that pre-primed canvasses already stretched onto a stretcher was not common or readily available for purchase in Denmark until the mid 1900s (Andersen et al 2009; Filtenborg & Andersen 2017). Entries made by Eckersberg in his diaries support this practice. Frequent entries describe his purchases of (pre-primed) canvasses (Andersen et al 2009; Villadsen 2009: 26 June 1816; 2 October 1816; 24 January 1817; 18 August 1832). Although he does not always mention the canvas being pre-primed this seems implied as he often records making the underdrawing as the phase directly following the stretching of the canvas (Andersen et al 2009). Generally, it appears that he purchased a length, often 4 *ell* (likely rolled), of pre-primed canvas, cut it to size and stretched it himself onto a strainer or stretcher.

Pre-primed canvasses during travelling years

It is much more likely that Juel purchased pre-primed, and perhaps sometimes pre-stretched, canvasses in his years of travelling from 1772 to 1780. Pre-primed canvasses would have been available in some of the larger artistic centres Juel travelled through, at least in Rome and Paris (De Mayerne 1620:5r; Haaf 1987; Van de Wetering 1997:22; Van Hout 1998; Witlox & Carlyle 2005, Villadsen 2009; Stols-Witlox 2017:141).

We know from Runge (1777-1810) that pre-primed canvasses were available in Dresden at least from around 1800. The question is whether this was also the case thirty years earlier when Juel was in Dresden. Runge was very fond of primed canvas from Dresden, which he purchased from various dealers and used for the majority of his paintings (Möckel & Castro 2013). In only two of twenty-eight paintings does he appear to have primed the canvas himself. The majority of

[36] "Ich werde euch nachstens ein Packel mit Pastellfarben fur den Prof. Juel senden, das ihr wohl an ihn uber Lubeck oder Kiel spedirt; er kann sie dort nicht haben, auch wird er wohl kunftig von dem hiesigen Malertuch gebrauchen, das sehr gut ist."

Runge's paintings are painted on coarse plain-weave canvasses consisting of flax, hand-spun and handwoven, with irregularities and threads varying in thickness. Nineteen out of twenty-eight paintings had a lower red-ochre ground layer, thickly applied, followed by a second off-white ground layer containing lead white and small amounts of yellow to light-brown ochre, as well as chalk. The binding medium found to be linseed oil with a low proportion of resin and egg. (Möckel & Castro 2013). Except for the presence of egg, this much resembles the type of canvas and double ground found in Juel's Dresden *Self-Portrait KMS3275*. As Runge mentions ordering his strainer, or stretcher, from a carpenter, he likely stretched the canvas in his studio (Möckel & Castro 2013). This is consistent with the suggested practice in Denmark.

Johann Gottlieb Puhlmann, an assistant in Batoni's studio from 1774 to 1787, described purchasing ready-made canvasses in Rome in 1777 (Puhlmann 1979:130). As is known for instance from Pernety, pre-stretched canvasses were available in Paris. The oval portrait of *Hauch KMS349*, believed mounted on the original strainer from Paris, actually has dimensions close to Pernety's standard size no.12 (Pernety 1757:535; cf. Section 6.1.2). The dark paint on the tacking margins may be evidence against Juel having acquired the canvas pre-stretched, however, unless this was applied as a background colour by the supplier (Fig. 7.8). Both *Hauch KMS349* and *Clemens KMS396* display cusping that appears to be primary, along all four sides, suggesting the canvasses may have been individually prepared. As the strainer or stretcher has been replaced several times on *Clemens KMS396*, the auxiliary support does not provide any information in this regard. Evidence is similarly lacking in *Prangins KMS4810* and *Tronchin KMS6151* as the tacking margins have been cut.

Priming of a single-sized canvas is practical in instances when an artist does not have many commissions or lacks the space allowing for storage of rolls or multiple stretched canvasses. Juel probably did not have a permanent studio in each location while living abroad, where the practice of priming larger canvasses, as well as storing them until sufficiently dry, would have been possible. We know only little of Juel's practice and accommodation facilities while travelling, although a few insights do exist (Glarbo 1925:30). For instance, the practical aspect of the execution of *Prangins KMS4810* is fairly well documented by the diary of the baroness herself (Monrad 1993). After the initial layout of the painting, at which point the baroness reported it was already well composed, Juel brought the painting with him to Geneva, and then Juel returned multiple times to the Prangins castle and painted the portrait on location, later returning to finish and varnish the painting.

The apparently sudden change in ground layers, as well as variation during the travel years compared to the previous Copenhagen years, suggests that either different materials had become available to Juel, that he was influenced by other painters or that he purchased his canvasses ready-primed. The fact that he does not appear to have adapted to the same type of ground consisting of oil and lead white without chalk, after his return to Denmark, suggests a different

approach or set of hands throughout the travelling years – or a difference in availability of materials. Further investigations of paintings from these years, possible identification of matching canvasses, as well as additional documentary evidence that may emerge in the future, could help to fill some of the gaps regarding Juel's practice while abroad in comparison to paintings produced in Denmark.

9.5 Chapter Summary and Conclusions

Juel's use of ground colour overall reflects the general tradition of ground layers as well as transition from coloured to lighter or white grounds towards the nineteenth century. During Juel's early years in Copenhagen, he used a very similar type of reddish-brown (orange) ground, suggesting this was studio-made. A direct influence from his apprentice years is not confirmed, as the ground layer of *Self-Portrait KMS3990* from his apprentice years does not correspond to the grounds seen in paintings from his early years in Copenhagen. His travelling years display a change and diversity in ground colours and structure compared to the paintings produced in Denmark, which suggests differences in either technical approach, availability of materials or, possibly, that he purchased the canvasses pre-primed from suppliers. Paintings from these years display his first use of light and white grounds, which he may have been inspired to use during his time in Rome or Paris. Following his return to Copenhagen, the use of ground layers displays continuous variation in colour and structure, in which no systematic reasoning can be established at this point. No evidence is found as to whether Juel purchased the canvasses pre-primed during these years, however, evidence shows the use of larger pre-primed canvasses, either studio-made or purchased, which were cut and individually mounted on strainers in the studio.

Material analyses revealed some key differences between the ground layers of the paintings produced in Denmark and those produced abroad. The ground layers of paintings produced in Denmark all contain a substantial amount of calcium carbonate (chalk) and little lead white, while the paintings produced abroad display little or no calcium carbonate. In contrast, the paintings produced in France and Switzerland contain mainly lead white. The pattern of presence or absence of calcium carbonate versus lead white in the ground layers corresponds to the differences in crack patterns between paintings produced in different geographical locations, as suggested in Chapter 5. This difference appears to be one of the main factors for the development of one type of craquelure over another, and has a significant influence on the mechanical and chemical properties within the structure of the painting. Contemporary research into mechanical properties of ground layers has shown that the choice between a white-lead ground and a chalk- or earth-pigmented ground can result in significantly different degrees of degradation. While a lead-white ground is strong and stiff, a chalk (and earth-pigmented) ground layer is weak and much more susceptible to climate fluctuations.

GC/MS analysis proved the use of drying oil as binding medium in the ground layers. Any presence of proteinaceous compounds such as animal glue or egg, which may have been added to

the ground mixture, to suggest the use of emulsion grounds was not confirmed. The analysis suggests the use of linseed or walnut oil for the paintings produced in Denmark, while a slower drying oil, such as poppy-seed oil may have been used in France and Switzerland. A slower-drying oil or a lower state of oxidation in the ground layers of the paintings produced in France and Switzerland, could explain the drying craquelure seen in the surface of the paint layers in these paintings.

The fact that Juel does not appear to have adapted to the same type of ground consisting of oil and lead white without chalk after his return to Denmark, suggests a different approach or set of hands throughout the travelling years – or a difference in availability of materials.

10 Paint Layers

The design layers of a painting are the result of a creative process based on the skill and personal choices of the artist, in terms of use of materials and technique, which is aimed at achieving the desired composition. The initial underdrawing, or sketch, gives insight into the painter's approach and original intentions. The build-up of paint layers informs us about the progression of the painting, the artist's methods in the technical application of the paint and changes made to the composition towards the outcome of the finished depiction. The different pigments, pigment combinations, types of binders, additives, layer structure and thickness all influence the physical and chemical stability of the paint layers and the integrity of the painting (Saunders and Kirby 2004; Van Loon et al 2012:214).

French painters of the mid-eighteenth century such as Charles-Antoine Jombert (1712-1784) and Jean Baptiste Oudry described the recommended build-up of paint layers for oil paintings (1766:107-119; 1752/2008). The painting process began with the *esquisse*, an underdrawing executed using chalk, which could easily be corrected with a damp sponge, followed by a thin paint application by brush along the same contours. The esquisse is depicted in a large number of eighteenth-century artists' portraits and allegories, indicating it was a widely used method for underdrawings. Following the esquisse, the application of paint is described as three well-defined stages: *ébaucher, peindre à fond* and *retoucher*. The first stage was the initial thin paint layer, which defined the elements of the composition. The succeeding stage consisted of the continuing build-up and modelling in layers to create an even transition between the elements and depth in the composition, before the final touches, glazes and highlights (retouches) were added in the last stage. The highlights were applied using a slight impasto to add immediacy to the painting. It was recommended that the layers between each stage should be allowed to dry completely before the next stage was initiated, possibly with intermediate varnish layers to prevent oil medium absorption from the subsequent paint layers (Oudry 1752/2008; Jombert 1766:114; Massing 1998:354-359; Slotsgaard 2015).

Various pigments were available to artists in Juel's era and progressively more became available over time, such as Prussian blue, one of the earliest in 1704 (Harley 2001; Kirby & Saunders 2004; Eastaugh et al 2008:314). Many pigments are stable, while others proved unstable, which quickly became known to artists who made choices or adjusted their method of application accordingly, while some of the earlier pigments fell out of use over time (Van de Wetering 1995; Van Eikema Hommes 1998; Saunders & Kirby 2004). A large number of names related to similar pigments and different qualities can be found (Dossie 1758:8-11; Mandelberg 1786; Massing 1998:340; Eastaugh et al 2008). In the treatises of the time, significant attention was given to the use of pigments, their different effects and even to the positioning of specific colours on the palette depending on the subject to be painted (de Piles 1684:40-50; Jombert 1766:89-101; Watin 1776, Dossie 1758, de Massoul 1797). The traditional palette consisted of lead white, Naples yellow,

yellow ochre, *stil-de-grain*, red lake, vermilion, red ochres, umbers, green earth, ultramarine (or Prussian blue) and bone or ivory black. For portraits, the palette included mixes of lead white and vermilion for the flesh tones strategically positioned in rows below the standard colours (de Piles 1684:40-50; Jombert 1766:89-101; Dossie 1758; Watin 1776; de Massoul 1797:21-22; Massing 1998:342). Further, ultramarine, lakes and yellow could be added to the flesh tones (de Piles 1684:47; Jombert 1766:104). The organisation of the colours on the palette seems to have been a matter of some importance as the artist was required to prepare, mix and lay out the colours required for each painting session in advance, placing them in strategic points. Portrait painters would be required to have pre-mixed flesh tints at hand once the painting session began. In this way, no time would be wasted on adjusting colours while the sitter was present in the studio (Seymour 2007:307).

Painters such as Juel and Abildgaard still prepared their paint in the studio by grinding the pigments in oil and storing them in pig bladders. Juel's self-portrait in the studio display pig bladders, oil and a small glass muller for grinding pigments (Fig. 10.13) and his estate auction lists both stone plates and mullers for grinding (Fugl 1803:30). As with the canvas-preparation, Juel's assistants may have assisted in this process. According to diaries of Hans Hansen and Eckersberg, this practice went on well into the following century, as regular entries describe this practice (Hansen 1907; Villadsen 2009; Bregnhøi & Raabymagle 2019:42). The anecdote from Switzerland reporting that Juel would not arrange his palette for orders less of 100 *louis d'ors* (see Section 2.1), suggests that this was a moiling task and the arrangement likely refers to the organisation of the palette before sittings, as described above.

It is not entirely clear from records how and where painters such as Juel and Abildgaard acquired their painting materials. They likely still acquired their pigments from pharmacists or grocers, as no evidence of registered colourmen exists until 1810 (Bregnhøi 2010:159; Bregnhøi & Raabymagle 2019:41). Accounts from the seventeenth and eighteenth centuries document that many imported materials such as pigments and resins were purchased from apothecaries, spice traders and grocers, and at times from customs officers from ships passing through the Sound (Degn 1969; Bregnhøi 2010: 157-159; Haack Christensen 2019). Also *Børsen*, the seventeenth-century stock-exchange building next to Christiansborg Palace, was a well-established place of trade, where many items could be acquired (Bregnhøi 2010). Many painters' materials comprised of just fragments of bigger items and were often characterised in more general terms such as colours (*farver*) or small-goods (*kramvarer*), making it hard to establish the scope of availability of these materials (Haack Christensen 2019). Other materials such as linseed oil, wax, chalk, carbon-based black (*kønrøg*) and brushes were locally produced (Bregnhøi 2010:155; Haack Christensen 2019).

Aside from the handbooks and treatises of the time, a more direct source indicates the available or used pigments in Denmark at this time. The estate auction catalogue after the death of Johan

Mandelberg, who was professor at the Danish art academy, lists several coloured chalks, pigments and colourants, providing an idea of his use of colourings and the assortment available at the time (1786:58-61). The list includes several earth pigments, both natural and calcinated such as "fine Italian earth", "fine Italian ochre", "calcinated Italian earth", "calcinated Italian ochre" and "terra". Among the red colours were vermilion and several lakes; *Florentinerlak, Carmin* and *Vienerlak* (Vienna lake), which could either be from cochineal or Brazilwood (Eastaugh et al 2008:395), *kugellak* (a generic term for lakes derived from dye-bearing wood) and a "fine dark lake". Various grades of Naples yellow are mentioned and *Zitgel* and *Zitgellak,* likely equivalent to stil-de-grain (Filtenborg 2014:55), as well as *Persik sort* (peach black) and *Scheverhvid* (lead white). These descriptions are seemingly consistent with the conventionality of the time and the typically used pigments. Based on visual analysis from cross-sections, the pigments used by Abildgaard also seem consistent with pigments mentioned in Mandelberg's studio and the typical eighteenth-century palette (Filtenborg 2014:54; Bregnhøi & Raabymagle 2019:40). Such a detailed listing of pigments is unfortunately not available from the estate sale in 1803 after Juel's death. Only general information is given, such as "boxes of pastels" and "several dry colours" (Fugl 1803:30). The analyses made in this chapter, however, show that also Juel's use of pigments and palette is very traditional for the time, although a few dissimilarities are detected as well.

This chapter characterises the design layers in Juel's paintings to investigate the structure of the composition and the build-up of paint layers, from initial sketch to finished portrait. Further, it aims to identify Juel's palette and pigment use; to establish whether there is compensation of different pigments or layers depending on ground colour; and to see whether use of pigments changed over time or depending on location. Lastly, the use and application of varnishes is briefly discussed.

10.1 Sketch and Compositional Changes

Drawing was of great importance both in Juel's training and at the academy. This is evidenced by the preserved drawings from this time (see Chapter 2). Although some drawings and studies for paintings are preserved, surprisingly few representations seem to exist, which can be directly transferred to portraits on canvas (Poulsen 1975). Poulsen's catalogue of Juel's drawings comprises some instances of drawn sketches for portraits, but includes mainly compositional outlines for more complicated arrangements and details such as hands, legs, shoes and clothing. Juel, for instance made a few drawings for the figure and hand position of *Prangins KMS4810* (Fig. 10.1).

It is not exactly clear how Juel laid out the composition for portraits and whether he initiated by making a drawn sketch on paper, as seen in a few instances. If so, very few have survived compared to the large number of finished portraits (Poulsen 1975). Juel's drawing skills were very quick. In the diary of Baroness Prangins, she describes how Juel drew portraits of at least five people in one evening (Monrad 1996).

Fig. 10.1 Jens Juel, drawn sketches for the outline of the hands and figure of *Prangins KMS4810*, the National Gallery of Denmark (SMK) (KKsgb5348 verso), black and white chalk on paper, 278 x 405 mm.

The rarity of preparatory drawings by Juel suggests that either the drawings are unaccounted for or that he recorded the features of the sitter directly onto the primed canvas. Central elements, such as the face, could be completed in the limited time he had with the sitter, while other parts such as the clothing or background, could be finished separately, or possibly by assistants. Several lay-figures and mannequins were present in Juel's studio and likely supported the finishing of the clothing (Fugl 1803). Reports from the studio of the portrait painter Batoni relate that during the two or three sittings he required from his clients, he concentrated on capturing the likeness of the facial features, which he recorded directly onto the canvas. The remainder of the portrait was often finished afterwards from a chalk sketch of the drapery, by use of a model or from one of several stock designs (Clark 1985:39). Juel could have used the same process and, as is reported, Juel usually required a similar three to five sittings of up to three hours (Poulsen 1991:20,85; Christensen 1996:24,52). Similar reports on quickness exist for other portrait painters – the skilled masters needed just a few compositional clues to carry out the portraits (Rouquet 1755:34-38).

Underdrawing

In the previous study, it was suggested that for the layout of the composition on the canvas Juel used the esquisse (Slotsgaard 2013; 2015). In the self-portrait in the studio from 1766, Juel has depicted himself in the process of painting an esquisse on the reddish-brown primed and mounted canvas (Fig. 1.1). The *porte-crayon* on the table next to him suggests he started with chalk (Fig. 10.13). The porte-crayon was designed to hold the chalk while sketching, making it easier to handle and keeping the hands dust-free (Fig. 10.2). This is also the utensil Juel is holding in his hand in *Self-Portrait KMS3990* (Fig. 3.1). The tool was seemingly a very important attribute to

artists, it is depicted in several artists' self-portraits and it is reported that painters such as Reynolds and Hogarth carried one in their pockets at all times (Mösl 2013; Peter 2016:99).

Fig. 10.2 The *porte-crayon* as depicted in Diderot & d'Alembert's encyclopaedia (1751-72).
It is similar to the utensil depicted both in *Self-Portrait KMS3990* and the self-portrait from 1766.
Detail of *Dessein, Instrumens Pl.II.*

Infrared (IR) photography was performed on three of the SMK paintings, *Hauch KMS349*, *Hielmstierne KMS349a* and *Clemens KMS396*, to investigate the use of a drawn sketch (Appendices 5.4, 6.4 and 11.4). These paintings were chosen as they have white ground layers. On coloured grounds, commonly the contrast between ground and underdrawing is not strong enough to make the drawing distinguishable. For a drawn sketch to be detected by IR it usually requires that an absorbent pigment, ideally carbon-rich, is used for the drawing (Van Asperen de Boer 1970; Bomford 2002; Pinna et al (ed.) 2009:172). An underdrawing like the esquisse is usually not possible to detect using IR as it would not absorb the IR radiation enough to create a significant contrast with the ground, and any small contrast would be masked by the overlying paint layers (O'Donoghue et al 1998).

Fig. 10.3 Detail images of *Hielmstierne KMS349a,* normal light (left) and transmitted infrared (TRIR) (right). The TRIR exhibits an indication of an underdrawing along the shoulder, sash and facial contours.

No carbon-containing underdrawing or guidelines were detected in the portraits using IR on the three examined paintings, nor in any of the paintings examined in the previous investigation (Appendix 26) (Slotsgaard 2013; 2015). The three paintings in this study were further examined

using transmitted infrared photography (TRIR). This method allows for an enhanced contrast between ground and underdrawing (Moutsatsou 2011; Cosentino 2016). The TRIR image of *Hielmstierne KMS349a,* shows an indication of a drawing, especially along the shoulder, sash and the facial contour lines (Fig. 10.3). TRIR of the two other portraits, *Hauch KMS349* and *Clemens KMS396,* perhaps indicates a vague sectional outline of a drawing (Appendices 5.4 and 6.4). While Juel is depicted painting with a white paint on the reddish-brown ground in his self-portrait from 1766 (Fig. 1.1), a sketch on a white ground would likely contain a bit of coloured pigment. Iron-containing pigments do not absorb a great deal of infrared so are not easily visible in IR, but if the drawing, either in paint or coloured chalk, contains small amounts of an absorbent pigment, it can be detected in TRIR. Even the vague presence of a drawing in these instances supports the notion that Juel made use of some type of underdrawing, which was likely executed in chalk and paint, even though it is hard to detect in most of his paintings.

Adjustments and pentimenti

While Juel appeared deliberate in his compositions, adjustments or *pentimenti* are occasionally visible. The X-radiographs, as well as paint layers with increased transparency over time, reveal that Juel in some cases made compositional adjustments during the painting process. For the majority of paintings these are small, such as a slight adjustment of a sitter's shoulder, arm or hand position (Appendices 1.3-22.3; Slotsgaard 2013; 2015). In *Rahr KMS3499,* Juel seems to have had trouble placing the sitter's right arm as depicted in Figure 10.4. Only in a few instances does the increased transparency of the paint layer reveal the adjustments as pentimenti visible to the naked eye.

Fig. 10.4 Detail images of *Rahr KMS3499,* normal light (left) and X-radiograph (right). The X-radiograph shows that Juel moved the position of the sitter's right arm during the painting process.

Changes in the composition appear to have had the most visible effect as local craquelure of the paint layer in *Tronchin KMS6151.* Otherwise, neither the type of underdrawing nor the small compositional adjustments seem to have had a visual effect on the stability of the paint layers in the majority of the paintings examined. While the alteration of the composition in *Tronchin KMS6151* is only vaguely obvious in the X-radiograph (Appendix 10.3), the paint surface displays drying craquelure corresponding to the adjustment and movement of the legs and the lower figure (Fig. 10.5). The additional layer of paint handling, in this case, caused increased stress between the paint layers.

Fig. 10.5 Detail image of *Tronchin KMS6151.* The paint surface adjacently right of the figure's legs displays drying craquelure corresponding to the compositional adjustment of the legs and lower figure.

10.2 Paint Layer Application

The few adjustments described above suggest that most of the compositions for standard portraits had been established from the beginning and Juel did not make many changes during the painting process. In general, Juel's painting process appears to have been very deliberate and assertive in its approach. Juel seems to have painted rapidly. He employed a fairly consistent method of working, which he occasionally varied, and he generally approached painting with a certainty and with confidence that his contemporaries admired (Hansen 1907; Christensen 1996a). Juel used a controlled wet-in-wet *alla prima* painting technique. With a confident hand, he modelled, integrated and overlapped or blended the transitions between the compositional elements creating a fluid and even paint surface. Sometimes a more paste-like layer is present and the texture of brushstrokes is evident. Often the drapery has a more rough or sketchy appearance in contrast to more detailed elements such as buttons, laces or jewellery. The build-up from darker to lighter mid-tones creates soft shadows and light, with added highlights and deep shadows in the final stages. The highlights are applied last and with a slight impasto. The impasto highlight create a relief effect compared to the adjacent smooth and even paint layer, adding depth to the portrait, figure and elements (Fig. 10.6) (Slotsgaard 2015; 2019).

Fig. 10.6 Detail of the sleeve of *Tronchin KMS6151* showing the use of transparent layering for visual effects and the relief-effect of the impasto highlights.

Layer build-up

As is evidenced by the cross-sections and through surface cracks under microscope, Juel used only one to two layers of paint, except for overlapping areas. This, either in the transition areas between compositional elements (see for instance cross-sections of *Rahr KMS3499* and *Holm*

KMS1766: Appendices 29.2 and 29.8) or in the deliberate use of the underlying elements as a visual effect (Fig. 10.6). It is at times hard to identify which elements in Juel's paintings were painted first as the transitions are often blended.

The use of only one or two layers is very simple in comparison to the painting practice seemingly widely adopted by French painters of the mid-eighteenth century and described by Jombert and Oudry. Juel appears to have skipped some of this process and the fast and simple layering of the paint is testified both by examination of the paintings and by Runge, who observed it when he was a student in Juel's studio in Copenhagen. Runge wrote in a letter to Johann Wolfgang Goethe:

> Professor Juel was so kind to let me paint in his painting room. Although he has very large practical experience, he for one cannot put it into words … Once in a while he [Juel] has a manner, in which he executes his paintings, which after my opinion cannot be recommended, he retouches them almost from the beginning and executes them partly, you don't know how and you are astonished by how beautiful it turns out in the end.[37]
>
> (Betthausen 2012:23 August 1801).

In comparison, Abildgaard was known for working more slowly. Parallel to his ground layers, Abildgaard's paint application also displays interchanging methods, alternating between the freer alla-prima technique and a systematic build-up of layers resembling the French technique. In some instances, several layers with full underpaintings and even intermediate varnish layers suggest an approach as outlined by Oudry (Filtenborg 2014:44-9). Abildgaard made changes to the composition more widely than Juel, as seen in X-radiographs and some cross-sections: more than ten layers are present in some of the principal sections of works by Abildgaard, while other secondary sections have thinner and fewer layers, down to one or two (Filtenborg 2014:72). In contrast, Juel's paint application displays a simpler structure and more rapid approach.

Intermediate layers or additives

None of the cross-sections in Juel's paintings display any signs of use of intermediate varnish layers when viewed under ultraviolet radiation. Neither does any ultraviolet fluorescence in the paint layers suggest the use of resinous mixtures in the paint, which seems to be drying oil. However, no specific binding media analysis of the paint layers were performed during this study.

Juel's use of few paint layers – without many adjustments and with seemingly limited-to-no use of intermediate varnish layers or mixtures – may be one of the stabilising factors accounting for

[37] "Professor Juel war so gut, bei ihm auf seinem Simmer mich…malen zu lassen. Dieser hat zwar eine sehr grosse Praktik, allein er kann sich nicht darüber äussern … Er hat indes itzt eine Manier, die Bilder herauszubringen, die, wie ich glaube, nicht zu recommendieren ist: er retouschiert sie fast von vorne an and bringt sie zum Teil heraus, man weiß selbst nicht wie, and man muß sich wundern, wie schön es doch zuletzt wird.'

the well-preserved state of and few losses seen in his paintings. If Juel's technique is compared to other portrait painters, such as Reynolds for instance, there is a great difference in paint application method and state of preservation. Reynolds used many paint layers and complex mixtures, adding media such as megilp and waxes to the binders. He made many changes in composition and design during the process and he often applied several layers to achieve the effects he desired (Fig. 10.7) (Townsend et al 1998; Gent et al 2014). This approach had severe consequences for the structural stability and adhesion between layers that resulted in significant cracking, flaking and losses – issues that became evident soon after the paintings were carried out and remain problematic for conservators today and for the stability of Reynolds' paintings (Kirby Talley 1986; Jones et al 1999; Gent et al 2014; Davis & Hallett 2014).

Fig. 10.7 Cross-section and detail from Sir Joshua Reynolds, *The Infant Hercules Strangling the Serpents,* c. 1788, the State Hermitage Museum. The cross-section shows a great number of layers and the use of intermediate layers (Gent et al 2014 and with courtesy of Kamilla Kalinina, Elizaveta Renne & Marika Spring).

Application depending on ground colour

There does not appear to be an overall difference in selection or use of pigments in the paint application because of different ground colours. Cross-sections from the cheek of the flesh of *P.J.Schouw KMS1113* and *Bagge KMS1115* (Fig. 10.8) display a similar pigmented single paint layer whether on a coloured ground or a white ground. When a darker reddish-brown ground was used, Juel sometimes took advantage of the ground colour in the contours of the face and the shadows. Sometimes the ground is visible in many sections; other times, it does not appear to be visible or particularly used. When not deliberately used, as well as when painting on a lighter ground, Juel simply painted the shadows in. One instance where the reddish-brown ground is markedly used and visible in the composition is *A.C.Schouw KMS1114*, which overall has a very scarce paint layer application (Fig. 10.9). This is in contrast to *Bagge KMS1115*, painted on a white ground (Fig. 10.10). Here the shadows are painted in instead. In such ways, Juel's paintings

at times display significant variations in the execution. This raises questions as to whether the portraits were sometimes executed, or partly executed, by another hand, such as one of his assistants, or whether Juel simply adjusted his technique depending on the colour of the ground.

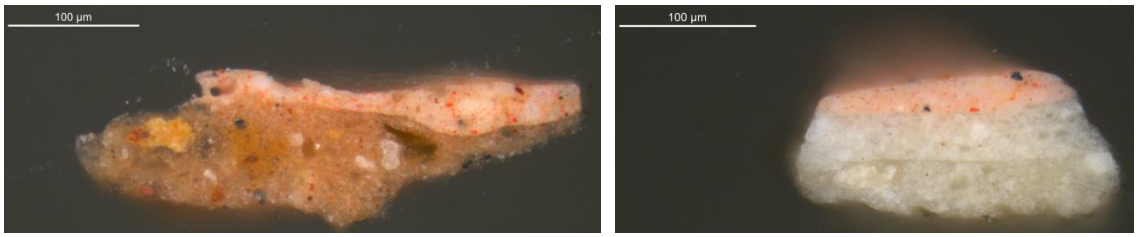

Fig. 10.8 Cross-sections from the cheek of the flesh in *P.J.Schouw KMS1113* (left) and *Bagge KMS1115* (right). Both display a similar pigmented single layer regardless of the ground colour.

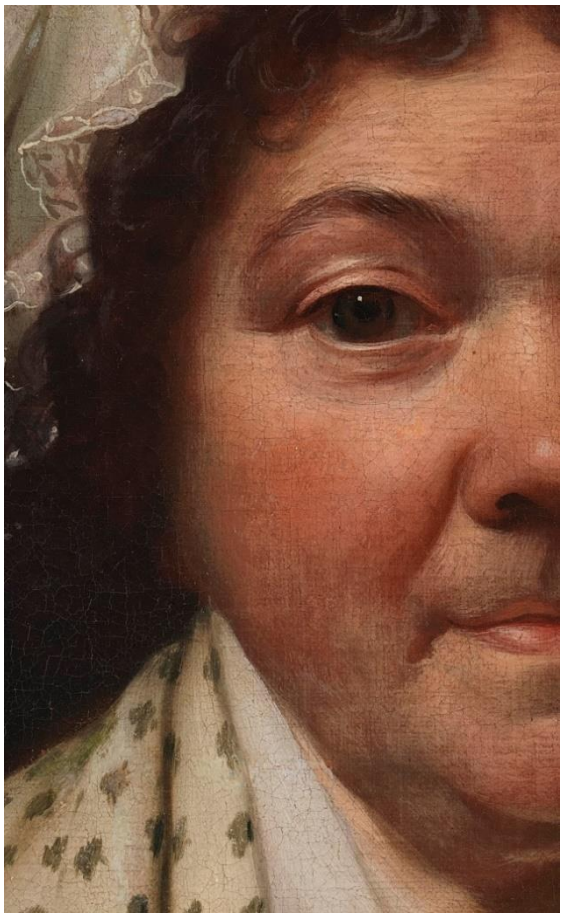

Fig. 10.9 Detail image of the face of *A.C. Schouw KMS1114* painted on a reddish-brown ground. The ground layers is markedly used in the composition combined with a very scarce and thin paint layer.

Fig. 10.10 Detail image of *Bagge KMS1115* painted on a white ground. Compared to Figure 10.9 the shadows are painted in and the ground is not used in the composition.

10.3 Pigments and Palette

There are two instances in which Juel himself showed his palette and provided a visual idea of which pigments he used. Firstly in his self-portrait from 1766 (Fig. 10.11) and again later in his

self-portrait from 1791 (Fig. 10.12). As suggested by Poulsen, the palette from 1766, partly hidden by the artist's sleeve, displays: "… white, Naples yellow, ochre and vermilion with different pinkish tones in the centre."[38] (1991:13). Poulsen mentions both Naples yellow and ochre, although only one type of yellow paint is depicted on the palette. This, however, may be due to the pig bladders placed on the table next to the artist. Three pig bladders with a yellow, a darker yellow and a red colour are depicted, which visually corresponds to the colours of Naples yellow, yellow ochre and vermilion (Fig. 10.13).

Fig. 10.11 Jens Juel's palette, detail of Juel's *Self-portrait KS93 (1)*, 1766, Figure 1.1.

Fig. 10.12 Jens Juel's palette, detail of *The Artist and his Wife Rosine, née Dørschel,* 1791, Figure 2.6.

Fig. 10.13 Materials for painting, detail of Juel's *Self-portrait KS93 (1)*, 1766, Figure 1.1.

[38] "… hvidt, neaplergult, okker og cinnober med de forskellige rosa toner i midten."

In the other self-portrait, from 1791, the entire palette is visible (Fig. 10.12) and as described by Poulsen: "… there are lead white, Naples yellow, a light and dark ochre, vermilion, madder lake, burnt sienna, ivory black and green earth; in the middle of the palette the three flesh tones can be seen and a grey mid-tone. Ultramarine, he probably had on the side, likewise red earth for the ground layer."[39] (1991:22; 1961:21). These are qualified suggestions and correspond to the treatises and traditional palette used by other painters at the time. The suggested pigments on the palette largely resemble the palette presented by Roger de Piles and with the colours placed in almost exactly the same position (de Piles 1684).

Pigment analyses

The technical analyses on the selected paintings during this project sought to identify scientifically Juel's use of pigments. Juel's palette and use of pigments throughout his career were investigated by cross-sections and SEM-EDX analyses, and by using various non-invasive surface analyses techniques: XRF, FORS and ER-FTIR. The latter were carried out only on the sixteen portraits from SMK. To identify pigments and pigment mixtures, micrographs of the paint surface supported the interpretation of the chemical elements present in the paint layers (Appendix 35). The various colour passages in the paintings were analysed along with a few standard points in the facial areas of the portraits for comparison.

Juel's palette and use of pigments appear to be very consistent throughout his career with only minor variations. They are very traditional for the time, corresponding to the standard palette and pigments described in contemporary treatises and as suggested by Poulsen. However, some dissimilarities have been found as well. Lead white, vermilion, red, yellow and brown ochres, umber, sienna, Naples yellow, Prussian blue, green earth and bone black was found to have been used throughout the entirety of Juel's career. The use of a red lake was suggested in only two paintings and the use of ultramarine was identified only in the paintings produced in Switzerland. Analyses have shown that Juel mixed pigments to accomplish the specific colours from a fairly narrow range of different pigments, as the colours of the different paint passages often consist of mixtures of the same few pigments. Table 10.1 shows the interpreted results of pigment analyses, giving an overall impression of Juel's use of pigment throughout his career in the different paintings. The identification of pigments and mixtures are elaborated in the following. An evaluation and discussion of how Juel's use of pigments may influence the physical and chemical stability of the paint layers are included in the main discussion (Section 11.3.2).

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[39]" … der er blyhvidt, neaplergult, en lys og en mørk okker, cinnober, kraplak, brændt siena, elfenbenssort og grønjord; midt på paletten ses de tre kødfarver og en grå mellemtone. Ultramarin har han sikkert haft à part, ligesom den røde jordfarve til grunderingen."

Table 10.1 General interpretation of pigments used in the **paint layers** by Juel in SMK paintings based on XRF, FORS and ER-FTIR related to Appendix 35, (s) = SEM-EDX. (r) = Raman. (?) = Equivalent coloured particles visually present in mixtures, but not identified by elements. Blue = Paintings produced abroad. Red = Not analysed by XRF, FORS and ER-FTIR.

Painting id.	Year	Lead White	Vermilion	Red Ochre	Red Lake	Yellow Ochre	Antimony/ Naples Yellow	Prussian Blue	Ultramarine	Green Earth	Copper-arsenite Green	Unspecified Ochre	Brown Ochre/ Umber or Sienna	Bone Black	Carbon-based Black
KMS3990	c. 1764	x	x	x		x		x		x		x			
KMS3499	1770	x	x			x	x	x		x		x	x		
KMS3634	1771	x	x	x		x	x	x				x		x	
KMS4801	1772	x	x	x		x	x	x		x			x		
KMS3275	1773-74	x	x	x		x	?			x			x		
KMS349	1776	x	x	x		x	x	x		x			x	x	
KMS396	1776	x	x	x		x	x			x			x		
KMS1766	1778-79	x	x	x			x	x	x				x	x	s
KMS4810	1778-79	x	x	x		x	x	x	x	x		x	x		
KMS6151	1779	x	x	x		x	x	x	x	x			x	x	
KMS349a	1780	x	x	x	s	?	?	?				x	x	?	
KMS1444	1785	x	x	x		x	?	x					x	x	
KMS1445	1785	x	x	x		x	?					x	x	s x?	
KMS1113	1799-1800	x	x	x		?		x				x	x	x	
KMS1114	1799-1800	x	x	x		x		?		?		x	x		
KMS1115	1799-1800	x	x	x		x	?	x		x		x	x		
SV1	1788											s		s	
SV2	1788	s	s												
SV3	1780s	s				s				s	s/r				
SV4	1790	s	s											s	
SV5	1797			s	s									s	
SV6	1797	s													

White

The only white pigment identified in Juel's paintings is lead white, which corresponds with standard practice of the time. This was the commonly used white pigment since antiquity and up until the appearance of zinc white (c. 1780) and titanium white (c. 1920) (Kühn 1986; Layer 1997). The term *lead white* represents a large range of similar materials, but generally refers to

lead carbonate, either cerussite $PbCO_3$ or hydrocerussite $Pb_3(CO_3)_2(OH)_2$ (basic lead carbonate). These can also be found in combination and with extenders like calcium, gypsum or barite (Eastaugh et al 2012:196; Gonzales et al 2019). The type found in Juel's paintings appears to be exclusively hydrocerussite, both in paint and ground layers (Siidra et al 2018). This was the most commonly used type in Europe since the Middle Ages and was prepared by a method known as the Dutch Process (Stols-Witlox 2011; Gonzales et al 2019). Juel used lead white widely in his paintings and it is found to be mixed in to tint the colours in the majority of paint passages (Appendix 35).

Red

For red paint layers, Juel primarily used vermilion and red ochre. Possibly a type of red lake over a layer of red ochre was used in the red jacket of *Hielmstierne KMS349a* and *J.Moltke SV5,* as SEM-EDX analyses indicate a significant presence of aluminium (Al) in these layers (Appendices 31.11 and 31.21) (Kirby et al 2005). The presence of a lake was not confirmed by FORS in *Hielmstierne KMS349a*, which instead suggested a mixture of vermilion and red ochre (Appendix 35.11). In comparison, the similar intense red-coloured vest and collar in *H. Gerner KMS1444* appears composed of red ochre under a layer of vermilion. As mentioned in Section 5.4.3, both *Hielmstierne KMS349a* and *J.Moltke SV5* display fading in the red paint in comparison to the section covered by the rebate of the frame. Such fading is commonly seen in red lakes (Saunders & Kirby 2004; Van Loon et al 2012:220). It has not been possible to investigate which type of red lake and how it may relate to the various lakes listed in Mandelberg's estate auction (1786), mentioned in the introduction of this chapter.

Yellow

Yellow ochre and an antimony-based yellow, likely Naples yellow, were identified as the yellow pigments used in Juel's paintings. Massicot and artificial arsenic sulphides were not identified in the paint layers, and each of these were only found in one instance in the ground layers (see Chapter 9, Table 9.1). However, while arsenic was not identified as an element in the paint layers by XRF, the presence of elemental lead from lead white is indistinguishable from the lead which may be present in massicot (PbO), and the possible presence of lead-tin yellow may be similarly masked in a few instances (Morrison 2010:122). No indication of the use of a yellow lake comparative to stil-de-grain has been found.

The previous study suggested that Juel started adding a yellow pigment to the paints in his later portraits; however, the current study revealed that this was also the case for the earlier portraits. In the majority of paint passages in most of his paintings, yellow particles are visibly mixed in with the paint; this is likely Naples yellow due to its antimony (Sb) content (Appendix 35). Interestingly, a similar prevalence of Naples yellow is seen in the portrait painter Batoni's paint mixtures, which Clark suggests may explain the blonde tonality and softness of colour, which is a striking feature in Batoni's paintings (1985:40). As this is visible in Juel's paintings from before

he had contact with – and possible influence from – Batoni in Rome, it suggests a wider practice and technical approach.

Blue

The primary blue pigment found in Juel's paintings is Prussian blue. Poulsen suggested that Juel kept ultramarine on the side, but analyses show that he may not have used ultramarine while working in Denmark, as this pigment does not seem to be present in any of the portraits painted there. Ultramarine is only identified in the three portraits painted in Switzerland: *Holm KMS1766, Prangins KMS4810* and *Tronchin KMS6151*. It may be that ultramarine was more readily available or cheaper in other countries than it was in Denmark, which allowed Juel to include the pigment during his travelling years. In general, sources suggest that ultramarine was perhaps not widely used or available in Denmark. In the Danish product encyclopaedia of 1807, it was reported that ultramarine was the most expensive and was rarely used (Bruun Juul:vol.3,284). The apothecaries' tariff lists (*Taxt*) of 1672 showed that ultramarine (*Søegrøn*) was between six and forty-eight times as expensive as other blue pigments (Haack Christensen 2019). While many other pigments used were listed in the Sound toll registers, they do not list ultramarine (STR Online). Kirby suggests that small amounts of material such as a packet of lake pigment or ultramarine, were unlikely recorded in toll documents (2019). However, madder lake is listed in the registers (STR Online), so the certainty of this statement could be questionable. From technical analyses of paintings in Denmark, so far ultramarine has only been found in three paintings from the early eighteenth century by Hendrik Krock (1671-1738). However, he seemed to have favoured Prussian blue and may have used ultramarine only at the request of the patron (Ludvigsen et al 2015). Filtenborg has only found Prussian blue and no use of ultramarine in paintings by Abildgaard (Filtenborg 2014).

As previously mentioned, Prussian blue was invented in 1704 and was soon the most widely used blue pigment in Europe until synthetic ultramarine and cobalt blue were introduced in the early nineteenth century. It exceeded other pigments such as azurite, smalt and indigo, and was praised for its handling properties, non-poisonous qualities, colourfastness and favourable price, which was much lower than ultramarine (Bartoll 2008; Harley 1982:72). Studies of painters working in Denmark, such as Krock, show that it was used there at least by 1721 (Ludvigsen et al 2015). However, at least by the mid-eighteenth century sources started to report and warn that Prussian blue is inclined to discolour or fade, and today this is a well-known phenomenon in paintings where the pigment is used (Pernety 1757:xcii; de Massoul 1797:182-183; Kirby & Saunders 2004; Kirby 1993; Berrie 1997; Samain et al 2013). As described in Section 5.4.3, the large background of *P.J.Schouw KMS1113*, which is identified as a mixture of Prussian blue and lead white, has faded significantly. Similar fading is seen in Abildgaard's paintings and in paintings by several Danish Golden Age painters where the pigment was used (Filtenborg 2014:57; Filtenborg et al 2015).

Green

Green earth was identified in the green paint layers in several paintings; however, in numerous other instances the green paint layer is identified as mixtures of Prussian blue and Naples yellow. This is seen, for instance, in *Battier KMS3634* in the green leaves of the bouquet (Fig. 10.14). At other times, all three pigments have been mixed to compose the green colour. The mixture of blues and yellows to make optical greens was not uncommon (Grissom 1986:144; Kirby & Saunders 1998; Cove 2017).

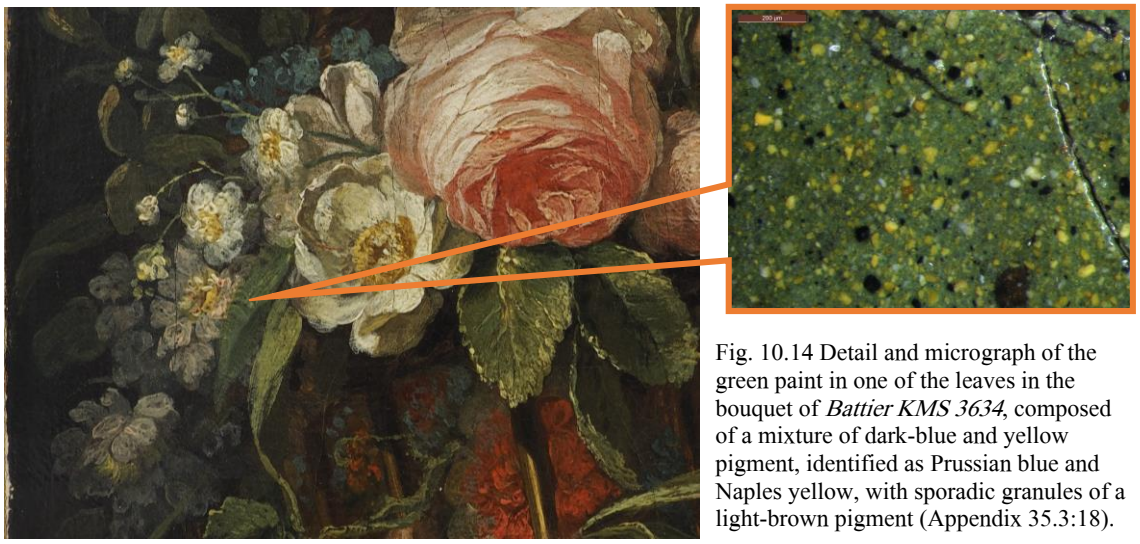

Fig. 10.14 Detail and micrograph of the green paint in one of the leaves in the bouquet of *Battier KMS 3634*, composed of a mixture of dark-blue and yellow pigment, identified as Prussian blue and Naples yellow, with sporadic granules of a light-brown pigment (Appendix 35.3:18).

The paint layers of the green dress in *Buchwaldt SV3*, are composed of two layers of green (Appendix 29.19). The pigment used is seemingly green earth due to its high potassium (K) content in SEM-EDX; however, as the only green or blue paint in the paintings examined, it also showed relatively significant presence of copper (Cu) and arsenic (As), which could indicate the presence of a copper green (Appendix 31.19). Raman spectroscopy of the sample suggested the lower homogeneous layer could be a copper-arsenite, such as Scheele's Green, which can be found in various chemical forms, while the top layer is likely a mix with green earth (Appendix 32). Scheele's green was invented in Sweden in 1775, and introduced in 1778, and was a precursor to emerald green or Schweinfurt green (Paris green) (Harley 1982:83–84; Fiedler & Bayard 1997:220: Eastaugh 2008:341). Its use as pigment for painting is generally little documented, and if Juel used this pigment in the 1780s, it could be an early occurrence of the use of this or a similar pigment in Denmark.

Earth-based pigments

Various earth pigments were used in Juel's paint layers. However, not all could be identified as a specific earth colours, either due to being present in mixtures or because they contain similar elements to one another. Ochres are variable naturally occurring earths, primarily composed of oxides and hydroxides of iron that produce a wide variety of colours of yellow, orange, red, purple and brown depending on their composition (Helwig 2007; Eastaugh et al 2008; Stols-Witlox

2017:90-93). While red ochre (hematite) and yellow ochre (goethite/limonite) could be specified in most cases, some paint passages containing earth pigments present in Juel's paintings were more difficult, and are therefore listed in Table 10.1 as "unspecified". Darker passages could be determined as brown ochre, or as sienna or umber by the presence of manganese, which usually does not occur in ochres (Eastaugh et al 2008:152,285,345). Earth is the more general term suitable when it is clear that the pigment is from a natural source (Helwig 2007), but this was only identified in two of the ground layers (see Chapter 9). Historically the nomenclature for the various ochres, earths (clays), umbers and siennas has been complex and inconsistent, and the choice of appropriate terminology remains problematic (Helwig 2007). As can be seen in documentary sources, and as listed in Mandelberg's estate auction, a large number of different names and varieties existed and Juel's use of various earth-based pigments can currently not be connected to these names. It can only be concluded that he made use of various earth-based pigments and that many varieties were available.

Black

Bone black (ivory black) was found as the primary black pigment used in the paint layers, while in only one instance (*Holm KMS1766*) was a carbon-based black identified. This is in direct contrast to the ground layers, where carbon-based black was primarily found, while bone black was only found in one instance. This difference could suggest a conscious choice in using bone black over other carbon-black pigments for paint layers specifically. Most blacks are carbon-based, but bone black can be identified specifically by the combined detection of phosphorous (P) and calcium (Ca) (Harley 1982:157-158; Winter & FitzHugh 2007:9). When painted in mixtures of lead white, the various carbon-based pigments can appear slightly brownish or bluish and could be used according to the tone the artist wished to obtain (Winter & FitzHugh 2007:13).

The carbon-based blacks identified in the ground layers are primarily small granular particles, possibly soot based, like the Danish produced *kønrøg* or peach-black listed in Mandelsberg's estate auction (Bregnhøi 2010:157-59; Mandelberg 1786). However, the carbon black found in *Holm KMS1766* is likely to derive from charcoal due to the linear form of the pigment particles, suggesting a wood source (Fig. 10.15) (Winter & FitzHugh 2007:23-27).

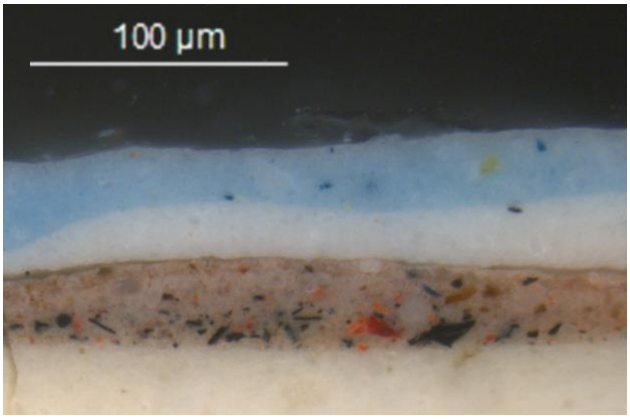

Fig. 10.15 Cross-section image of *Holm KMS1766* showing linear particles corresponding to charcoal black.

10.4 Varnish

For centuries, it has been common practice to apply a coat of varnish as a finish on oil paintings (Phenix & Wolbers 2012:524). As traditional natural varnishes deteriorate over time causing yellowing, loss of transparency and eventually cracking, which can obscure the images beneath them, they are often removed periodically in conservation treatments and replaced by new varnishes (De la Rie 1987; Phenix & Wolbers 2012). Upon assessment, a few of Juel's paintings present with a very yellowed or degraded varnish. Extreme yellowing of the varnish is seen, for instance, in *C.S.Gerner KMS1445* and *Bagge KMS1115,* while crystalline cracking and flaking is most evident in *J.B.Neergaard SV1* (Fig. 10.16). At times, Juel's paintings display the presence of multiple varnish layers in cross-section, as a new layer was applied on top of an older varnish, or a residue left behind from previous varnish removal can be seen in ultraviolet fluorescence (Appendix 29; Appendices 1.2-22.2).

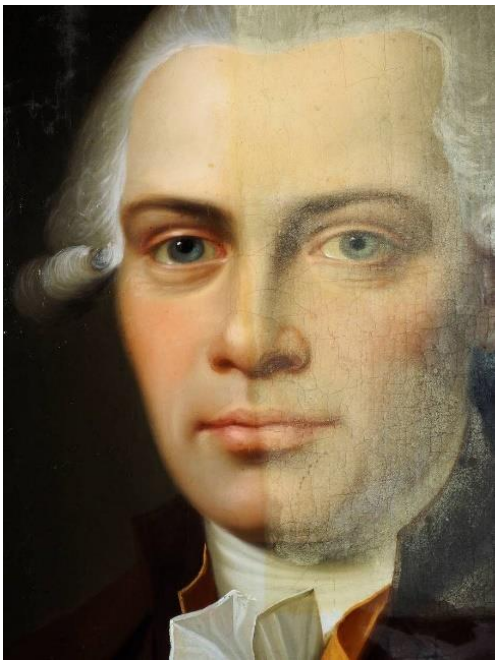

Fig. 10.16 Detail of *J.B.Neergaard SV1* during varnish removal. The right half displays the highly degraded and visually disruptive varnish, while the left half displays a complete and uninterrupted paint layer after varnish removal.

From at least one source, it is known that Juel varnished his paintings. In the diary of Baroness Prangins, written at the time Juel was creating her portrait, she reported that Juel returned to the Prangins' castle to finish and varnish the painting (Monrad 1993). For most of Juel's paintings, the original varnish layer has not been preserved. However, in a some of the portraits from Svenstrup the original varnish layer may have been preserved and it could appear that Juel also made use of a temporary egg-white varnish.

Original varnish

The application of an additional varnish layer on top of an older aged varnish layer was evident in the portraits from Svenstrup. The last layer of varnish was applied without the painting having been removed from the frame; this is evident from residues on the inside of the frame and the section of the painting covered by the rebate of the frame which remained uncovered by the later-applied layer. As the portraits from Svenstrup have a minimal documented treatment history, the initial layer visible along the edges covered by the rebate of the frame might have been original. Varnish samples from *J.B.Neergaard SV1* and *A.M.B.Neergaard SV2* were removed for FTIR analysis, both from the possible original varnish along the edge of the painting (samples 1A and

2A), and from the central part of the painting with the later-added varnish for comparison (samples 1B and 2B) (Appendix 34). FTIR spectra of each of the four samples all suggested the presence of mastic or dammar varnish.

Varnishes such as mastic and sandarac had been used for centuries before Juel was working, while dammar was not introduced in Europe until the nineteenth century (1828) (De la Rie 1987; Mayer & Myers 2002; Phenix & Townsend 2012: 257-60). It is therefore possible that the sub-layer consisted of mastic and the later-applied is a dammar, but it is not possible to come to a more secure conclusion. Many different recipes for varnish existed in sources at the time (Massing 1998:347-49; O'Donoghue 1998:185). In the Danish publication *Fernisse-Bog Indeholdende practiske Anvisninger til at tilberede alle Slags Fernisser ...,* at least twelve different recipes for paintings are included (Hallager 1799:73-79). A handwritten varnish recipe found in Abildgaard's papers includes components of sandarac, mastic and oil of turpentine. It is signed with an "M", and Filtenborg suggests it was given to Abildgaard by Professor Mandelberg, his former teacher (Filtenborg 2014:59). Sandarac residue was possibly detected in two of Juel's paintings by GC/MS (cf. Section 9.3), but it is unclear whether this might derive from such an original mixture or have been later applied.

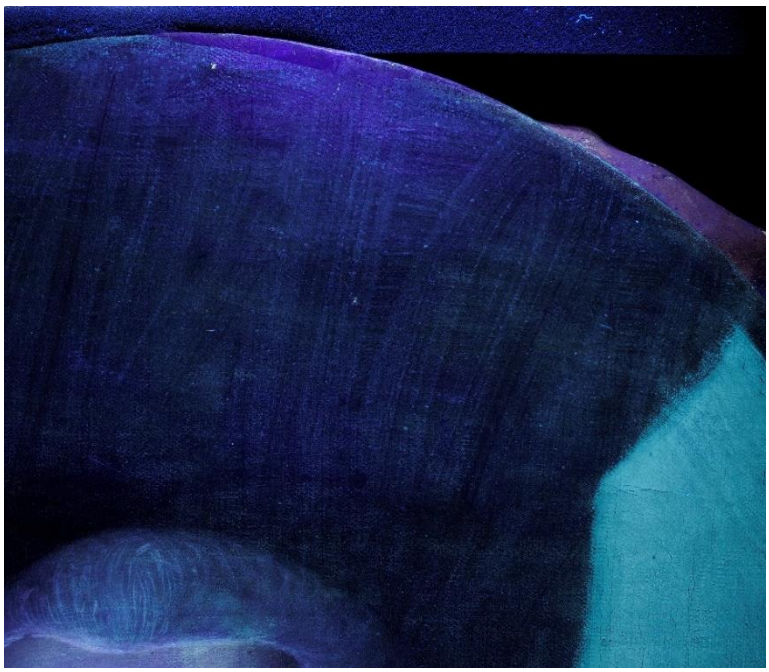

Fig. 10.17 Detail UV image of *J.B.Neergaard SV1*, displaying a thin residual fluorescent and insoluble layer beneath the removed resin varnish (the latter is still visible in the lower-right corner of the image). The streaky nature of the sub-layer suggests it was applied with a brush. ATR-FTIR analysis identified the layer as protein suggesting it could be a layer of intended temporary egg-white varnish.

Temporary egg-white varnish

Juel may at times have used a temporary varnish, although it is unclear to what extent this practice was used. During varnish removal on *J.B.Neergaard SV1* and *A.M.B.Neergaard SV2* the appearance of a very thin residual fluorescent and insoluble layer beneath the resin varnish

became evident and the streaky nature of the layer suggested it was applied with a brush (Fig. 10.17). An additional cross-section was removed from the edge of *J.B.Neergaard SV1,* where this layer was present. ATR-FTIR analysis identified the presence of protein and possibly that the layer was a temporary egg-white varnish (Fig. 10.18) (Meilunas et al 1990).

Egg-white varnishes have been identified as having been used for various purposes since the Middle Ages. At least by the nineteenth century it does not appear uncommon that they were used – often but not always for temporary applications – on oil paintings, where they could easily be removed with water before a more permanent varnish was applied (Bouvier 1827:584; Woudhuysen-Keller 1994; Carlyle 2001:233-236; Phenix & Townsend 2012). Egg varnish was considered well suited for oil paints that were not completely dry, but had to look their best for sale or exhibition. For instance, is it described that in Gainsborough's studio, paintings were displayed for up to five months before the paintings could be varnished (Sloman 2002; Ayres 2014; Peter 2016:103-04). A temporary egg-white varnish could have been used in such instances (see Section 2.6). Such a varnish was, for instance, found in paintings by Juel's former assistant Caspar David Friedrich (Mösl et al 2017), and Eckersberg described in March 1827 how he varnished paintings temporarily with egg white and washed it off again about one month later (Villadsen 2009:243,249-50). The practice was further referred to in a Danish magazine for artists and craftsmen (Ursin & Hummel 1838:248). The magazine described that when the egg varnish was removed, a mastic varnish was suitable for an oil painting.

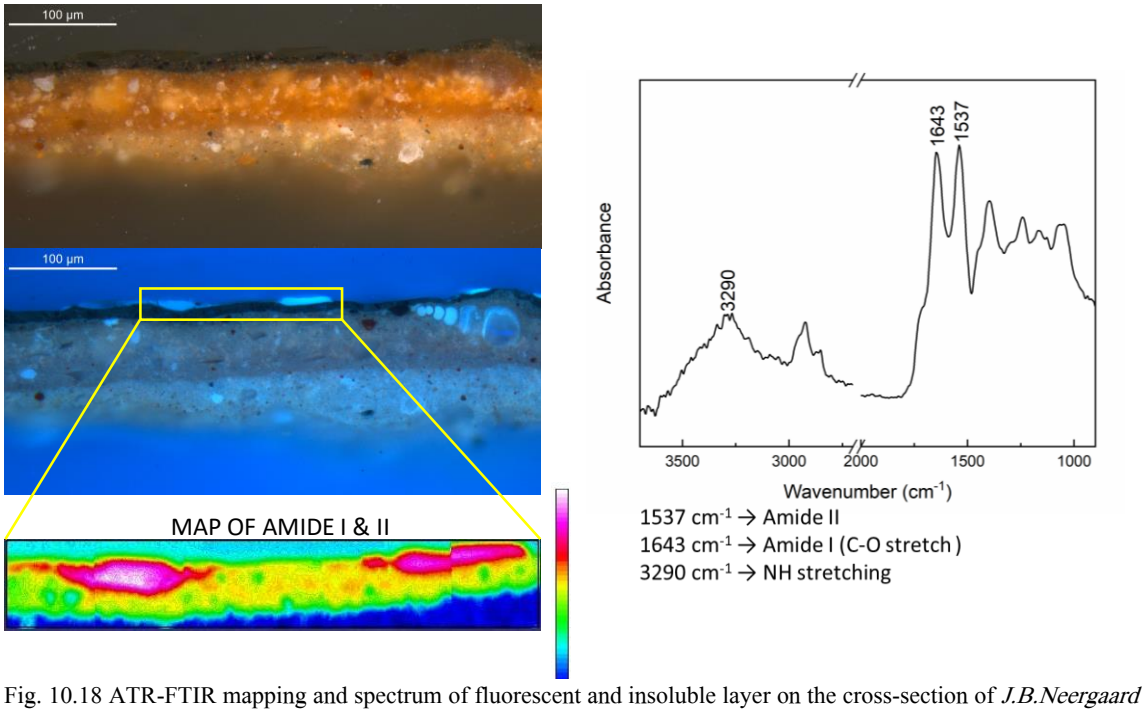

Fig. 10.18 ATR-FTIR mapping and spectrum of fluorescent and insoluble layer on the cross-section of *J.B.Neergaard SV1* (cross-section SV1-598c). The presence of a protein was identified by the presence of the Amide I and Amide II bands and the N-H stretch at absorbances associated with the proteins of egg (Meilunas et al 1990:41).

10.5 Chapter Summary and Conclusions

Few preparatory drawings for Juel's portraits exist, or have been preserved, and it is possible that Juel in most cases recorded the features of the sitter directly onto the canvas during the limited time available during sittings, while clothing and the background could be completed afterwards. No carbon-containing underdrawing could be detected. The vague presence of an underdrawing using transmitted infrared photography, in combination with the self-portrait from 1766 depicting Juel in the process of carrying out an esquisse as well as the presence of the porte-crayon, suggests he used the esquisse as an underdrawing, which follows the practice of other painters at the time. For the majority of the portraits examined, only small adjustments and minor pentimenti were detected using X-radiography. This, in combination with few paint layers, mostly one or two, shows that Juel had a very deliberate and assertive approach, suggesting that most of the compositions for standard portraits had been certain from the beginning and Juel did not make many changes during the painting process. The simple layering of the paint and his rapid approach for executing his paintings does not correspond with the layered build-up otherwise recommended by the French mid-eighteenth-century painters. Neither does Juel appear to have made use of intermediate varnish layers.

There seems to be no significant difference in the layering or pigment use in paintings with different coloured grounds, although when painting on the coloured grounds Juel sometimes included the colour of the ground in the composition in the shadow areas, while other times, as well as when painting on light grounds, he painted the shadows in.

Juel's palette and use of pigments proved very consistent throughout his career, with only minor variations. It is very traditional for the time and corresponds to the palette and pigments used by other painters of the era and those described in contemporary treatises. Lead white, vermilion, red, yellow and brown ochres, umber, sienna, Naples yellow, Prussian blue, green earth and bone black were found to have been used throughout the entirety of Juel's career. Often he used these pigments in various mixtures to create the colour he desired. The use of a red lake was suggested in only two paintings and the use of ultramarine was identified only in the paintings produced in Switzerland. Ultramarine was very expensive in Denmark and seemingly only rarely used. Juel's usage of the pigment while abroad suggests a different availability or price, allowing the painter to use it. Only the paint layers that was identified as red lake or Prussian blue display evident fading, which is an issue commonly known for these pigments. Further evaluation and discussion of the stability of Juel's use of pigments are included in the following chapter (Section 11.3.2)

As customary for the time, Juel applied varnish to his finished paintings. He may have used mastic or sandarac and in some instances he appears to have made use of an egg-white varnish, likely temporary. This could be washed off before the final varnish was applied.

11 Main Discussion

> The characteristics of a pattern are determined not so much by individual features but by their interrelationship. The synthetic effect of the whole pattern is more important than an analysis of its parts.
>
> – Spike Bucklow, 1997

While the individual layers and elements of Juel's paintings and practice have been examined and discussed in the previous chapters, it is important to look at the whole pattern of what information the examination of the paintings can provide as a material expression of history and practice in combination with documentary sources. This must be considered with regard to Juel's use of materials and his practice, as well as what they can provide towards an enhanced understanding of the general practice, the availability of materials and the emerging art market in Denmark in the late eighteenth century. Furthermore, this can lead to an improved understanding of the tensions in the entire structure of the painting, how the layers influence each other and their combined role in the preservation or degradation of the paintings. The discussion also includes reflections on conservation treatments of the paintings with some general advice and concerns with a view to their future preservation. Not all questions are, or can be, answered by the investigation made in this thesis; it does however, provide some insights towards a greater understanding of these matters. This information and their correlations are discussed in this chapter.

11.1 Material Knowledge and Availability

Documentary sources establish Juel as an amiable and conscientious character who was ambitious and interested in both the practical and theoretical aspects of his line of work. Although a combination of societal circumstances, timing, talent and taste played a role in Juel's success as a portrait painter, he also had an innovative approach in the establishment of his name and business of portrait painting, which provided him with incomparable accomplishments, fame and the status of a public figure (Slotsgaard 2019). Juel was by far the most productive Danish painter in his era. When comparing Juel to his contemporaries, especially portrait painters around Europe, many concurrences can be found in their training, careers and theoretical knowledge. The shared trends and practices especially regarding the influence of academic teaching, are evidenced for instance by the practice of drawing (see Chapter 2). Runge's comment on Juel's painting technique (see Chapter 10), using the term *retoucher* as expressed by Oudry, also suggests a strong awareness of the French paint application method or a sense of common terminology in Europe. Likely, the sharing of information during the Grand Tour supplied common knowledge as well as the many publications on theory and practice, which were compiled and published during the eighteenth century. The era was generally characterised by a fast development in information sharing, with the first directories, establishments of newspapers, vast publications of books and

the advancement of commerce, transport and shipment opportunities. Many trends, initiated in larger cities such as London and Paris, eventually also reached Copenhagen, Denmark, leaving the city's population not far behind in many instances, while other fashions appear to have taken a bit more time (Feldbæk 2012; Juul 2013).

Supply and demand

The availability of materials or items must have been contingent on necessity and demand. It appears that many materials commonly available in Europe at the time were also available in Copenhagen. However, the extent of access to some materials appears to have varied. As demand grew, it enabled both new and recognised trades to evolve and establish shops and supply chains. This is for instance seen in the establishment of furniture shops in Copenhagen from the 1740s, and the further initialisation and slow emergence of ready-made items, which were previously only acquired through commission (see Chapter 6) (Stürmer 1979:479; Dybdahl & Dübeck 1983:20; Farr 1997). The establishment of colour merchants' shops throughout Europe during the eighteenth century was also stimulated by an active need (Kirby 2019). Other countries outside of Denmark saw earlier examples of such merchants, but no evidence has been found before the early nineteenth century of similar professions in Copenhagen. This was probably because the demand was too limited and would necessitate the presence of a significant group of people who required materials for colouring, whether for glass, ceramics, textiles or painting (Haack Christensen 2019; Kirby 2019; Simon 2019). Juel was beyond doubt one of the most successful and productive painters in his time, while several other artists were struggling to find work and receive commissions (cf. Chapter 2). This raises questions with regard to supply and demand, and the likelihood that until around 1800, in Denmark many items were acquired in an old-fashioned way. Most factories that existed were small, and many specialist manufacturers concentrated on one or just a few products (Degn 1969:34: Kirby 2019). Strainers were likely produced by order from one of the woodworking crafts and the canvasses used for painting were the same as those for household products, and for the purpose for painting, they were still assembled in the studio until well into the nineteenth century. The availability of pre-primed canvasses from suppliers outside the studio, especially in Denmark, is less clear. While it is evident that the individual painting canvasses were cut from larger primed sections, without written evidence it is difficult to conclude whether they were produced in the studio of the artist (likely by assistants) or supplied by others such as coarse painters. If the latter, they were likely by commission, rather than kept in store. No written evidence has so far been found prior to Eckersberg's diaries (1816) that proves that pre-priming by suppliers was an established alternative to studio priming in Denmark in the eighteenth century (Villadsen 2009). Comparing ground layers and canvasses between paintings by Juel and Abildgaard, and other contemporary painters, could provide material evidence that they shared suppliers if matches were determined.

Availability and choices

The examination of Juel's paintings shows that his use of materials is largely typical of what was in use and obtainable throughout Europe. However, the absence of some materials reflects both a limit to the immediate availability of some materials and the material choices made by Juel. The absence of ultramarine in the examined paintings by Juel produced in Denmark, for instance, compared to its use while abroad suggest a difference in availability. Either it was not readily obtainable in Denmark, or it was too costly, so the painter decided not to use it. Furthermore, the letter from Runge from 1802 (cf. Section 9.3) where he informs his brother that he is sending Juel a parcel of pastels since Juel cannot purchase them in Denmark, also gives information that not all materials were readily available. The fact that Juel had painted pastels since the mid 1780s shows that he must have acquired them by conscious choice somehow, perhaps through other connections abroad. Documentary evidence of any potential preserved orders or letters Juel might have made abroad would not be located in Denmark and could easily have evaded studies so far. While Juel was notorious for not writing much, other artists and contemporaries corresponded more elaborately, which is for instance seen in the preserved correspondence of Sergel, Abildgaard and Thorvaldsen, showing that several artists in different locations shared an elaborate network (Gøthe 1898; Arkivet, Thorvaldsens Museum). Furthermore, newspaper entries reflect that items, which were not immediately available for purchase, could be obtained from other countries depending on practicalities and the economic situation of the purchaser (Mediastream, *Adresseavisen*; Venborg Pedersen 2013:59-60). This suggests that if Juel had wished to use certain materials beyond those found in his painting at certain times, he probably could have, but seemingly to a large extent he chose to use those readily and locally available. Juel, with his sense of business and ability to establish himself not only as the most famous but also as the most expensive portrait painter of his time in Denmark, might be expected to have he had certain funds; however, he was also notoriously incapable of managing his finances, which could have been reflected in his spending choices (Weilbach 1877-78:345; Røder 1904:156; Glarbo 1929). When materials were locally available or perhaps more affordable, for instance as was probably the case with ultramarine while abroad, Juel chose to use them. However, customs regulations and banning of goods due to mercantile restrictions are also seen in some instances, which may have limited accessibility of some items at certain times. Further research into archival documents, both in Denmark and abroad, may provide additional evidence about market conditions and goods available for art and artistry in Denmark in the pre-industrial era.

11.2 Materials and Technique

One of the suppositions for this thesis is that Juel, rather than making use of secret formulations, used the same materials as were available to his contemporaries, and that the way he used them was simple, with good technical skills and an assertive hand. This assumption has been confirmed throughout this thesis. The examination of the selected portraits from throughout Juel's career shows that the materials employed by Juel largely coincide with commonly used materials available to artists in the second half of the eighteenth century. When reviewing technical sources

and technical research it becomes clear that the influencing factors for changes between eras or artists are often local trends and accessibility, new inventions or industrial developments.

Materials in Denmark versus abroad

The preliminary investigation suggested a change had occurred between the early and later period of Juel's career and one of the hypotheses was that Juel was influenced by new techniques and uses of materials during his years abroad. While differences in technique and materials were found between those used in Denmark and those used abroad, except for the use of white ground layers, Juel does not appear to have permanently adopted the use of materials and techniques he encountered while abroad. Upon return to Denmark, it seems that he returned to using the same types of materials as before his travels. What this investigation shows, is that the materials and technique used in Denmark do not change much and remained practically the same throughout his career. While the ground layers in Juel's early career are very similar in colour and structure, the later period in Denmark displays a much more varied use of ground colour, including white grounds. However, the colour aside, the components, structure and properties of the ground layers remain practically unchanged. Similarly, while the use of pigments varies in the individual paintings, Juel seemingly used the same pigments throughout his career while in Denmark. In the previous investigation, it was further suggested that Juel added a yellow pigment to his flesh tones in the later period, which might have been a foreign influence; however, this investigation shows that this was also used in his earlier paintings. The systematic use of yellow pigment (Naples yellow) seen in several paint layers is also found in portraits by Batoni, which suggests a wider practice and technical approach that Juel was aware of before any possible influence from Batoni's practice in Rome (see Chapter 10). One exception in pigment use, while in Denmark, is the possible presence of Scheele's green in *Buchwaldt SV3*. This pigment emerged around 1780 and, if used, could suggest that Juel was both willing and able to use new and untested pigments or materials in some cases. Further analysis of other paintings containing green paint passages is necessary to confirm the presence or extent of use of this pigment.

As mentioned before, the greatest divergence in the use of materials in canvas paintings throughout Juel's career is seen in the paintings produced abroad. Small variations in canvas quality, the possible application of a sizing layer and significantly different ground layer compositions suggest either outside influences, that Juel purchased canvasses pre-primed, or that different materials were readily available for artists in those locations. The ultramarine used in some of the paintings produced abroad suggests both a choice and an increased access to this pigment, possibly because it was cheaper than in Denmark. Neither the type of ground found in the paintings abroad – the traditional double ground of red and light grey, or white lead grounds without calcium carbonate – nor the use of ultramarine is confirmed in paintings after Juel returned to Denmark and thus it appears that he returned to using the same type of materials as before his travels. Again, either this was a choice to keep to the steady base of knowledge upon which he was trained and practised, or due to the accessibility of materials. At least, this practice

indicates no interest by Juel to experiment with techniques or expressions, and this attitude could be connected to his business-oriented foundation and consistent production.

Painting technique

The examination of individual paintings indicates changes and variations throughout his career; however, the technique and studio practice is particularly illustrated by the paintings found to match as a group, as it provides clear evidence of the process of creation, from initial preparation to the finished portrait. At least while working in Denmark, it is well known that Juel had assistants working with him in the studio. It is not entirely clear which elements of the practical execution may have been performed by Juel's assistants or whether they primarily assisted in the production of copies (see Chapter 2). The two Svenstrup paintings likely by Juel's assistant Herman Kofoed, *P.J.Neergaard SV7* and *Tønnesdatter SV8*, share technical features with Juel's paintings, with similar approaches in both the preparation and paint handling (Appendices 23, 24, 29.23 and 29.24). While comparative studies between originals and copies from Juel's studio have been left out of this thesis, the similarity in features suggests a general local technical approach.

Comparisons throughout the thesis have been made between the technique and materials used by Juel and Abildgaard. This also shows that their use and choices of materials largely correlate, as well as their approach in preparation and use of large pre-primed canvasses. At other times their technique is rather different, especially in their paint handling. However, even this can be difficult to distinguish between. For instance, it is reported that Juel supposedly painted the sky in one of Abildgaard's Terence paintings (Filtenborg 2014:23,48,88). As the sky in all four paintings displays a different paint handling from the additional parts and was painted before architectural elements were added, Filtenborg raises the possibility that perhaps Juel is the originator of all four skies. Furthermore, art historians cannot completely agree on the attribution of the portrait of Bajocco (Kragelund 2006). Abildgaard nonetheless painted more slowly and made more changes during the creative process, resulting in more paint layers (cf. Chapter 10). Filtenborg has reported that no systematic issues inherent in the paintings appear in those examined. This is in contrast to other contemporaries, such as the English portrait painter Sir Joshua Reynolds, whose use of mixtures of binders and additives had severe consequences for the structural stability of his paintings. Juel does not appear to have experimented much with binder mixtures or used complex build-ups of paint layers, which could be one of the stabilising factors accounting for the well-preserved state of and few losses seen in Juel's paintings.

Although Juel may have developed a more rapid technique over the years, no obvious decrease in the quality and durability of the resultant artworks produced in Denmark appears as a result. It is striking that the most issues seen because of technique or approach are found in the paintings produced abroad; the foreign-made paintings display drying cracks and *Self-portrait KMS3275* has wrinkling in the paint surface – both issues that are likely to result from uneven drying between ground and paint layers. Not only did the paintings produced abroad display differences

in use of materials, but they also responded differently in the drying process. In several of the treatises published during the eighteenth century, which have been mentioned throughout this study, visual consequences as a result of the use of certain materials and techniques were occasionally debated. It is not always clear to what extent the artists were aware of the influence of their choices in materials and techniques on the preservation of their paintings. This raises the question of whether Juel was conscious about the choices and consequences thereof, or unaware of the different materials used in the ground, in the case that he purchased them pre-primed. Alternatively, it could be that due to practicalities he was rushed into painting on ground layers that had not sufficiently dried, which he may or may not have been aware of at the time. It is also not entirely known, at what rate such issues appear, and whether he became aware of such issues himself, encouraging him to return to the techniques and confident practice rooted in the stable foundation of his training.

Mixtures in the tin container

More than a hundred years ago, Karl Madsen questioned what "good mixtures" were in the tin container on Juel's table, with reference to Juel's self-portrait from 1766 (Fig. 1.1). The introduction to this thesis claimed that over the past century our ability to obtain information as to what mixtures Juel used has advanced since Karl Madsen posed his question. With the examinations and analyses made throughout this study we now have a much better idea of the mixtures of pigments, fillers and binders applied to Juel's canvasses.

Although it is still not known exactly what mixture was in the tin container (or *pinceliere*) on Juel's table, based on sources it likely just contained oil for cleaning brushes (Jombert 1766:80; Watin 1776:11; Anonymous 1799:8; Massing 1998). Some sources suggest using the contents of the pinceliere in the mixture for the ground layer (Merrifield 1849:779; Van Eikema Hommes 2004:37; Stols-Witlox 2017:51). However, such content would likely contain a complex mixture of pigments from the brush-cleaning process during paint application, which would end up in the ground layers (Stols-Witlox 2017:51). No such complex mixtures of pigments were found in the ground layers of Juel's paintings. The overlap between pigments used in the ground layers and the paint layers is limited and even displays the use of different pigments in some instances, such as carbon-based black for ground layers and bone black for paint layers. Therefore, Juel likely did not use this content for the ground layers.

11.3 Materials and Technique and their Correlation to Degradation Patterns

As discussed in Chapter 5, although Juel's paintings display various surface phenomena, cracking and craquelure, and many have undergone structural conservation treatments, the studied paintings seem to be in good condition; this is suggested by the few losses, the fact that the canvasses display a low state of degradation and the overall visual appearance of the paintings. The limited paint losses suggest that the adhesion between layers remains stable. The various

types of craquelure, however, make it evident that different reactions have occurred in the paintings, either spontaneously or over time.

The two primary variances in the morphology of the crack patterns of paintings produced in Denmark (and Germany) and those produced in France and Switzerland contributed to the overall hypothesis for this thesis – that Juel used different materials or techniques while travelling. The specific differences in craquelure and degradation patterns cannot be fully explained in this thesis, mainly because the reasons for many crack patterns are not fully understood. However, the examination of the paintings and the characterisation of materials and techniques allow for some identification of the relationship between the materials used and the overall crack-pattern formation.

The most evident difference in materials between the two groups of paintings discussed in this study is found in the ground layers. Those differences are mainly in the quantity and distribution of calcium carbonate (chalk) and lead white. The paintings produced in Denmark contain ground layers with high quantities of chalk and little lead white. This is in contrast to the other group of paintings produced in France and Switzerland that has high amounts of lead white and no chalk. Other factors commonly associated with differences in craquelure morphology, such as differences in canvas characteristics, sizing and ground-layer thickness, could not be identified with certainty or determined to be the influencing factor between the two types of craquelure (cf. Chapters 8 and 9).

The mechanical differences between these pigments and fillers (lead white, earth pigments and chalk) are important and have a strong influence on how the paintings with different types of grounds respond to the environment and external forces. The choice between a white-lead ground and a chalk- or earth-pigmented ground can result in significantly different degrees of degradation (Mecklenburg & Lopez 2006; Tumosa & Mecklenburg 2013; Mecklenburg et al 2013) (see Section 9.2.1). What is found in this investigation, is that these pigments and fillers have a distinct effect on the mechanical properties of the ground and therefore on the way in and degree to which cracking occurs with relation to the entire structure of the painting. Knowing the materials, and the properties that the different materials give to the two different types of ground layers, allows us to recognise and hypothesise about what we are seeing and why. The influence of the materials used and their properties concerning tension in the structure, the initiation and propagation of craquelure, as well as the long-term stability of the paintings, are discussed in the following sections.

11.3.1 Causes of Tension and Crack Propagation

Cracks and craquelure are a visible record of the physical tensions within the structure of a painting (Keck 1969; Mecklenburg 1982; Karpowicz 1990). In most of the paintings studied, the visible craquelure is less pronounced in areas covering the original strainer. This is usually due to

the moisture-buffering properties of the wood, which reduces relative-humidity and temperature fluctuations from the surrounding environment (Michalski 1991; Lighterink & di Pietro 2007; Padfield et al 2020). While we do not know exactly when the strainers on the SMK paintings were replaced, the fact that the cracking corresponds to the dimensions of the original strainers shows that the initial cracking occurred before replacement of the strainers. These observations support the notion that relative humidity is an influencing factor for the initial tension in the painting structure, resulting in stress relief in the form of cracking. Ambient moisture causes swelling of the threads in the canvas and induces expansion of the wooden auxiliary support (Bilson 1996; Fuster-López et al 2017; Vila et al 2017; Andersen et al 2019). This, in turn, causes relocation of forces into the ground and paint layers resulting in differences in the location, density and shape of crack formation (Andersen et al 2019).

For the paintings produced in Denmark, the morphology of the crack patterns displays a combination of smaller and larger cracks and islands of both straight and curvy lines. The jagged nature of some of the cracks that follow the threads, suggests that the layers of the painting are influenced by the swelling and shrinkage of the canvas yarns responding to changes in relative humidity (Scharff et al forthcoming). As previously mentioned, a ground layer consisting primarily of chalk and/or earth pigments is weak and susceptible to changes in ambient moisture. Thus, the contraction and swelling of the canvas due to relative-humidity cycles may cause the initiation of cracks in the ground layer. The canvas supports in the paintings produced in Denmark are denser (have higher cover factor) and have thicker and more tightly spun threads compared to the canvas supports of paintings produced in France and Switzerland. This makes these canvasses more prone to swelling and contraction, thus the combination of a weaker ground with a more reactive canvas would be expected to initiate more cracking.

In contrast, the cracks found in the paintings produced in France and Switzerland display larger islands of diagonal and straight lines, which do not appear to be directly related to the canvas-weave structure. Therefore, the swelling and shrinkage relative-humidity cycles of the canvas might be less of an influencing factor in the crack initiation and propagation in these ground layers. Rather, they could be initiated by exposures to low temperatures. Lead-white paints have relatively high glass-transition temperatures (T_g) and as such may be much more vulnerable to lower temperatures than other pigments such as earth colours (Phenix 2009). Both low relative humidity and low temperature can cause paints to become stiff and brittle; however, it is found that lower temperatures can have a much more severe influence on the embrittlement of strong paint films such as lead white, due to its higher glass-transition temperature (Mecklenburg 2005; Phenix 2009). The paintings could have been exposed to low temperatures resulting in enough tension in the structure to make them crack during ordinary climate cycles early in their history.

That cracking in the ground layer can be related to swelling of the threads of the canvas is supported by the presence of micro-cracks (Scharff et al forthcoming). These are discussed in

Chapter 5 (Table 5.3). These micro-cracks are visible in the X-radiographs in the location above the intersecting threads, parallel to the spinning degree, where the ground layer is thinnest. In several instances, micro-cracks appear directly related to the propagation of larger cracks, which are visible in the surface of the paint layer. Mainly, this is the case for those of Juel's paintings produced in Denmark. This is, however, not the case for all of the present micro-cracks. Some are present without having propagated to the paint layers. While these micro-cracks are also present in some of the paintings with lead-white grounds, they do not seem to have propagated into larger cracks in these paintings and are seemingly not visible in the surface of the paint layer (Fig. 5.18). It is still unclear why micro-cracks are only seen in some instances or why they propagate into larger cracks in some paintings and not in others – the worry is that their underlying presence is a potential cause for further cracking. For the paintings produced in France and Switzerland, which have a lead-white ground, the larger cracks are as suggested in Chapter 5 rather as having propagated from drying cracks already present in the paint layer (Willigen 1999). As discussed in Section 9.3.1, the formation of drying cracks is likely a result of the ground not having properly cured before the paint layers were applied, which could be due to the use of a slower-drying oil or a lower state of oxidation in these ground layers.

What is important is that once cracks occur, they act as a stress-relieving mechanism in the painting structure (Keck 1969; Mecklenburg 1982; Karpowicz 1990; Paquette et al 2002). Likely, equilibrium has occurred within Juel's paintings in relation to their environment, which does not deliver excess stress to the structure in their current state (Michalski 1993; Michalski 2014; Vila et al 2019). The paintings from SMK entered the museum at various times from 1838 to 1958. Before this, and until climate control was introduced at the museum by the end of the 1960s, they would have been exposed to multiple cycles of various climate fluctuations (Andersen 2013:17-19; Andersen et al 2014). The Svenstrup paintings have been stored and displayed in the climate of a large private home, with repeated similar seasonal cycles over many years. The canvas, furthermore, sits slightly loose on the strainer, suggesting that stresses are relieved in the paintings due to permanent deformation.

It has been hypothesised that the creation and propagation of cracks and craquelure continue until crack saturation is reached (Bratasz & Sereshk 2018; Bratasz et al 2020). Once cracking and deformation has occurred and tension is relieved, the stresses arising from historically similar levels of environmental fluctuations are practically eliminated; the paintings become less susceptible to environmental changes, and it requires substantially more tension to accumulate in the structure before it necessitates further stress relief. This generally means that paintings with developed craquelure patterns are significantly less vulnerable to climate variations if they have remained stable within this environment for many years. This is the theory of "proofed fluctuations" (Michalski 2014). This may be one of the explanations as to why many of Juel's paintings continue to be in good condition. Another important consideration in this regard, however, is that actions such as structural conservation treatments (re-mounting, stretching and

keying out) typically introduce new tensions and stresses into the structure of the painting, which can cause the paintings to crack further before a new equilibrium is established. This is further discussed in section 11.4.

11.3.2 The Influence of Pigments on Mechanical Properties

The small amount of losses seen in Juel's paintings suggests that the paint and ground layers have not lost their significant cohesion and adhesion strength. Thus, it appears that some of the typical inherent factors that cause instability in the ground and paint layers are not present (Mecklenburg 1982; Ackroyd & Young 1999; Paquette et al 2002; von der Goltz et al 2012:370).

While the strength of the ground layers is important, the paint layers on top of the ground also have an influence on the structural stability of the painting; the pigments used in both the ground and the paint layers influence each other (Mecklenburg et al 2013). The pigments used in the paint layers of Juel's paintings, as presented in Chapter 10, are somewhat limited and correspond to a traditional late-eighteenth-century palette. The overall pigments in the paintings do not seem to contribute to internal stresses that cause cleaving and flaking, either between the canvas and ground, or between the ground and paint layers. None of the pigments used in Juel's palette represent those that are typically associated with very brittle paint films that result in extreme flaking and instability, such as verdigris and the later-emerging zinc white (Mecklenburg et al 2004; Mecklenburg et al 2013). While lead white forms strong paint films, most other pigments found in Juel's paintings are slow dryers that form weak paint films but retain some flexibility. This applies to the earth pigments and ochres, as mentioned above, as well as organic pigments (red lake and carbon-based black), Naples yellow, natural ultramarine, Prussian blue and vermilion (Keune et al 2008; Tumosa & Mecklenburg 2005; 2013).

In the majority of paint passages in Juel's paintings, lead white is included in the paint mixture to adjust tint and tonality (Appendix 35). In these paint passages, lead white adds stability to the paint films. Likewise, the small amounts of lead found in some of the ground layers of the paintings produced in Denmark provide some increased strength to the otherwise-weak chalk layer. If paint films containing weaker pigments are mixed with a stronger reactive pigment, such as lead white, the stronger pigment contributes to a more durable film (Mayer 1930:118; Mecklenburg et al 2013). This can happen even though the lead-pigment content comprises less than twenty-five percent of the mixture (Mecklenburg et al 2013). Possibly the concentration of the lead pigment could be much smaller and still be effective, the effect perhaps being proportionally minimised (Mayer 1930:118; Mecklenburg et al 2013). Similarly, a lead-white ground has the potential of increasing the durability of the layers that are located above, and strong lead-white-containing paint layers can also provide some stability to a weaker ground below (Mecklenburg et al 2013). It is proposed that some metal ions, such as lead, are capable of migrating not only within a layer, but also between layers. Migrating metal ions can affect the film formation and properties of adjacent layers. Thus, adjacent layers containing certain

pigments can provide either stability or instability to the structure – also with regard to sensitivity to solvents (Mecklenburg et al 2013). When metal ions are present, pigment-medium interactions often result in the formation of soaps, as is seen in several paintings by Juel in this study (Section 5.4.4). However, it is still not entirely clear or agreed upon what effects or properties soaps may induce in the paint layers or if they can result in issues in the future (Mecklenburg et al 2005; Noble & Boon 2007).

The possible strengthening effect may explain why a painting with a double ground such as *Clemens KMS396*, whose preparation consists of a lower red-earth ground with random particles of lead and calcium under a lead-white layer, displays craquelure that appears less affected by the canvas and shares more common features with the paintings with lead-white grounds alone. This could possibly explain the link between Bucklow's observation that this type of craquelure is related generally to French grounds in the eighteenth century, and the fact that the majority of French paintings examined from this era appear to have a similar double ground (Bucklow 1997; O'Donoghue et al 1998; Duval 1992). However, such possible correlation must be determined by further and other studies.

11.4 Conservation – Past and Future

In summary of the above sections, it is not only the difference in ground-layer composition between the two groups of paintings identified – those produced in Denmark and those produced abroad – that affects the reaction to moisture and temperature within the paintings' structure, but the overall use of different pigments also shows important influences on the long-term stability of the paintings.

What is evident from this investigation is that there are differences in strength between the two types of grounds. Paintings with a lead-white ground are stronger than those with a ground that mainly contains chalk. A lead-white ground may therefore not be in as much a danger of further cracking, if new tensions are introduced. Those paintings with chalk and/or earth grounds are weaker and more vulnerable to both environmental fluctuations and new tensions. At some point, conservation intervention may become necessary in Juel's paintings. With regard to the rule of proofed fluctuations, it is important to consider how interventions such as structural conservation treatments, re-mounting, stretching and keying out, may introduce new tensions and stresses into the structure of the painting. These stresses can actually cause the paintings to crack further, resulting in flaking, paint loss or other types of damage, before a new equilibrium is established, rather than improving the structural stability. Such interventions are generally considered to reverse, or "nullify" the proofed-fluctuations rule (Michalski 2014).

The variation detected in Juel's use of ground layers and their recognised influence on degradation patterns strongly advises that caution should be taken and attention paid to the type of ground

layer present in any painting to undergo conservation treatment, with the awareness that paintings with different grounds may respond differently as a consequence.

Different factors increase and decrease the strength and stability of the layers, and the issues that affect the condition of the paintings as a whole are complicated. The complexity of the condition of the paintings is increased further by their individual history of treatments, storage, handling and display conditions. Understanding the structural behaviour of both original and added materials in the paintings is essential, as this understanding assists conservators in developing the best strategy for the long-term care and preservation of the paintings.

Most of Juel's paintings included in this study have been subject to cleaning cycles and lining treatments: treatments that could have caused permanent damage and changes in properties. For instance, excessive heat during lining treatments or overexposure to solvents during varnish removal can cause the paint to become permanently more stiff and brittle (Hedley et al 1990; Tumosa et al 1999; Phenix & Sutherland 2001; Mecklenburg et al 2005; Erhardt et al 2005b).

In Juel's paintings, the structural treatments such as lining appear to have been performed mainly as a preventive measure. There is not evidence of a great amount of paint loss, significant cupping related to cracks or signs of canvas degradation in Juel's paintings, which would suggest a severe need for structural intervention. While conservators with the best intentions performed these treatments, we now know that such treatments are not always beneficial to the paintings, and in Juel's paintings, the lining treatments appear to have caused more damage than good. Firstly, some of the lining treatments in Juel's paintings were performed using a rather rough approach that is, for instance, evidenced by the systematic losses and flattening of impasto seen in some of the paintings, which was likely caused by too much heat and pressure (Chapter 5). Secondly, such interventions and additions of new materials could influence the reactions of the materials, stresses in the structure and the long-term stability of the paintings as well – this is the case both in Juel's paintings and in paintings in general (Andersen & Fuster-Lopez 2019). The materials that have been introduced into the paintings during lining and consolidation treatments, such as adhesives or glue-paste and wax-resin mixtures, can affect the properties of the paintings. Tests of glue-paste linings showed that the linings offer significant support to a painting at fifty percent relative humidity, but severely increased the stress level in the structure in dry conditions and offered no support above seventy percent relative humidity (Andersen 2013). It was also found that wax-resin linings do not have a significant response at low relative humidity, but at levels of above sixty percent, there was a slow but significant increase in force over twenty-four hours in some painting canvases (Andersen 2013; Andersen et al 2014; Gregers-Høegh 2019). Furthermore, research suggests that changing ambient environments can result in bulging. The bulging may represent a permanent enlargement of the painting and, if keyed out, the stress cycle can start again (Andersen et al 2019). Therefore, in many cases, paintings that are lined with certain methods require tighter climate control than un-lined paintings (Mecklenburg 1982;

Hedley 1988; Andersen 2013; Fuster-López et al 2017). However, according to Andersen and Fuster-Lopez, in the same manner as described above regarding proofed fluctuations, once the glue-paste film in some linings is aged or cracked, resulting in stress relief, it may be of less concern when it comes to forces developing in the structure during relative-humidity fluctuations (2019).

The exact physical mechanisms involved in degradation, as well as the structural consequences of some conservation treatments, still require further attention (Andersen & Fuster-Lopez 2019). However, current knowledge and the findings made in this study inform the increasing concern towards lining treatments that have evolved since the 1970s (Villers 2003) and highlight that the traditional methods are not always beneficial to the paintings. With regard to the consequences that various conservation and restoration treatments can have on paintings, we should continue to weigh up what aesthetic appearance is acceptable against what is beneficial to the artwork, and consider how these matters can be balanced while best preserving the painting – not only as a physical object, but also in terms of its integrity and the artist's intent.

With the above in mind, there are considerations to make for both untreated and treated paintings – not only the original material of the paintings, but also the added material should be borne in mind. While this thesis has provided some clear indications of the material composition of Juel's paintings and their differences in properties, the specific treatment strategy in each case remains for the individual conservator to decide, considering the individual painting's history and needs. Furthermore, other paintings by Juel not investigated here may individually present other issues. For instance, conservators at SMK Pauline Lehmann Banke and Troels Filtenborg report that the large-scale painting depicting Niels Ryberg and family (Fig. 7.3) exhibits widespread flaking between ground and paint layers and is currently in need of conservation; this is unlike many of the portraits examined during this study. Inherent issues may be different in this painting than the standard-sized portraits due to the large-scale dimensions, technique or structure of materials.

12 Conclusion

Juel was the most productive Danish painter of his era, with a career spanning forty years that can be divided into periods: his apprentice years, early years in Copenhagen, eight years abroad travelling throughout Europe and his later and most busy years following his return to Denmark. With the hypothesis that Juel used different materials while abroad and possibly that this influenced changes in his technical approach between the early years and later career in Copenhagen, the aim for this thesis was to investigate how Juel's materials and technique varied with regard to time, location and availability of materials. Furthermore, consideration was given to how these differences correspond to degradation patterns – especially the differences in craquelure seen between the paintings produced in Denmark and those produced abroad.

When comparing Juel to his contemporaries, especially portrait painters around Europe, many concurrences can be found in their training, careers and practical and theoretical knowledge, and generally Juel used the same materials as were available to other painters of his time. The examination made in this thesis showed that Juel did use different materials while abroad, especially for the ground layers. It is not entirely clear whether this was a result of changes in technical approach, availability of materials or, possibly, that he purchased the canvasses pre-primed from suppliers. The identified differences in the ground layers especially, appear to be one of the main factors in the development of one type of craquelure over another, and have a significant influence on the mechanical and chemical properties within the structure of the painting. These discoveries support the hypothesis for this thesis, repeated above, that Juel used different materials during his years abroad. However, except for the occasional use of white grounds after this period, the years abroad do not seem to have had significant influences on his technique in the years following his return to Denmark, rather he seems to have returned to a similar approach as in the early years.

Use of materials and technique

The characteristics of the canvasses used for Juel's paintings fit the market conditions of the era and were likely produced and purchased locally. The presence of selvedge show that the weft is most commonly vertically orientated and that for standard portraits Juel made use of the full width of the canvas roll. Some of the paintings produced abroad could show evidence of the use of a sizing layer, however, in most paintings produced in Denmark no sizing layer could be identified and possibly this traditional practice was omitted. In the paintings produced in Denmark, the canvasses are usually cut from larger pre-primed canvasses and it could appear that mounting onto the strainer took place in the studio of the artist. Those produced abroad in a few instances display signs of individual preparation. Juel's use of ground colour reflects the general tradition of ground layers, as well as the broad transition from coloured to light grounds towards the nineteenth century. During the early years in Copenhagen, Juel used a very consistent reddish-brown ground, suggesting it could be studio-made. The ground layers in paintings produced

abroad display a shift, with an emergence of the traditional red-under-white double ground and his first use of light and white grounds – possibly due to Juel purchasing the canvasses pre-primed from suppliers. Following his return to Copenhagen, the use of ground layers displays continuous variation in colour and structure, in which no systematic reasoning can be established at this point. No evidence was found as to whether Juel purchased the canvasses pre-primed from local suppliers during these years or if this practice remained in the studio. Juel's paint application shows a very assertive and deliberate approach with few changes and a rapid technique resulting in only one to two paint layers. He does not seem to have experimented with intermediate layers and additives in his paint. Juel's palette and use of pigments proved very consistent throughout his career and very traditional for the time, consisting of lead white, vermilion, red, yellow and brown ochres, umber, sienna, Naples yellow, Prussian blue, green earth and bone black. Ultramarine was identified only in the paintings produced in Switzerland. Ultramarine was very expensive in Denmark and perhaps rarely used. Juel's usage of the pigment while abroad suggests a different availability or price. Juel finished with a varnish and may have used mastic or sandarac, and in some instances he appears to have made use of a temporary egg-white varnish.

Differences in materials between locations – and their correlation to craquelure

Besides the use of ultramarine while in Switzerland, the main difference between materials used in paintings produced in Denmark compared to those abroad is that the paintings produced in Denmark have more dense canvasses, as well as thicker and more tightly spun threads compared those produced abroad. Analyses of the ground layers suggested the use of drying oil as a binder, with no addition of egg or glue, in all grounds. Linseed or walnut oil was likely used for the paintings produced in Denmark, while a slower-drying oil, such as poppy-seed oil, may have been used in France and Switzerland. A slower-drying oil, or a lower state of oxidation, in the ground layers of the paintings produced in France and Switzerland could explain the drying craquelure seen in the surface of the paint layers in these paintings. One of the key differences is that the ground layers of paintings produced in Denmark all contain a substantial amount of calcium carbonate (chalk) and little lead white, while the paintings produced abroad displays little or no calcium carbonate. In contrast, the paintings produced in France and Switzerland contain mainly lead white. The pattern of presence or absence of calcium carbonate versus lead white in the ground layers corresponds to the differences in crack patterns between these two groups of paintings. While a lead-white ground is strong and stiff, a chalk- and/or earth-pigmented ground layer is weak and much more responsive to climate fluctuations. The choice between a lead-white ground and a chalk- or earth-pigmented ground can have a distinct effect on the mechanical properties of the ground and therefore on the way and degree to which cracking occurs with relation to the entire structure of the painting. Dense canvasses with thicker threads are more prone to swelling and contraction, thus the combination of a weaker ground with a more reactive canvas would initiate more canvas-related cracking.

The fact that Juel does not appear to have adapted to the same type of ground consisting of oil and lead white without chalk after his return to Denmark, suggests a different approach or set of hands throughout the travelling years – or a difference in availability of materials.

Conservation

The majority of Juel's paintings are in good condition and some paintings remain with the original mounting. They have likely reached equilibrium with their surroundings over a long time as per the rule of proofed fluctuations. Careful consideration to this aspect and how interventions such as structural conservation treatments, re-mounting, stretching and keying out may introduce new tensions and stresses into the structure of the painting should be made before performing treatments on these paintings. The variations detected in Juel's use of ground layers, their differences in properties, as well as their recognised influence on degradation patterns, strongly advise that caution should be taken and consideration given to the type of ground layer present in the painting to undergo conservation treatment. That many of Juel's paintings have undergone structural treatments, such as lining procedures in the past, increases the complexity of the condition of the paintings. In many cases, this traditional approach was carried out as a preventive measure and with the best intentions; however, it may have done more harm than good to the paintings. Furthermore, the lining adhesives can affect and alter the properties of the paintings and their response to the ambient environment. Therefore, the conservator must take into consideration not only the original materials of the paintings, but also the added materials, as well as their individual history and needs, before establishing the specific treatment strategy for Juel's paintings.

12.1 Contribution to Knowledge and Avenues for Future Research

With the examinations and analyses made throughout this thesis, technical art history in Denmark is enhanced by the study of Juel's paintings, providing a better understanding of the materials and techniques used in Juel's portraits on canvas. The results of material analyses in combination with documentary evidence provide some indication of the circumstances of Juel's choices, the available materials and the market for art and artistic practice in the pre-industrial era. It appears that many materials commonly available in Europe at the time were also available in Copenhagen. However, the absence of some materials in Juel's paintings, such as ultramarine, which he used while in Switzerland, suggests that the extent of access to some materials varied. The availability of materials or items must have been contingent on necessity and demand, which includes the access to pre-primed canvasses and whether this was yet an established line of work outside the studio. Juel's suppliers of materials may be established by investigation of archival evidence with regard to city developments and commerce in Denmark, as well as in the locations he visited while abroad. This archival research has not been undertaken during this study. Previously, many archival sources have been studied by historians, mainly to shed light on socio-economic history. The increasing access to archival sources due to digitisation, such as the Sound Tolls registers

and the early Danish newspapers, might allow for a more thorough and focused investigation on market conditions and goods available for art and artistry in Denmark in the pre-industrial era.

Two sets of paintings were found to most likely originate from the same canvas roll and pre-primed canvas. The majority of Juel's paintings are not signed and dated; they are dated art-historically, based on documentary sources, style and events in the sitter's life. The established matches between the production of paintings made in this study do not always correspond to the art-historical dating applied to the matching portraits, which have eight to nine years between them, suggesting that the dates for some of the paintings should be adjusted. No official adjustment has been made to the dates listed on the background of these findings. However, more elaborate studies of Juel's paintings concerning weave mapping and ground application may reveal more about the work processes of Juel's studio. Ideally, this could aid in the establishment of a new timeline for Juel's production and assist in authentication of his paintings – although this would require examination and X-radiography of a very large number of paintings.

The investigation made in this thesis provides physical evidence that there is a correlation between materials used and degradation patterns – in this case, craquelure especially. It is not always straightforward to identify the material or mechanical property within a painting structure that may be a responsible factor for certain responses. Mechanical properties of materials can be tested in a laboratory, but their actual effect on paintings in combination with other factors can be difficult to test or prove. Thus, the findings of this investigation provide evidence, found in the materials and techniques used in the examined paintings, of differences that are important for the broader understanding of the properties of ground layers and their influence on the structural stability of the paintings. Findings, which seemingly correspond with tests on mechanical properties of different materials conducted in the laboratory and suggested in technical literature.

The interrelationships between various factors are complex and there is still much room for further research; however, it is evident that a correlation exists. A structured study researching the relative quantitative distribution of certain pigments and fillers – for instance, chalk versus lead white bound in oil – and how this distribution affects properties such as strength, drying, absorbency, ion-migration forces and solvent sensitivity on adjacent layers, could help answer some of the questions which remain unanswered. These questions relate to both the artist's choices and knowledge of materials from practical experience, and to the paintings' expected response to conservation and restoration treatments. The findings of this thesis may provide a point of departure towards expanding the understanding and explanation of the formation of cracks in paintings. This relates not only to Juel's paintings, but also to the preservation of paintings in general, contributing to the understanding of paintings' degradation, and enabling a more targeted approach to both preventive and active conservation.

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paa Bygningerne saavelsom og hvorledes Vogne, Meubler, Skilderierammer, Figurer, Jernværk og deslige forgyldes og bronzeres med Anviisning til at bevare sig fra den saa kaldede Maler-Kolik, Til menige Mands Nytte uddraget af de bedste og berømte Mesteres Anviisninger. Copenhagen: Liunges Forlag.

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