Ground Layers in European Painting 1550–1750

CATS Proceedings, V, 2019

Edited by Anne Haack Christensen, Angela Jager and Joyce H. Townsend

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Back cover illustrations: (*top left*) detail from Girolamo Troppa, *Mercury Killing Argus*, oil on canvas, 96 × 132 cm, Statens Museum for Kunst, Copenhagen, inv. no. KMSsp122 (photo: Jakob Skou-Hansen/SMK) and (*bottom left*): detail of a cross-section showing the ground structure in VIS; (*top right*) detail from Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels*, 1623, oil on canvas, 320 × 240 cm, Church of Saint John the Baptist at the Beguinage, Brussels (photo © KIK-IRPA); (*bottom right*) Carel Fabritius, *Portrait of Abraham de Potter*, 1649, oil on canvas, 68.5 × 57 cm, Rijksmuseum, Amsterdam, inv. no. SK-A-1591.

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FOREWORD

Mobility Creates Masters (MoCMa): a groundbreaking international network

In 2017 CATS was awarded a grant within the framework of the Independent Research Fund Denmark. The aim of this grant was to strengthen research areas that are scattered geographically and institutionally, and to support networks which could lead to bigger projects or larger interdisciplinary groups of researchers working across institutions.

The Mobility Creates Masters (MoCMa) research network investigated the introduction, character and impact of coloured ground layers in paintings across Europe during the Early Modern period. The MoCMa meetings, launched in collaboration with IPERION-CH, were held between 2017 and 2019. The purpose of the network was to strengthen collaboration between researchers from different countries and research institutions, and to share knowledge, experience and results. It has resulted in the sharing of data, the establishment of new collaborations and research projects into the impact of artists' mobility on material choices and techniques. Furthermore, the network has stressed the importance of continued and indeed intensified research into the complexity of coloured ground layers in paintings from the 16th and 17th centuries, and their impact on the perception of the paintings both then and especially today.

The fifth international CATS conference proceedings highlights a multitude of results from the investigation of the ground in early modern European painting. We hope that this volume will provide a stimulating read on a subject about which much more will be said in the future. As with the previous four volumes in the series, this book is available as a paperback from Archetype Publications.

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- University of Stockholm
- Nationalmuseum, Stockholm
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- National Gallery, London
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TROUBLESHOOTING COLOURED GROUNDS: DEVELOPING A METHODOLOGY FOR STUDYING NETHERLANDISH GROUND COLOURS

Moorea Hall-Aquitania and Lieve d'Hont

ABSTRACT The 'Down to the Ground' project (DttG, University of Amsterdam/Delft University of Technology) attempts to build an overview and deeper understanding of the spread and use of coloured grounds in the Netherlands during the period 1550–1650. A project of this scale requires broad collaboration, the incorporation of previously collected data, and tools and protocols that allow meaningful combinations of research data on colour with techniques ranging from visual observation to chemical analysis. This paper identifies the successes and difficulties of the projects that have brought us to our current point in the study of coloured grounds and proposes a way forward in the context of DttG.

Introduction

How do we describe colour in a meaningful and more objective way? Individuals perceive colour differently, the limits of language hinder our very conception of colour, and the way we choose to interpret and describe colour is often done unsystematically, without a view of reproducibility by others. The desire for quality data from paintings often stands in conflict with practical issues, accessibility, and ethical considerations preventing actions that would increase objectivity. The 'Down to the Ground' project (DttG), a collaboration between the University of Amsterdam (UvA) and Delft University of Technology (TU Delft), is writing an interdisciplinary history of coloured grounds that establishes how these grounds spread to the Netherlands in the 16th century, determining how coloured grounds changed painters' practices, and creating an understanding of the visual qualities of paintings both at the time of their making and after centuries of ageing.

Past research projects on coloured grounds have almost all been oriented towards a single artist or have provided overviews based on data obtained from single collections. Groen and Hendriks published on Frans Hals's grounds in 1989; Hendriks *et al*. researched Goltzius in 1991; Dunkerton and Spring's 1998 study covered only paintings in the National Gallery, London; Noble studied the ground in portraits in the Mauritshuis, The Hague, collection in 2004; Groen's extensive 2005 overview concerned Rembrandt and a few contemporaries; and Hendriks made an inventory of grounds in the Frans Hals Museum in 2006. Miedema and Meijer's 1979 work was wider in scope, but their conclusions were based on catalogue entries and surface examination; Vandivere's 2013 dissertation considers Karel van Mander's *primuersel*; in 2017 Stols-Witlox focused on written sources on coloured grounds within a much broader time period of 1550–1900; and while there are other sources on coloured grounds besides these major contributions, the broadest study to include technical information across collections is Martin's 2008 investigation of grounds in various European artistic centres between 1600 and 1640. All of these studies[1] have informed DttG, and some of the specific insights they provided will be discussed.

This paper considers various practical issues faced within the study of coloured grounds as they surface through new examinations of paintings and close study of earlier publications. The discussion in the following sections moves from the surface via the subsurface to data processing, first with a discussion of perception and the many features that must be taken into account when examining the surface of a painting with the naked eye; second with a review of the analytical

Fig. 1 Reconstruction by Lieve d'Hont (in progress) of François Ryckhals, *Boy Sleeping in a Barn*, Mauritshuis, The Hague, inv. no. 929. This detail shows the underpaint of the vegetables and shelf arrangement covering the black ground and white underdrawing.

techniques used to assess ground colour and composition; the third section considers how we describe colour and proposes methods that should lead to more objective and clear descriptions for the sake of future research; and the fourth calls for transparency, a crucial step if we wish to incorporate mixed-quality data into a wider context.

Perception

Several members of the DttG team are painting conservators. This generally indicates a highly developed colour perception because they continually make precise use of colour in many aspects of their work. During technical examination, colour descriptions – together with other aspects such as transparency and particle size – help to identify pigments tentatively and to distinguish between original and non-original material. Conservators also look for changes in colour where what is depicted does not meet their expectations, and, most importantly, conservators must have excellent colour mixing and matching skills for inpainting. The colour of ground layers receives much attention, as it informs an important aspect of painting technique. Knowing the ground's colour and composition can help with dating, locating where it was painted, and even attributing a painting. The ground also has a strong influence on the painting process and the final appearance of the painting. Visual observation, both with the naked eye and aided by a stereomicroscope, remains an important analytical technique in this type of research, often supplemented by further technical analysis. DttG generates its own data through the investigation of case study paintings. Furthermore, we incorporate observations from earlier research, recorded in conservation reports, technical notes in collection catalogues, and other publications, allowing the project to build on a large foundation. However, such records have often been compiled with very different aims than ours, which means that the project needs to tackle an important question: what issues can we expect when we use both our own and others' eyes as tools in the study of coloured grounds?

Subjectivity is the first issue to consider: each set of eyes has its individual variations, and the way we process information is determined by our personal frame of reference. If a certain phenomenon is known to us, it is easier to recognise and thus to see it. Knowing that an artist often worked on a specific ground colour will direct the eye to look for that ground colour. The next issue is that conservators are trained to compare colours directly: the difference between original and overpaint, a discoloration or a colour changing before their eyes. It is much harder to look at colour in isolation or to compare colours of different objects or at different times. This is due to the fact that the eye is not a colorimeter and many factors influence perception such as lighting conditions, adjacent colours, and our expectations.[2] For example, the contrast of a lighter paint against a dark ground makes it flash out as a light colour, while when contrasted with white it is perceived as darker. The same applies to contrasts with complementary colours. Since perception is always influenced by the context, it is difficult to remember colours as they appeared. Therefore, we need tools to systematically look at, document and describe colour, especially in a research project in which aspects of colour form a major data source.

Before investigating grounds, their colours and other aspects, it is important to define the research questions, since these determine the scope and methodology of the study. In DttG, the research is roughly divided into two directions: one dedicated to the coloured ground itself (investigating the spread of coloured grounds to the Netherlands) and one focusing on the ground within the layer system of paintings (researching the role of ground colour within the painting process and its influence on appearance). The latter is a necessary angle if we wish to understand how coloured grounds work. Indeed, a specific ground co-determines the choice of materials and their application for the artist, and painting on a coloured ground requires different methods from those used when painting on a white ground. Thus, the ground colour has an influence on the build-up and number of layers necessary as well as the speed of execution required to complete a picture. In addition, a coloured ground prompts specific visual effects in the finished painting, such as the overall tonality. With this in mind, investigating the ground colour in a painting's context can be a challenge. For example, subtle optical effects such as light scumbles over a dark ground can have a significant impact on how the ground is perceived (Fig. 1). Similarly, a neutral grey ground can appear very cool, even tending towards blue, if mainly warm colours are applied on top.

A clear example of the issues highlighted above lies in the way mid-toned grounds are discussed. By applying light and dark underpainting on top of a mid-toned ground, a painter can define the tonal range, creating a result comparable to *chiaroscuro* drawings on coloured paper (Fig. 2). Painters can also use a mid-toned ground at a later stage by allowing it to shimmer through or leaving it exposed in areas lingering

between the lights and shadows or around contours. But what is a mid-tone? Perceiving a ground or any other area in a painting as light, mid-toned, or dark is dependent on its immediate surroundings. This can be clearly illustrated by the checker shadow illusion, an optical illusion published by Edward H. Adelson. Two squares of the checkerboard – one perceived white in a shaded area and one perceived black in a lit area – actually have the same grey colour, and only by connecting the two areas can we perceive them as such (Fig. 3). Our perception of a colour is influenced by adjacent colours and by the context of what is depicted. This effect is especially problematic when comparing the grounds of two different paintings, since their overall darker or lighter tonality may influence our idea of what we perceive as the exact middle between these extremes. Thus a mid-toned ground says much more about the function and context of its use than about its exact colour and lightness.

We need to be aware of this differentiation and to characterise both the context and function of the ground when examining, describing, and cataloguing, in order to determine its colour more objectively. Depending on the artist's individual technique, the ground itself might not be exposed, yet it could still influence the final appearance of the painting. In addition, knowing the precise ground colours helps to answer art historical questions such as how the use of coloured grounds might have spread. To complicate matters further, we need to distinguish between the appearance of the ground alone before the artist started painting and the consequence of the painting process, ageing, and conservation treatments on the ground's current colour.[3] Furthermore, discoloration and increased transparency of the paint on top also influence how ground layers are perceived and how they affect the current appearance of the painting.[4]

Previous technical investigations of grounds have focused more on colour than function. Visual observation by itself has only led to broad conclusions, such as those of Miedema and Meijer.[5] Few studies discuss the role of the ground colour. In her chapter on Haarlem studio practice, Hendriks considered the use of the ground in the build-up of the painting and describes where the ground was left exposed or covered.[6] Very rarely has attention been directed towards the influence of the ground on the painting process itself. Vandivere's research on Van Mander's *primuersel* is an excellent example of how this can be done, combining primary source research, painting investigations, and reconstructions.[7]

Access to paintings is indispensable for in-depth investigations which, in the case of DttG, is achieved by collaborating with museum partners. In our investigations of paintings, we work with the following tools and intentions. First, we consider the use of a colour chart (for hue) and a grey scale (for lightness) crucial during both the examination and documentation of colours. They allow us to process images consistently through white balancing and colour calibration, so they can be compared to each other. Secondly, we use a system to describe and categorise colour (discussed in the next section). Thirdly, during examinations, a checklist with questions based on literature study, earlier observations, painted reconstructions, and information from contemporary written sources is used.[8]

Fig. 2 Federico Barocci (attributed to), after Raphael, *Cumaean Sibyl*, 1556–1566, pen and brush on greenish-blue paper, 380 × 230 mm, Rijksmuseum, Amsterdam, inv. no. RP-T-1953-358.

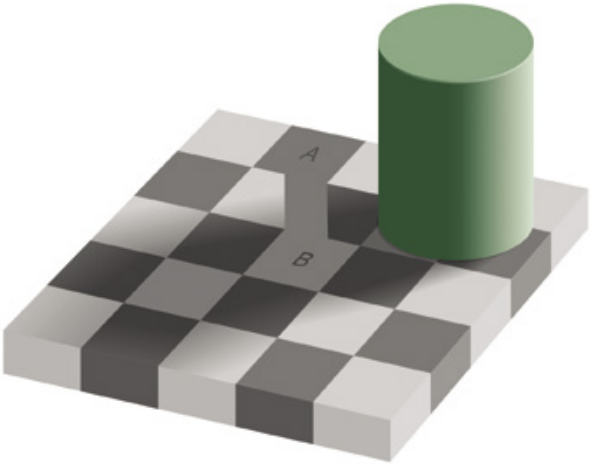

Fig. 3 Edward H. Adelson, *Checker Shadow Illusion*: squares A and B have the same grey colour as can be seen when they are connected.

This helps the researcher to systematically address aspects of the ground and paint layers – such as opacity/transparency, colour contrasts, and material affordances – as well as provide clues that may assist in determining the artist's intent.

Finally, selected case studies are subjected to focused research by making reconstructions with historically informed materials. These allow us to test hypotheses concerning the role of ground colour during the painting stages and to further investigate interesting visual effects. Visual observation alone is insufficient to answer all our questions on the use of coloured grounds, but it forms the foundation for further investigations with other techniques.

Analysis

When taking the step from visual observation to scientific analysis we have to narrow focus to specific research questions. It is simply not feasible or desirable to fully sample and analyse every interesting painting. Not all research questions require information on the chemical composition of the ground but some do. Several museum partners offered the DttG team access to paintings, documentation, and samples. Re-examining old samples minimises additional sampling, while new microscopes, cameras and improved protocols – including colour calibration – aid their interpretation and comparison. Despite the newest equipment, it is still not an easy task to describe and classify the ground colour from a cross-section or to relate what we see in the sample under high magnification to the surface effect observed with the naked eye. Even a highly trained eye can be deceived when travelling through the surface into a cross-section. When Groen and Hendriks described the *Portrait of Petrus Scriverius*, dated 1626 and painted on panel, they observed with the naked eye a 'light greyish ochre' layer. This became 'light brownish' when the surface of the ground was examined through a binocular microscope, while the final pigment identification via paint sample analysis was 'lead white, with a little red ochre'. The pendant painting with a comparable ground appeared 'yellowish' with the naked eye and 'translucent whitish' with a binocular microscope.[9] Was this the effect of increased transparency of the ground and perhaps of the wood shimmering through?

Studying grounds using cross-sections is more reliable than basing conclusions solely on surface observation. However, this technique also has major drawbacks: it is invasive, often multiple samples are necessary for a good overview, and the lower layers are sometimes missing in samples. In 2005, in the context of Rembrandt's grounds, Groen wrote that her tables include a presumed colour description of the ground 'generally determined from paint cross-sections on the basis of the composition of the paint mixture encountered in them … We chose for cross-sections, because, in our experience, observation with the naked eye – not supported by microscopy or cross-sections – often yields unreliable statements about the colour of the ground.' However, she also stated that 'the samples are too small to extrapolate from the sample to the colour and tonal value as seen by the naked eye on the painting support … the ground layer in the cross-section, under the microscope, always proves to appear lighter than in the painting'.[10] For objective colour information, it would be necessary to perform colour measurements on the cross-section or on a colour-calibrated digital image. Susan Smelt's research for the Rijksmuseum Paint Sample Database is promising in this respect and demonstrates the need for appropriate protocols for consistent photography of cross-sections.[11] The issue of defining the colour of optical mixtures in cross-sections is addressed by Russell *et al.* 2020.[12] What is very clear is that there is a great difference between systematic documentation and the (subjective but equally valuable) interpretation of a researcher's observation.

A complicating factor in relating cross-sections to observations on the painting's surface is the transparency of certain materials. Transparency influences the way a cross-sectional view differs from a view through layers in the transverse direction. This is very apparent, for example, with chalk bound in linseed oil, where the refractive index of the pigment/filler and binder are very close to each other. As a result of this, the layer colour in a cross-section is more strongly influenced by the colour of the binder than at the surface. Traditional chalk and glue grounds are found on panel, but chalk is also often observed in mixtures, since it was used in *lootwit*, a cheaper lead white variety consisting of a mixture of lead white and chalk.[13] Moreover, the (translucent) colour of a low-reflective material in a (discoloured) medium-rich layer is hard to distinguish, as Groen explained when discussing quartz grounds.[14] Apart from the difficulty in estimating the proper colour of such layers in cross-sections, the layers underneath also contribute to the cumulative colour visible at the surface.

Previous research has used several means to classify grounds, depending on the research questions and the techniques applied.[15] Groen and Hendriks organised their data by date and as the sample group was small, it was feasible to group paintings and discuss shared, specific aspects such as chalk grounds on canvas.[16] In their study of Italian grounds, Dunkerton and Spring divided paintings into three categories based on tonal value and a fourth group consisting of (off-) white grounds containing lead-tin yellow. Their identification of the prevalence of lead-tin yellow primings in Florentine practice is a clear example of the results of post-processing categorisation. They differentiated between the description and the composition of the ground, which provided the opportunity to present data obtained through different methods, while being clear about their level of knowledge.[17] Two large studies conducted at the Centre de Recherche et de Restauration des Musées de France (C2RMF) combined colour information with chemical composition through scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDX) to define ground categories.[18] Martin's investigation at C2RMF was a very detailed categorisation using 'six groups based upon the predominant colour of the ground (white, red, brown, yellow) and its main component: chalk, earth or lead white', dividing these up in subgroups depending on distinctive features, number of layers and the presence of drying agents.[19]

The question arises as to whether such groupings would also work in a Netherlandish framework. In studies that focus on a Dutch context, such as DttG, different types of

classifications are encountered that sometimes differ from those of other European artistic centres. The majority of the paintings in the two French studies were on canvas, while for the period of 1550–1650 in the Netherlands three important supports were used: panel, canvas, and copper plates, each with their own traditions. Moreover, double grounds, including chalk grounds with a thin *imprimatura* or priming on top, play a major role in the history of grounds in the Netherlands. It is necessary to take the whole preparatory system into account, not only the colour of the upper layer. Groen separated Rembrandt's grounds first on the basis of the support and then further distinguished specific grounds for canvas, such as the quartz ground, that carry extra relevance for Rembrandt.[20] Hendriks divided the Haarlem grounds into categories that suited that city specifically, highlighting for example the importance of light pink oil-based grounds on both canvas and panel.[21] Albrecht *et al*., in their study of Jan Steen's grounds in 2019, used principal component analysis (PCA) to cluster grounds based on the presence and ratio of the chemical elements detected through SEM-EDX.[22] This is an interesting method to group grounds but requires consistent and detailed data. Finally, as demonstrated in the discussion of Rembrandt's *Self-Portrait* from 1669 in the Mauritshuis, imaging techniques such as macro-scanning X-ray fluorescence spectroscopy (MA-XRF) provide information on the ground on the macro scale, revealing patterns in the application of the ground or showing where the ground layer is exposed.[23] From this overview of past research projects it becomes clear that there is no single type of classification that works best. It is evident, however, that the most meaningful conclusions can be drawn when visual observations are combined with further technical analysis, and that a tailor-made system for classification based on the research questions for each project is essential.

Colour description

What do we talk about when we talk about colour? The preceding sections have highlighted issues of perception and analysis; we now consider what to do with that data and how to combine our information with the work of others. Our recent attempt to digitise and incorporate the tables of Rembrandt's ground colour created by Groen into the DttG database was challenging due to a lack of systematic colour naming and inconsistent usage of colour terms in Groen's descriptions of various ground colours.[24] The struggle to understand parts of her data inspired reflection on how our project was using (and misusing) descriptive language. Using Groen's work as a case study we formulated a system for discussing colour.

In her tables of Rembrandt's grounds, Groen used a variety of different standard colour terms (e.g. brown, yellow), modifiers (e.g. light, dark), multimorphemic terms (e.g. yellowish, greyish), and abstract expressions (e.g. beige, fawn, sand). In the table of grounds on panel, she used 20 different colour descriptions for a group of 60 paintings, all of which have comparable pigment compositions. In most panel grounds, the lower ground contains only chalk (calcium carbonate) and the upper ground consists of a combination of lead white, chalk, yellow/red/brown earth (including ochres and umbers), and a carbon black.[25] A variation in the colour of the earth pigments and the differing combinations and ratios of pigments in the second ground layer will certainly affect their colour, while ageing conditions often have an influence on the colour of the oil or glue binding media. A ground layer containing lead white, chalk and umber was described by Groen in different entries as 'yellowish', 'brown', 'yellowish brown', and 'light yellowish brown'. It is unclear whether these names reflect actual colour differences or variations in the investigating conditions as discussed in the previous sections. However, setting aside what could be a large range of colours within this sampling, Groen's varied colour naming makes it difficult for subsequent researchers to understand and categorise the colours she was describing. And this is a problem arising within the research of a single author investigating the grounds of a single painter, probably with the same or similar equipment. The problem is exacerbated exponentially when one complicates any of these factors. For example, one mention in Groen's table is a citation of an entry by David Bomford in which he described a second ground layer with the same composition as noted above of lead white, chalk, and umber as 'warm brown'. Is this an issue of individual colour perception? The type and calibration of equipment being used? A difference in language? Is Bomford's 'warm brown' effectively the same as Groen's 'light yellowish brown'? While this is an interesting theoretical problem, the researcher hoping to take Bomford and Groen's data and place it into a larger context needs a practical solution.

The issues introduced above are part of a much larger and more difficult problem: how do we describe colour in a meaningful and objective way? There may never be a perfect answer to this, as people may perceive colour differently, the limits of language hinder our very conception of colour, and colour is so variable that giving numerical coordinates within imagined colour spaces so that colours can be understood and reproduced across platforms has already taken up many years of work by researchers. To describe colour verbally in a way that others will be able to understand and adopt is an arduous task but it is a challenge that must be tackled if we want to work with large amounts of data and share these within a group. To this purpose, we would like to propose a system for describing and tagging colour consistently. It is essential to define the difference between yellow and brown before tagging groups of ground colour so that later a researcher will be able to categorise large numbers of paintings in the knowledge that their data have been carefully curated, and perhaps more importantly, so that another researcher can understand and use this (in many ways subjective) data on ground colour. It is a useful exercise to think in terms of 'predigesting' information for a computer so that it can be more easily sorted. Issues of changing technology, varying access and equipment, white balance and imaging are subjects that must be tackled elsewhere. Here, we will assume that one person has access (again) to all the cross-sections studied by Groen, Bomford, and the others whose observations are

Fig. 4 X-Rite Macbeth ColorChecker Chart. Middle values chosen for DttG system, based on manufacturers' sRGB D65 values, are white: #f3f3f2, black: #343434, red: #af363c, green: #469449, yellow: #e7c71f, blue: #383d96, brown: #735244, purple: #5e3c6c, pink: #c15a63, orange: #d67e2c, and grey: #c8c8c8, with the 'light' and 'dark' modifiers varying by 20% in brightness.

included in Groen's 2005 tables, and is attempting to create a system of naming colours in a way that can be reproduced by a third party and queried on a large scale.

A starting point for developing this system, which is to be used for the very specific purpose of classifying 16th- and 17th-century ground colour in paints but may have wider use, is Brent Berlin and Paul Kay's theory of basic colour terms.[26] First published in 1969, their universalist theory is that colour cognition is an innate, physiological process rather than a cultural one. Berlin and Kay identified 11 possible basic colour categories in English – white, black, red, green, yellow, blue, brown, purple, pink, orange and grey – and defined these categories using the following set of criteria:

- 'It is monolexemic' (red, not reddish or somewhat red).
- 'Its signification is not included in that of any other colour term' (for example, 'crimson' is a sort or subgroup of red, while 'sapphire' is an example of blue).
- 'Its application must not be restricted to a narrow class of objects' (for example, 'blonde' is restricted to hair, wood and beer).
- 'It must be psychologically salient for informants' (for example, 'the colour of my father's car' is not psychologically salient for most readers).[27]

Applying these principles to Groen's colour descriptions highlights the ambiguity and subjectivity of unstructured colour terms. Groen broke each of the Berlin-Kay criteria, and yet her publication was pioneering in its depth and scope, remaining one of the most frequently referenced sources on ground colour to date, and offering a methodology that has greatly informed the DttG system. Groen's specificity in describing ground colours should not be lost and oversimplified, as individual observation offers valuable detail that may be lost in a rigid system. To these ends, we have included a field for the examiner's personal description of colour that serves as raw data for the colour groups in which grounds are then placed. Simply dividing Rembrandt's ground layers into 'brown' or 'yellow' is probably not the answer, as it eliminates all subtlety and variation; further subdivisions are needed in order to find a middle ground of using a descriptive system that combines an adequate sensitivity for colour variation with the ability to categorise highly similar items.

We are thus faced with a Goldilocks problem: searching for a system for colour description that is not overly subjective or extremely simplified but 'just right'. The aim is to create a system wherein a third party will understand what we mean with the description 'pink'. Because colour data is so subjective, especially when language is involved, the system simply has to be usable. Essentially, each piece of evidence (a ground layer) should be taken and sorted into different bins. The decision of what to call the bins does not matter that much beyond functionality – 'brown' is a scientifically meaningless term without a measurement – but the number of bins does matter since it will define the scope of variation. The primary linguistic rules of this system are based on Berlin and Kay's basic colour terms with modifiers for light value (although hue modifiers may be added later). Thus, each ground layer will be categorised within a range of 11 basic colour categories and three light modifiers (light, neutral/none, and dark). The naming system is based on a visual approximation of the colour of a layer compared to corresponding colours on the Macbeth ColorChecker (Fig. 4). We are also developing a customised grounds colour checker to accompany the database. By identifying the colours that are important for this project and finding the

most representative example of a colour – 'Haarlem pink' for example – we can measure it in an objective way (in Photoshop, using L*a*b* colour space) and then tag that as an example of what 'Haarlem pink' means in this context.[28] The same applies to light grey, dark grey, red, light and dark brown, yellow, etc. However, for the time being, the Macbeth ColorChecker is a useful and accessible tool and comparator. More important than the exact system used to ensure that everyone is on the same page is the transparency with which that system is explained. In effect, 'What colour are you talking about?'

Transparency

The need for a well-defined colour system speaks to the larger demand for structuring data so that they are usable and sharable, and not simply documentary. How does a researcher take admittedly subjective data from a variety of sources and not only pick out elements that are the most relevant for sorting and organisation, but also take account of its origin and reliability? Not all data are created equal, but almost all are useful. The most important question to ask when starting to tease apart the details and metadata on an object is an obvious one. Simply: 'What do you want to know?'

Most – if not all – of the past studies discussed above are united in their prioritisation of 'good' data, which explains their more limited scope. The focus on new technical analysis meant that the availability of paintings wielded immense influence over each project. DttG aims to gather the threads of all of these past studies and weave them into a larger image of coloured grounds in the Netherlands in the period 1550–1650. This would not be possible without both the data and the lessons learned from previous research, and it is worth considering why a project of this scope has not been done before.

The answer to this has already been given – quality data. While there has been a significant amount of interest in coloured grounds in the Netherlands, technical analysis is still less prevalent than we would hope. Sampling and imaging of paintings is time-consuming and expensive, therefore technical research is usually limited to funded projects linked to a single museum or artist, or to conservation work on single paintings. As mentioned earlier, it is simply not possible to sample every painting that might be desired for a project. Both access and ethics prevent this. Furthermore, depending on the location of a painting, many analytical techniques may not be applicable due to the character of the artwork itself or the facilities of its holding institution. Some paintings were sampled decades ago, but the samples or their images are of lower quality than the current standard.

However, when aiming for an overview of a country's technical development across the span of a century, every piece of evidence helps. If we were to sample (or re-sample) every single painting we would like to investigate in order to include it in the study, we would be lucky to be able to examine 100–200 works over the five years of our project and we would be ignoring the efforts of all the researchers who have already contributed to this topic. By including data from previously published and unpublished material, even if it does not adhere to the highest levels of visual and chemical analysis we are aiming for, it is possible to expand our sample size exponentially. The higher the number of samples, the more accurate conclusions we can draw. In purely scientific terms, the conclusions reached from incomplete or suboptimum data are not statistically meaningful. Yet from an art historical point of view, any technical evidence will add immense value when combined with narrative sources concerning networks, mobility, and knowledge transmission.

The crucial element of using mixed qualities of data is transparency. If readers know what information conclusions are based on, they are able to see where conjectural leaps have been taken. It does not make sense to shy away from using weak information when it is, nonetheless, information. Clearly, a written report from a conservator walking into the gallery and examining a canvas with the naked eye to discern the colour of the ground cannot provide the same quality as information gained from multiple cross-sections from different areas of a painting examined with light microscopy and SEM-EDX. However, this does not mean that the observation is of no use – the information may not be strong enough to support a conclusion such as the first-ever use of a brown ground, but when it is combined with chemical analysis and visual examination of grounds from 10 or 20 paintings by the same artist, it can certainly contribute to ideas concerning the artist's oeuvre. There is one crucial condition for this approach however: when studying data on hundreds of paintings, both current and future researchers should be aware of the level of reliability of each piece of data.

In order to solve this problem within DttG, we propose a simple reliability rating column with a legend. For each painting, there are currently 30 fields in our database, ranging from artist, date, and dimensions to the chemical compositions of different ground layers.[29] While some have free text and notes, most of the fields are simple enough to be sorted and queried. One of these fields contains a number from 1 to 5, representing the data reliability. The most reliable data are given a rating of 1, meaning that SEM-EDX and microscopy have been performed on samples from the painting so that the basic chemical composition of the ground layers(s) is known.[30] The data become less reliable as the number increases, ending in 5, which means that no technical information is available on the painting but it has been included because visual data based on art historical research is promising. By rating each piece of data about a painting, it is simple to filter the entire database so that only paintings with a 1 or 2 rating are shown, if desired. We can also use this system to decide what is publishable or share a breakdown of the reliability rankings on which the conclusions are based. The published source and/or the individual responsible for the data is also included, so that each entry in the database can be easily traced and cited. Solutions such as these allow us to use existing data with more confidence, and while no system is perfect, knowing the quality of the data is a first step.

Conclusions

This paper has highlighted many of the issues we have encountered within the context of the research we are conducting within DttG. However, in most cases the preliminary conclusions we have reached and the systems we have started to develop can be applied to any study of coloured grounds and of artworks more broadly. The eye remains one of our most powerful analytical tools, and when paired with a systematic approach and technical analysis (when available) it can yield a wealth of information. How we organise and query that information must also be carried out in a considered and transparent way, and the methods we have developed so far are only the beginning.

We would like to conclude by making a case for using imperfect data responsibly. Collating bits and pieces of chemical and visual evidence has a value of its own if done intelligently and the combination can be indispensable in a context such as the DttG project. However, it requires a system that allows results to be presented in a way that does justice to the method and is honest about what is lacking, while making available what we do have. Miedema and Meijer had no access to technical data yet their provisional, bold conclusions opened up the field to new questions and many hypotheses have now been proved. We can be daring, including and using all the scientific and other tools available, without losing the poetry and conjecture of past work in the humanities.

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29. We are currently using an Excel workbook as a simple database to track painting metadata and information on grounds. This can be easily queried, is inexpensive and familiar to most researchers, and it can be uploaded to a more advanced database later if necessary.
30. Binding medium analysis has not been broadly conducted for this study. The next step would be to add a 0 rating for samples that do have this information.

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EXPERIMENTS USING IMAGE PROCESSING SOFTWARE (NIP2) TO DEFINE THE COLOUR OF PREPARATORY LAYERS IN 16TH-CENTURY ITALIAN PAINTINGS

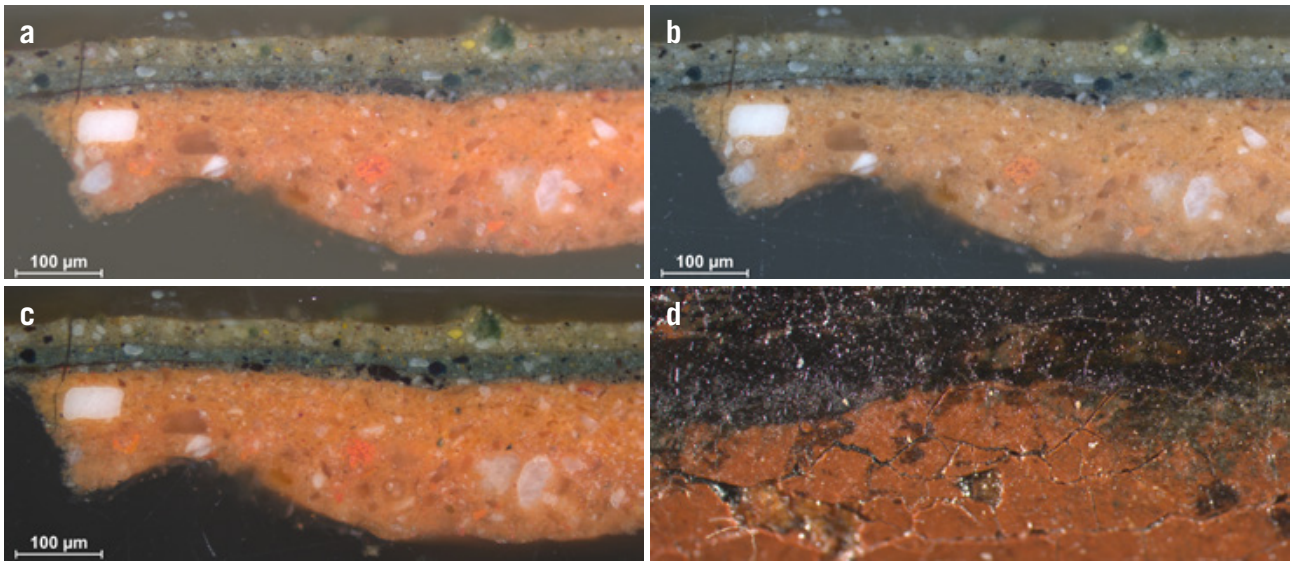
Joanna Russell, Marta Melchiorre Di Crescenzo, Joseph Padfield and Marika Spring

ABSTRACT This paper describes the use of a new Nip2 image processing function to define the average colour in an irregular area of an image. This function was explored as a means of measuring the colour of preparatory layers in images of paint cross-sections, as part of the development of a database on 16th-century Italian preparatory layers within the EU-funded IPERION-CH project. The colour averaging procedure was tested on images of cross-sections from a selection of paintings, and provided a method of defining colour systematically using L*a*b* values. The results were helpful in deciding how to group paintings according to the colour of their preparatory layers, and in reviewing the naming of these colours, which can otherwise be variable and subjective. The process highlighted in particular the importance of consistent photography of cross-sections, and a separate exercise was carried out in parallel to develop a more standard imaging protocol, including a comparison of the National Gallery method and results with those of other institutions collaborating on the project. The colour averaging procedure was not directly incorporated into the database, but has been a useful exercise in testing and confirming that paintings are being described and grouped in an appropriate way.

Introduction

The National Gallery, London, has been leading a project on the collaborative design and development of a database of preparatory layers used in Italian 16th-century paintings. This was carried out as part of the EU-funded IPERION-CH project,[1] and has involved several partner institutions, principally the Centre for Art Technological Studies and Conservation (CATS), Copenhagen, the Doerner Institut, Munich and Museo Nacional del Prado, Madrid. The database provides a means of bringing together research carried out by the different partners on works in their own collections, producing a shared resource that will be available online and which can be interrogated to compare results and identify trends in the use of preparatory layers for paintings. Information is being collected on the colour and composition of preparatory layers, including cross-section images and chemical information from the results of scientific analysis, together with the dates and places associated with artists and paintings. The search filters in the database can then be used in many different ways to aid research, for example to track the different types of preparation used by an artist throughout their career or to relate different types of preparatory layers to certain date ranges and geographical regions using the timeline and map visualisation of the search results. The 16th-century period in Italy is of particular interest due to the new developments in the use of coloured preparatory layers that were taking place during this time. This focus was also chosen partly because a substantial body of work already existed on paintings from this category in the National Gallery's collection that could be used as an initial dataset to populate the database and which had been published by Dunkerton and Spring in 1998.[2]

As part of the construction of this database, several questions were considered as to how the comparability and consistency of information provided by the different institutions could be improved. The production of images of paint



e

L*	a*	b*		L*	a*	b*	
57.7	24.3	35.2		45.3	26.8	34.2	

Fig. 1 Francisco de Goya, *Doña Isabel de Porcel,* The National Gallery, London, inv. no. NG1473. (a) and (b) Paint cross-section photographed under the microscope at different times using different imaging conditions. (c) The same sample photographed using the revised National Gallery protocol. (d) Detail of a photomicrograph of the preparation as seen on the painting surface. (e) L*a*b* values and equivalent colour patches measured from the preparatory layer in (c) (on the left) and the preparation visible in the photomicrograph in (d) (on the right). (Photos © The National Gallery, London.)

cross-sections was one aspect that was addressed since these may be taken using a wide variety of microscope and camera equipment, and with different protocols, giving very different results. The review of imaging procedures was carried out together with the IPERION-CH partners in a round robin exercise, which is further described below.

The design of the database necessitated the selection and use of limited, well-defined terminology in order to be able to group and search the information most effectively. One of the more difficult aspects of this was found to be in the use of colour terminology. For the purposes of examining the introduction and spread of particular types of preparatory layers, the colour of the preparation is one of the key descriptors. The experience of looking through old records quickly reveals how layer colours may be described in a multitude of different ways by different individuals, or even by the same individual at different times; the same paint layer might be 'light brown', 'buff', 'biscuit' or 'beige'. An additional challenge derives from the fact that data are being collected from partners with different linguistic backgrounds who might use specific words to describe colours that are difficult to translate or understand in another language. In order to group colours together, a more systematic method of defining colour might be desirable in order to avoid similar colours being described in different ways.

In discussing the colour of the preparation it was decided that, for the purposes of classification in the database, this should be defined as the bulk colour of the preparation as it might have appeared to the artist on the support at the start of the painting process. This is not always necessarily the same as the colour of the uppermost preparatory layer in cases where the preparation consists of multiple layers that may contribute to an overall effect. This bulk colour may not always be easy to discern on the surface of the painting but may need to be judged from viewing it through cracks, at the edges of the picture, at the edges of losses, or in other areas of the painting not covered by further layers. However, determining whether the colour observed is really the preparation or a local underpainting is not always straightforward, and the colour may be obscured by varnish or dirt. If samples are being taken from the painting in order to investigate preparatory layers, it may be easier to estimate the colour from these, either from an unmounted fragment or from the layer in a cross-section. In the latter case, experience is required in order to interpret the colour, as it can be difficult to describe the overall colour based on the mixture of particles in a layer.

A method was explored in which the average colour of a layer in a digital image of a paint cross-section could be numerically defined, both to resolve the problem of judging and describing an overall colour from the mixture of particles viewed in a layer and to gain a better understanding of the relationship between the colour seen in a cross-section layer and the appearance of the layer on the painting's surface.[3] The paintings discussed in Dunkerton and Spring 1998,[4] which formed the basis of the National Gallery's contribution to the database, had previously been categorised into three groups according to the darkness of preparatory layers: 'white and off white', 'tinted and coloured (from light to mid-tone)' and 'coloured (from mid-tone to dark)'. The preparation on each painting had also been given a basic colour description consisting of a main colour word, sometimes with additional terms to modify the lightness or hue, producing a compound description such as 'mid brownish-grey'. This terminology was reviewed and compared to the colours resulting from the

colour averaging process to determine whether this would be a useful tool for grouping the paintings in a systematic manner, an issue that becomes more important when combining information generated by different researchers from a range of institutions. Using image processing in this way relies on the quality and consistency of the images, therefore the improvement of imaging protocols was also addressed while carrying out this work.

Imaging of cross-sections

It was observed from the National Gallery's records that images of the same cross-section could be very variable in appearance, particularly if they were recorded at different times, using different microscope and camera setups. This was particularly noticeable in one example where past work carried out on Francisco de Goya's portrait *Doña Isabel de Porcel* (NG1473) was undergoing review. The cross-sections showed a red preparation that could appear quite different depending on the imaging conditions – from a salmon pink to a rusty orange hue (Fig. 1a and b). In this example, the image may have been deliberately adjusted by changing lightness and gamma[5] settings to highlight features in the dark paint layers.[6] Other examples were also noted where some older images did not appear to have been recorded with a consistent white balance, resulting in a yellow or greenish cast to the image.[7]

A round robin imaging exercise was carried out to review current protocols and to explore how consistent the appearance of the same samples would be when imaged by the different participating institutions. The aim of the exercise was initially to gauge the variation in approach and in the resulting images across the institutions, and then to try to improve the consistency of the imaging results. It was also desirable for some partners to adopt a more standard approach in-house to achieve more similar results when the work was being carried out by different individuals. The same three paint samples, mounted and prepared as polished cross-sections, were circulated to the participants for each to image with their usual procedures. The samples were selected to include materials that can be difficult to photograph: one containing azurite (which can tend towards cyan in appearance under certain conditions), one with vermilion (that can appear too pink instead of the more scarlet tone that would be a more faithful rendering of the pigment) and one with a dark red-brown ground (which, as noted above in the example from the painting by Goya, can vary in hue considerably depending on how it is photographed).[8] The results were compared and in the course of this exercise the procedures were reviewed and adjusted to achieve more consistent images between the partners.

At the National Gallery, cross-sections are photographed in darkfield using a Leica DM4000 M microscope with an AxioCam HRc Zeiss camera, and AxioVisionRel.4.8 software.[9] The computer is equipped with a colour-calibrated monitor.[10] The white balance is carried out working on the full frame as visible at the lowest magnification that will be used to image the samples, focusing on a standard reflective surface. The position of the red, green and blue curves in the histogram is used to check the result of this correction – if the three curves do not overlap, the selected area is inspected for dust or damages and the 'white balancing' is repeated on a different section of the standard reflective surface. This is carried out once at the start of each session and is used for all subsequent captures. The same lighting conditions used for recording the white balance are employed for imaging the samples, which are prepared for photography by mounting the polyester blocks containing the paint cross-sections on a white glass slide with a small piece of Blu Tack,[11] using a press to level the surface, and by wetting the samples with a drop of odourless kerosene. The sample is viewed on the monitor and, after framing the image to crop out excess areas of blank space (here the mounting resin surrounding the sample), an exposure measurement is made with the camera software and then refined manually as necessary (e.g. to improve the visibility of details in darker layers or to remove over-exposed areas, as identified using a tool in the camera software). The images are then captured using a standard set of values for the brightness, contrast and gamma in the camera settings.[12] For most of the samples, images taken using these standard settings replicate closely what is viewed down the microscope eyepieces, although small manual adjustments of these parameters are sometimes required to produce images that record as much information as possible. For example, images of a sample containing very dark and very light layers might require a manual adjustment of gamma. Before the round robin imaging exercise, these settings (gamma, brightness and contrast) were often adjusted before taking the images. As a result of the exercise, it was decided to first record an image for each sample using the standard settings and then, only where necessary, to modify the gamma, brightness and contrast (recording the new values) as part of post-processing.[13]

The imaging method uses a pragmatic approach in order to maintain a reasonably efficient way of working while maximising the quality of the resulting images, but it does still involve some subjectivity.[14] After the exercise, the principal adjustment made to the method used at the National Gallery was to change the type of surface used to carry out the white balance by replacing the white opaque glass slide that was employed previously with an X-Rite ColorChecker Gray Balance photographic card. In order to test which surface would give the best results, images of a standard white Spectralon block (99% reflectance) were taken after carrying out the white balance on the two different surfaces: the white opaque glass slide and the X-Rite card. On comparing the results it could be seen that calibrating with the X-Rite card produced a better and more neutral white image of the Spectralon block, showing that it was a better choice as a 'white balancing' calibration target.[15] The exercise provided an opportunity to review and record the basic settings for photography and to improve on the consistency of the approach. It was also helpful to discuss and specify a working procedure to ensure that although several different people in the department may be carrying out this work, all will be using the same method.

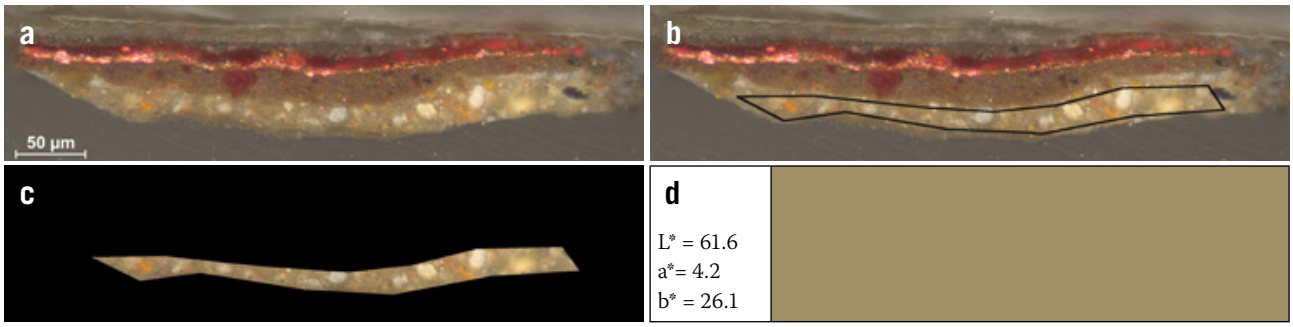


Fig. 2 Giovanni Girolamo Savoldo, *Mary Magdalene*, The National Gallery, London, inv. no. NG1031. (a) Paint cross-section including a pinkish-beige priming layer. (b) The same image with an outline superimposed to represent the area of the sample defined in the Nip2 software. (c) Image produced in Nip2 with the defined shape against a black background. (d) Colour patch representing the average colour measured in the area illustrated in (c), with L*a*b* values that define this colour. (Photos © The National Gallery, London.)

A separate research project had already been carried out at the Rijksmuseum to perform colour calibration of images taken down the microscope by imaging and measuring the colour of the 140 patches of an X-Rite ColorChecker Digital SG chart.[16] The results were used to create a colour profile to correct microscope images. The researchers at the Rijksmuseum, although not partners in the IPERION-CH project, also kindly agreed to participate in the round robin exercise by imaging the three samples and applying their colour calibration to the resulting images. It was reassuring to note that the colour calibrated images of the samples produced with this method were very similar in appearance to those acquired at the National Gallery.[17]

Colour averaging using Nip2

A method was trialled using Nip2 software for the mathematical measurement of colour in digital cross-section images. Nip2 is an open-source image processing system, originally developed at the National Gallery and now utilised in a wide range of applications for the mathematical manipulation of images.[18] An additional piece of code, written for Nip2 within this project, calculates an average colour from an irregular region defined in an image.[19]

To use the colour averaging tool, the cross-section image is first imported into the Nip2 software, then a series of points is placed on the image to define the shape of a polygon, outlining the area of the image inside which the colour will be measured. In this case the points were placed to encompass as large an area as possible of a preparatory layer, avoiding any anomalous reflections, areas obscured by mounting resin or parts very near the edges of the layer, especially where strongly coloured materials lie adjacent. The software joins the dots and averages the colour inside this irregular polygon. The function works by placing the defined area against a black background, then calculating the average of all non-zero (non-black) pixels (Fig. 2). The resulting hue is displayed as a colour patch in Nip2 with the values that define this colour, an output that can be described in terms of different colour space coordinates. For these tests, colours were principally measured in terms of CIELAB 1976 colour space, in which colours are expressed in terms of three coordinates, L*, a* and b*, in which L* defines the lightness, while the hue is defined by two perpendicular axes, a* for red to green and b* for yellow to blue.[20] Describing the lightness and hue separately in this way makes it easier to relate the numbers to the colours than with the RGB (red, green, blue) colour model that is used for visual display systems.[21]

Tests were carried out using this method to measure the colour of preparation layers in images of cross-sections, principally using examples from the set of 16th-century Italian paintings previously studied and focusing particularly on the darker categories – 'tinted, from light to mid-tone' and 'coloured, from mid-tone to dark'. Many of these preparations consist of two layers – most often a coloured priming (or *imprimatura*) over an off-white gesso ground layer. In these cases, only the colour of the uppermost preparatory layer was measured. However, there were a few exceptions where preparations consisted of more than one strongly coloured layer, as discussed below. Paintings from the category of 'white and off-white' were not addressed, firstly because there are fewer possible colour descriptions in this category, with everything being described as either white or off-white, and secondly because of the more significant effect of the yellowing of the binder in these cases. Many of the paintings in this category have a preparation consisting only of gesso (usually calcium sulphate with variable degrees of hydration), bound in animal glue, which often appears considerably discoloured in cross-sections, therefore measuring the colour of the layer in these cases is more likely to reflect the extent of discoloration than to provide useful information on the layer colour.

Results

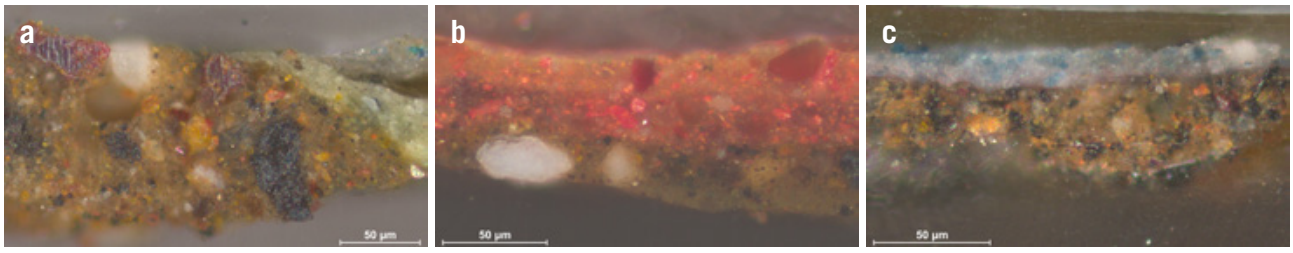
The colour averaging procedure was carried out on digital images of cross-sections from the group of Italian 16th-century paintings (see Table 1) and from a small number of other examples including the Goya portrait previously mentioned. In the latter example (and in a few other instances), a photomicrograph image was available in which the preparation visible on the surface of the painting could be compared to the colour measured from the cross-section layer.[22]

Table 1 Paintings ordered according to the lightness (L*) values recorded from the uppermost priming layer in cross-section images with the Nip2 colour averaging procedure. Where colours were recorded from more than one sample from the same painting, these are listed together (although in some cases L* values differed by as much as 10 units). The shaded rows designate paintings assigned to the 'mid-tone to dark' preparation category.

Paintings in the National Gallery, London	**Preparation colour**[1]	**Preparation colour description following review**	**L*a*b* values recorded from cross-section images using Nip2 tool**			**Lightness category**[1]
			L*	**a***	**b***	
Correggio, *Christ Taking Leave of his Mother* (NG4255), probably before 1514	Dark yellowish-brown	Dark yellowish-brown	27.1	4	19.5	Mid-tone to dark
Moretto da Brescia, *Portrait of a Man* (NG1025), 1526	Yellow-brown	Dark brown	30.9	7.3	16.7	Mid-tone to dark
Jacopo Bassano and workshop, *The Purification of the Temple* (NG228), probably *c*.1580	Black	Black	32	0.9	-1	Mid-tone to dark
Correggio, *Venus with Mercury and Cupid* (NG10), *c*.1525	Red-brown	Reddish-brown	32.2 42.5	12.7 12.2	23.9 26.5	Mid-tone to dark
Giovanni Battista Moroni, *A Knight with his Jousting Helmet* (NG1022), *c*.1554–58	Dark yellow-brown	Dark yellowish-brown	34.1 34.6	4. 1 2.7	20.9 17.3	Mid-tone to dark
Giovanni Battista Moroni, *Portrait of a Lady* (NG1023), *c*.1556–60	Dark yellow-brown	Dark brown	39.1	6.0	16.9	Mid-tone to dark
Giovanni Battista Moroni, *Bust Portrait of a Young Man with an Inscription* (NG3129), *c*.1560	Red-brown	Dark brown	43.9	6.8	18.2	Mid-tone to dark
Moretto da Brescia, *The Madonna and Child with Saints* (NG1165), *c*.1540	Dark brown	Dark brown	45.6	6.9	19.3	Mid-tone to dark
Moretto da Brescia, *Saint Jerome* (NG2093), *c*.1540	Brownish	Brown	45.7	8.6	24.8	Light to mid-tone
Jacopo Bassano, *The Good Samaritan* (NG277), *c*.1562–63	Red-brown	Reddish-brown	49.3	10.6	16.3	Mid-tone to dark
Leandro Bassano, *The Tower of Babel* (NG60), *c*.1600	Dark red-brown	Reddish-brown	49.6 51.1	12.3 11	31.8 24.8	Mid-tone to dark
Moretto da Brescia, *Saint Joseph* (NG2092), *c*.1540	Brownish	Brown	51.5	7.4	28	Light to mid-tone
Girolamo Romanino, *Saint Alexander* (NG297.2), *c*.1524	Mid brownish-grey	Mid brownish-grey	51.9	2.2	7.5	Mid-tone to dark
Martino Piazza, *Saint John the Baptist in the Desert* (NG1152), 1513–22	Light to mid warm grey	Light grey	57.8	0.5	9.8	Light to mid-tone
Giovanni Girolamo Savoldo, *Mary Magdalene* (NG1031), *c*.1535–40	Pinkish-beige	Mid brown	61.6	4.2	26.1	Light to mid-tone
Correggio, *The Madonna of the Basket* (NG23), *c*.1524	Light pinkish-grey	Light pinkish-grey	65 73.5	3.5 4.4	12.4 15.8	Light to mid-tone
Sebastiano del Piombo, *Judith (or Salome?)* (NG2493), 1510	Very pale grey	Light grey	69.3	0.2	4.1	Light to mid-tone
Titian, *The Virgin and Child with the Infant Saint John and a Female Saint or Donor* (NG635), *c*.1532	Pale grey	Light grey	69.9	0.3	9.9	Light to mid-tone
Paris Bordone, *Christ as 'The Light of the World'* (NG1845), *c*.1550	Light yellow-beige	Light brown	72.7 67.0	5.8 5.0	12.4 17.5	Light to mid-tone
Possibly by Jacopino del Conte, *Portrait of a Boy* (NG649), *c*.1540	Light brownish-grey	Light yellowish-brown	75.0	0.8	16.2	Light to mid-tone
Follower of Pontormo, *The Madonna and Child with the Infant Baptist* (NG6375), probably 1560s	Light orange-beige	Light yellowish-brown	80.0	0.5	15.3	Light to mid-tone

[1] As defined in 1998 – see note 2

Comparing the L*a*b* values of the colour measured from the photomicrograph image to that measured from the cross-section layer, it could be seen that the hue was very similar, but the value of L* (lightness) was different (Fig. 1c and d). It is to be expected that the colour of the layer as seen in the cross-section will appear lighter than the colour as viewed from the



L* = 43.9 a* = 6.8 b* = 18.2		L* = 39.1 a* = 6.0 b* = 16.9		L* = 45.6 a* = 6.9 b* = 19.3	

Fig. 3 Paint cross-sections from (a) Giovanni Battista Moroni, *Bust Portrait of a Young Man with an Inscription*, (b) Giovanni Battista Moroni, *Portrait of a Lady*, (c) Moretto da Brescia, *The Madonna and Child with Saints*, The National Gallery, London, inv. nos. NG3129, NG1023 and NG1165. Averaged colours from the preparatory layer of each are shown below. The colours of the preparatory layers assigned in 1998 (note 2) were 'red-brown', 'dark yellow-brown' and 'dark brown' respectively. (Photos © The National Gallery, London.)

surface of the painting due to the high illuminance used over a small area when looking at a sample at high magnification under the microscope, and this was borne out by the results of colour measurement. It is also likely that the preparation may appear darker on the surface of the painting due to the presence of dirt and the saturating effect of varnish layers on top (which may also be discoloured).

Among the 16th-century Italian works, samples from at least 10 paintings in each of the categories 'light to mid-tone' and 'mid-tone to dark' were examined (see Table 1 in which the results are ordered according to the lightness L* value of the measured colour). In a small number of cases, colours were averaged from two samples from the same painting to gauge the consistency of results. Some variation in the measured colours was observed but differences were small. The greatest shift was observed between two samples from *Venus with Mercury and Cupid* (Correggio, NG10), which had very similar a* and b* values but slightly different L* values. In this case the difference was thought to be due mainly to a different exposure level used in the two images: one sample had lighter coloured paint layers than the other, resulting in a shorter exposure time being used compared to that for the darker coloured sample (see earlier section on imaging of cross-sections for a description of how exposure times were set).

In the darker colour category, the colours measured from the cross-sections were compared and grouped according to the colour description the painting had previously been given based on visual examination.[23] This revealed some inconsistencies in colour naming, where several patches had very similar colours but had been given slightly different descriptions. For example, three paintings had previously been categorised respectively as 'dark yellow-brown' (Giovanni Battista Moroni, *Portrait of a Lady*, NG1023), 'red-brown' (Giovanni Battista Moroni, *Bust Portrait of a Young Man with an Inscription*, NG3129) and 'dark brown' (Moretto da Brescia, *The Madonna and Child with Saints*, NG1165), but the colours recorded from these examples were actually very close, both to the eye and in their L*a*b* values. When the cross-sections from these works were examined side by side, as a check on this result, it became apparent that it would make sense to give these the same colour description of 'dark brown' (Fig. 3).

The same procedure carried out on paintings from the light to mid-tone category gave similar results. Paintings variously described as having preparations that were 'light to mid warm grey' (Martino Piazza, *Saint John the Baptist in the Desert*, NG1152), 'very pale grey' (Sebastiano del Piombo, *Judith (or Salome?),* NG2493) or 'pale grey' (Titian, *The Virgin and Child with the Infant Saint John and a Female Saint or Donor,* NG635) produced colour patches that appeared sufficiently similar for all three paintings to be given the same label of 'light grey'.

The variations in the earlier descriptions were not surprising given that the colours of the preparatory layers were named without the intention of placing the paintings in a database using a limited number of fixed colour terms. Updates to the technology used for the examination and photography of cross-sections have also made a significant difference, compared to 1998 when these colour descriptions were assigned.[24] Comparison of colours was only possible through direct observation of the actual cross-sections while examining them under the microscope, quite challenging for more than 130 paintings, or through comparison of 35 mm slides where the possibilities for adjusting settings to improve the visibility of different features were much more limited compared with the digital cameras and software available today. It has also been noted that the microscope currently in use at the National Gallery allows us to observe finer details in cross-section samples than could be distinguished with the equipment used in the earlier study, for example to see fine particles of lamp black within an off-white priming layer.

A limited list of colour terms facilitates the searching and filtering of results in a database, therefore it was decided in the database design to use a fixed list of basic terms for the main preparation colour, containing black, brown, green, grey, off-white, pink, red, white and yellow. Further 'colour modifier' and 'lightness descriptor' terms were used as optional additional terms to add further colour or lightness information, for example to describe a layer as dark yellowish-brown.[25] The use of up to three terms to describe colour permits a large number of different colours to be defined, allowing nuanced descriptions. Table 1 lists the suggested new colour descriptions defined according to this standardised method, which were updated with reference to the findings of the colour

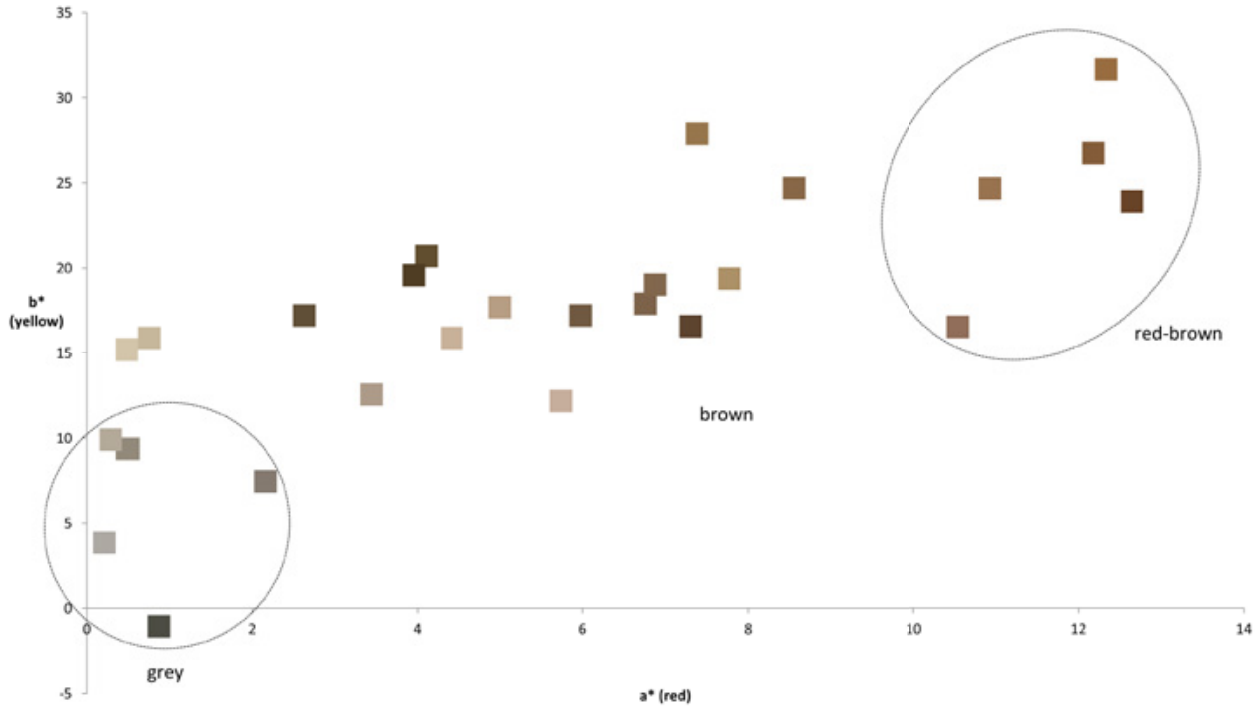


Fig. 4 Scatter plot of colour patches recorded from the paintings listed in Table 1, positioned according to the a* and b* values measured from the uppermost preparatory layer, showing the range of colours found and some approximate colour groupings. Note that this two-dimensional plot does not incorporate the third coordinate needed to fully define the recorded colours: the lightness (L*).

averaging procedure to ensure that similar colours are named in the same way.

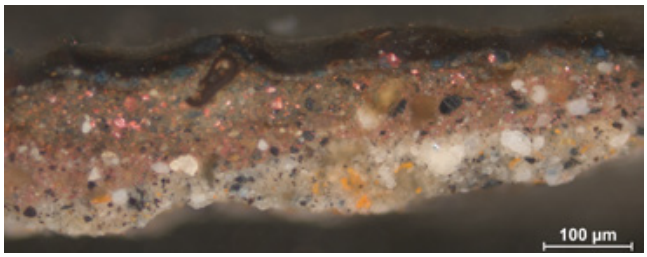
The colour averaging exercise produced a series of colour patches that represent the range of preparatory layers found in this group of paintings. For future categorisation of paintings it may be useful to assemble these into a colour chart to which new samples can be compared in order to assign appropriate colour descriptions. However, comparing the image of a cross-section to such a set of patches may not always be straightforward, particularly for more heterogeneous layers composed of coarse particles of different colours. To avoid difficulties in perception, a more objective method would be to use the tool to measure the colour from the layer in a cross-section for each new sample, and then to utilise the L*a*b* values to group it numerically with similar colours.

Comparing L*a*b* values

The L*a*b* values measured from the test cases were compared to determine whether trends could be identified. Ordering the results by their L* values, it was found that the paintings did separate out into the two previously defined categories, 'light to mid-tone' and 'mid-tone to dark', although the dividing line between these two categories is somewhat arbitrary (see Table 1). In the original study, the distinction was made according to whether the colour was considered to be dark enough to cause a change in the artist's technique, although this in itself is difficult to judge.[26] In the works examined in this study, L* values below 52 were found for those paintings placed in the category 'mid-tone to dark'. The only exceptions were the two paintings by Moretto da Brescia in which the preparation consisted of a thin brownish medium-rich layer over a gesso ground, as discussed further below.

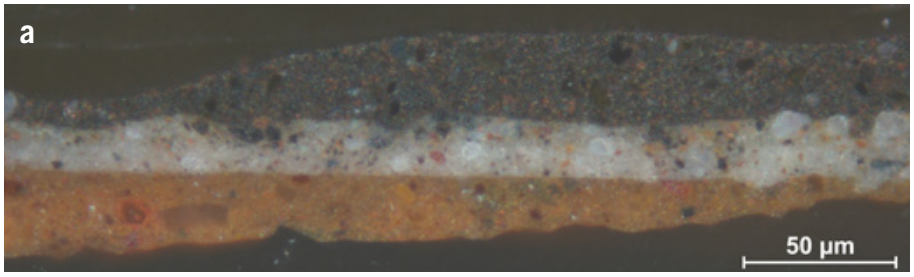
The a* and b* values of the colours were plotted against each other to see the range of colours and how clusters might form (Fig. 4). Colours with values of both a* and b* close to zero result in greys. The remaining colours all had higher positive values of a* and b*, giving varying brown shades, while those with higher a* values might be described as red-brown. This scatter plot does not take account of lightness, the third coordinate. From examining the data it might be possible to record the colour of a new sample in the same way and use these numerical values to group it with similar colours. The L* coordinate could be used as a check on which lightness category the work should be placed in,[27] and the a* and b* values could be used to place the colour on the scatter plot that would enable it to be grouped with similar colours. In the future it may be possible to incorporate the tool within the database so that the colour of preparatory layers in cross-section images can be measured as they are added to the database.

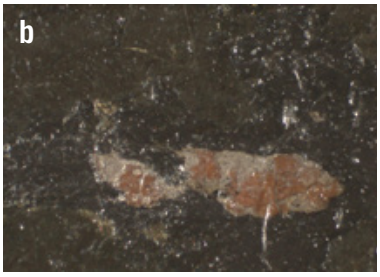
In assessing the effectiveness of the colour averaging approach, the most important factor is in the quality of photography – in particular, both the way in which the white balance is carried out and the exposure level of the image will have an impact on the colours resulting from the procedure. The random variation of the particles in a cross-section layer may also have a significant effect – for example, when a layer contains a strongly coloured particle that is particularly large in proportion to the rest of the layer. Some variation



Upper layer: red-brown	L* = 49.3 a* = 10.6 b* = 16.3	
Lower layer: pinkish-grey	L* = 61.3 a* = 5.2 b* = 16.1	

Fig. 5 Jacopo Bassano, *The Good Samaritan*, The National Gallery, London, inv. no. NG277. Paint cross-section with two preparatory layers shown beside the colours recorded from those layers. (Photo © The National Gallery, London.)





c

L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
45.3	10.6	20.2	56.8	0.2	4.3	50.9	4.6	12.1	54.1	3.1	12.0

Fig. 6 Jacob van Walscapelle, *Flowers in a Glass Vase*, The National Gallery, London, inv. no. NG1002. (a) Paint cross-section showing grey over brownish-red preparatory layers. (b) Photomicrograph of a loss on the painting surface showing the preparatory layers beneath the black paint layer. (c) Colours averaged in the cross-section image from (left to right) the lower preparatory layer, the upper preparatory layer, equal areas of both preparatory layers, and the upper preparatory layer in the photomicrograph. (Photos © The National Gallery, London.)

was found to result from measuring different samples from the same painting, and also from changing the exact region of the image chosen to define the colour, therefore it would not make sense to use the L*a*b* values too rigidly but rather for a loose grouping of similar colours. Where more than one sample from the same painting is measured, the L*a*b* values should be averaged to give a more representative result.

More complicated cases: layering effects

The previous examples focused mainly on preparation layers where it was reasonable to assume that only the uppermost layer of the cross-section was contributing to the overall colour effect. Most of the preparations consisted of one or two layers. Where there were two layers, the first preparatory layer was usually a simple off-white gesso layer, functioning principally to fill the canvas interstices and modify absorbency, rather than having a colour function. However, in a few cases the underlying layers may have an influence on the perceived surface colour.

One example where the uppermost preparatory layer is not solely responsible for the overall colour effect can be found in the 'light to mid-tone' colour category, in two panels forming the wings of a triptych by Moretto da Brescia, *Saint Joseph* (NG2092) and *Saint Jerome* (NG2093). In this case, the brownish priming is a thin, medium-rich layer on top of a gesso ground. The upper layer is pigmented, containing lead white, red earth and black pigments, but the high medium content and thinness make it translucent, so that the gesso layer beneath shows through, resulting in the bulk surface appearance being lighter than the measured colour of the upper layer alone would suggest. This is an example where the lightness value recorded from the layer in the colour averaging exercise on its own would lead to these layers being grouped in the darker preparation category, although they properly belong in the lighter category (see Table 1). Other examples were encountered of priming layers containing glass particles in a medium-rich layer which, although reasonably transparent when viewed on the surface of the painting, may appear relatively dark and grey or brownish in a cross-section image.[28] In such cases it is expected that again the colour averaging approach would not be particularly useful.

Preparations consisting of more than one coloured layer were rare in the group of Italian 16th-century paintings studied. One example was found in *The Good Samaritan* by Jacopo Bassano (NG277) in which the preparation consists of a dark red-brown layer over a mid-pinkish-grey layer (Fig. 5). The colours averaged from the two layers were similar in hue, differing mainly in the lightness value, and in this example, which has a darker upper layer, it is likely that the lower layer has not made a significant contribution to the overall colour effect.

It is anticipated that the database of preparatory layers may be expanded in the future to include a wider range of paintings than those studied here. One category of preparations that might be interesting to study are those consisting of a pale grey over a dark red preparation layer, as is frequently found in Dutch 17th-century works.[29] The perceived colour effect from such a layer structure can be difficult to determine when examining paint cross-sections, as this will depend on the thickness and transparency of the upper layer. It is also possible that changes in transparency of the layers will have occurred due to ageing, meaning that the effect perceived today on the painting surface may differ from that achieved when the layer was first applied. An understanding of the optical effect of applying one colour over another is also important in interpreting an artist's practice. It has sometimes been suggested that the upper grey layer was applied by the artist to modify the colour of a commercially primed canvas. However, descriptions of such grey-over-red preparations are given in contemporary technical treatises such as the De Mayerne manuscript,[30] so it seems more likely that it was a means of preparing a canvas in a cost-effective manner using cheap earth pigments to fill and smooth the surface of the support before the desired final colour was applied on top.

A work by Jacob van Walscapelle, *Flowers in a Glass Vase* (NG1002) has a preparation of this type, consisting of a grey over a brownish-red layer. The colours of the two preparatory layers in the image of the cross-section were measured both together and separately, and were also compared to the bulk colour observed on the painting where this was exposed at the edge of a paint loss. This showed that the bulk colour effect measured from the photomicrograph was very similar to that measured from the combined preparatory layers in the cross-section, but shifted slightly towards the uppermost layer colour, being a little lighter and less red (Fig. 6). Although this colour averaging method did not take account of the scattering effect of light produced by a light layer over a dark layer, it did nonetheless give a reasonable approximation of the bulk colour in this case.

Conclusions

The colour averaging procedure has been a valuable exercise as a check on colour descriptions as well as being an interesting means of determining how colours of grounds should be classified. As the IPERION-CH project to create a database on preparatory layers has a limited duration, it has been necessary to prioritise creating the overall structure and the addition of data, meaning that it has not been feasible to include the colour measurement tool directly in the database at this stage, although this could be a useful addition in the future. The results showed that in general, the colour averaged from the preparatory layer in the cross-section image did give a good approximation of the bulk colour of the preparation. The lightness of the measured colours appeared to be the most significant difference between colours measured from cross-sections and those seen on the painting surface, particularly for dark coloured grounds. It is also clear that consistent imaging of the samples is key to obtaining useful results, as well as being valuable for general record-keeping and enabling more reliable comparisons between samples. The colour averaging method was also useful in the process of improving imaging protocols, for example in evaluating the optimum surface to use for white balancing the images, and could have wider applications for comparing the photography of samples.

The method could be explored further as a tool for grouping paintings by preparation colour. Fig. 4 gives an idea of the range of colours found in this set of paintings and could be assembled into a colour chart to which each new sample could be compared for classification purposes. Using some form of comparison when grouping preparatory layers would be useful. The averaged colours are easier to compare than the actual cross-sections although this approach is not appropriate in all cases such as samples with relatively transparent layers. The colour averaging results could also be used more directly to group paintings according to their numerical colour values. For the time being, it has been possible to carry out a visual check on the data being entered but issues with naming colours are likely to become more important as the database grows and data generated by a larger group of studies are added.

Acknowledgements

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Notes

1. IPERION-CH (Integrated Platform for the European Research Infrastructure ON Cultural Heritage) is a Horizon2020 project funded by the European Commission (grant number 654028) involving a consortium of 24 partners that are major centres of research in heritage science (http://www.iperionch.eu/). The work was carried out as part of Work Package 8: JRA3 - Developing of digital documentation and data, Task 8.4 – Sharing in practice: developing research-led digital resources from existing archives/data. See https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c8d6a2b7&appId=PPGMS (accessed October 2020).

2. This work documented preparatory layers in over 130 paintings: see J. Dunkerton and M. Spring, 'The development of painting on coloured surfaces in sixteenth-century Italy', in A. Roy and P. Smith (eds), *Painting Techniques, History, Materials, and Studio Practice*, London, IIC, 1998, pp. 120–130. Many of the paintings listed in this work have been subject to further study since this publication, revealing new information on the composition of preparatory layers, notably in the use of unusual black pigments: M. Spring, R. Grout and R. White, '"Black earths": a study of unusual black and dark grey pigments used by artists in the sixteenth century,' *National Gallery Technical Bulletin* 24, 2003, pp. 96–114; and in the inclusion of colourless powdered glass: M. Spring, 'Colourless powdered glass as an additive in fifteenth- and sixteenth-century European paintings', *National Gallery Technical Bulletin* 33, 2012, pp. 4–26. Further 16th-century Italian paintings were studied (and some of those in Dunkerton and Spring 1998 re-examined) in G. Mancini and N. Penny, *The Sixteenth Century Italian Paintings. Volume III: Bologna and Ferrara*, London, National Gallery Company, 2016.
3. It should be noted that the measuring of colour described here is simply an averaging of the red, blue and green (RGB) values of the coloured pixels in a digital image to give a single colour with a defined set of coordinates. This does not bear any relation to the measurement of colour using spectrophotometry in which the response of a material to the range of wavelengths in visible light is measured as a spectral reflectance curve.
4. Dunkerton and Spring 1998 (cited in note 2).
5. Gamma is a characteristic of digital imaging systems, defining the relationship between the light detected by the camera and the luminance used in the image display.
6. The exact differences between the images shown in Fig. 1 are not fully documented – although some software settings are recorded in the image metadata, others are not, and details such as how the white balance was carried out and the exposure settings are not known.
7. White balancing of an image is the process of correcting for any consistent colour cast or colour shifts caused by the lights or camera equipment, often by using a standard white or grey surface as a reference.
8. Two of the samples were prepared at the National Gallery using the usual procedure of embedding in Tiranti clear casting polyester resin (orthophthalic resin with methyl methacrylate and styrene), set with Butanox M50 hardener (methyl ethyl ketone peroxide). The sample with the red-brown ground was prepared at KIK-IRPA (Brussels) within the CHARISMA project, as part of Task 2.1a, Methodologies for sampling and sample preparation. The sample was first glued to the surface of a small Plexiglas cube with methacrylate resin (Spofacryl) and covered with a layer of the same resin. A second small Plexiglas cube was then placed on top before the resin had hardened.
9. The images are recorded as 14-bit zvi files (the proprietary format of the AxioVision software), with a resolution of up to 13 megapixels.
10. Colour calibration of the monitor was carried out using a Hewlett-Packard GretagMacbeth device with i1Match software.
11. Plastic reusable adhesive putty (https://diy.bostik.com/en-UK/products/stationery-craft/blu-tackr, accessed October 2020).
12. The standard values used are brightness: –0.51; contrast: 1.02; gamma: 0.45. This value of gamma is recommended in the camera software for the best colour reproduction.
13. The brightness, contrast and gamma values are saved within the bespoke 14-bit zvi image files and can be adjusted at any time in the camera software before exporting the images as either TIFF or JPEG, depending on what is required. For the purpose of the colour averaging exercise, these were exported as 8-bit JPEG images.
14. It would be possible to standardise the method further, for example by using a standard exposure time. However, considering the variety of colour and lightness of the layers that can be found in paint cross-sections, standard exposure settings would not give informative images in many cases. During this exercise it was decided to test the colour averaging method on the same images that are taken for ordinary documentation purposes.
15. Nip2 was used to measure the average colour of the images of the standard white Spectralon block using the same procedure described later in the text. The values measured on the image taken after white balancing on the white opaque glass were: L* 85, a* 3.1, b* 6.7. The values measured on the image taken after white balancing on the X-Rite card were: L*87, a*0.9, b* 0.8. In the latter result both a* and b* values are closer to zero, the point that would correspond to a neutral grey.
16. 'The Paint Sample Database of the Rijksmuseum and colour calibration of microscopic images', presentation by Susan Smelt, IPERION-CH, WP9 Expert meeting: Preparation for painting – grounds and primings in European paintings 1500–1800 (13–14 June 2016, Copenhagen).
17. The colour averaging procedure described in this paper was carried out on images of the same sample taken at the Rijksmuseum and the National Gallery with the updated protocol, on an area of the red-brown preparatory layer as a means of checking the similarity of the result. This showed very similar L*a*b* values for the two recorded colours, corresponding to a ΔE* (colour difference) of 2.7. Comparison of the Rijksmuseum image with an image taken before the National Gallery protocol was updated showed a greater difference of 6.1 (ΔE* was calculated using the formula: $\Delta E^* = \sqrt{((L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2)}$).
18. Nip2 may be downloaded from https://github.com/libvips/nip2/releases. See also K. Martinez and J. Cupitt, 'VIPS – a highly tuned image processing software architecture', in *IEEE International Conference on Image Processing*, Genoa, 2005, pp. 574–577, doi: 10.1109/ICIP.2005.1530120, available from https://eprints.soton.ac.uk/262371/ and https://scholar.google.co.uk/scholar?q=ieee+international+conference+on+image+processing+2005&hl=en&as_sdt=0&as_vis=1&oi=scholart (all links accessed October 2020).
19. This section of code and instructions as to how it may be used are now available at: https://github.com/libvips/nip2-extras/tree/master/tools/Non%20zero%20colour (accessed October 2020).
20. The standard values of L* range from 0 (black) to 100 (white); a* runs from green (negative values) to red (positive) and b* from blue (negative) to yellow (positive), with 0 on both a* and b* axes representing a neutral grey. See ISO/CIE 11664-4:2019(en) *Colorimetry – Part 4: CIE 1976 L*a*b* colour space*, available from https://www.iso.org/standard/74166.html; and *Precise Color Communication* Konica Minolta, 1998, available from https://www.konicaminolta.com/instruments/knowledge/color//index.html (all links accessed October 2020).
21. RGB coordinates (but not L*a*b* values) may be used to define custom colours for display on a monitor and for a PowerPoint presentation, therefore these coordinates were also recorded and used for the display of colour patches when this work was presented.
22. The photomicrograph images from which the bulk surface colours were measured were taken with a Zeiss Axiocam HrC mounted on a Wild M650 stereobinocular operating microscope, with a white balance performed on a Macbeth ColorChecker chart.

23. Dunkerton and Spring 1998 (cited in note 2).
24. Ibid.
25. In this example, lightness descriptor = dark; preparation colour modifier = yellowish; main preparation colour = brown.
26. For example, the darker category would encompass works where the ground is dark enough to form a mid-tone or shadow, necessitating a 'dark to light' method of painting, with opaque bodied paint required to create lighter tones; see Dunkerton and Spring 1998 (cited in note 2).
27. Although it was previously observed that variations in lightness values can occur between images of different samples from the same painting (e.g. for the two samples from NG10) due to variation in exposure, these differences were not sufficiently large to place the samples in a different lightness category from each other.
28. One example of this was found in *The Story of Papirius* by Domenico Beccafumi (NG1430), in which colourless glass was the only inorganic component identified in the priming. For further examples of glass-containing primings, see Spring 2012 (cited in note 2).
29. K.M. Groen, 'Grounds in Rembrandt's workshop and in paintings by his contemporaries', in E. van Duijn (ed.), *Paintings in the Laboratory: Scientific Examination for Art History and Conservation*, London, Archetype Publications, 2014, pp. 21–49.
30. Ibid., p. 23.

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NEW LIGHT ON THE USE OF ASH IN THE GROUND PREPARATIONS OF BAROQUE PAINTINGS FROM SPAIN, NORTH AND SOUTH AMERICA

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ABSTRACT The unique crystal shapes and skeletal structures of calcite particles associated with plant ash are crucial markers for the unambiguous identification of this material in the ground layers of paintings, particularly when small amounts of sample are available and/or when the heterogeneity of the elemental compositions makes it difficult to assign with certainty an ash origin to the components. For the present study, the ground preparations were analysed in paintings by Diego Velázquez (painted in Madrid and Rome), Luca Giordano (painted in Naples and Madrid), Cristóbal de Villalpando and José Sánchez (active in New Spain, Mexico), and in six works by Colonial South American artists. Ashes were identified in most of these paintings by the presence of crystals bearing the characteristic morphology, complemented by elemental analysis. Our results indicate that the practice of using ash in grounds, described in the treatises by Francesco Pacheco (1564–1638/1644) and Antonio Palomino (1655–1726), also occurred in Colonial Latin America, probably under the influence of the Spanish School.

Introduction

The use of ash in the ground preparations of 17th-century paintings produced in Madrid was reported by Jover de Celis and Gayo[1] in a study that provided the first scientific evidence of a practice described in the treatises by Francesco Pacheco (1564–1638/1644), published posthumously in 1649, and Antonio Palomino (1655–1726), published in 1715 and 1724.[2] To prepare the canvas supports, the authors of these treatises mentioned the use of sifted ashes, which Palomino specifically referred to as *cernada*, the residual, insoluble fraction from the production of lye, the alkaline solution obtained from plant ash.[3] The *cernada* was mixed with animal glue and applied either directly to the canvas or after a thin layer of animal glue. This first preparatory layer was known as *aparejo* or *aparejo de ceniza*. The *imprimación*, or priming, was applied on top, after the *aparejo* was sanded with pumice to create a smooth surface. Both writers were dismissive of the use of *aparejo de cenizas*, agreeing that it caused paint to flake. Coming from an Andalusian background, Pacheco mentions that this method is used in Madrid.[4] The alkaline solution obtained from leached ashes was used since antiquity for washing, bleaching and making soap, and was still in use in Spanish rural areas until the 1950s.[5] Additionally, ash of plant origin has been employed as a raw material in several technological processes, among which the best known is glass production.[6]

The composition of plant ash varies widely depending on multiple factors such as the plant type, the growing conditions, what parts are burned, the temperature and length of burning, as well as the degree to which the ash is weathered or leached in the case of its use in the ground preparation of paintings.[7] Plant residues in the ash comprise microcrystalline calcium carbonate aggregates, elongated silica structures, vesicular glassy slags and very fine crystalline material.[8] Along with the plant residues, ash may also contain carbonates, silicate particles, charcoal and soil aggregates. All these components are of relevance to the composition of ashes used in the ground preparation of paintings but the morphology of the calcium carbonate aggregates is of particular interest,[9] as discussed below.

Abundant particles of calcium carbonate with characteristic morphologies have been widely reported in association

Table 1 List of the paintings studied with works for which leached ash, rich in calcite pseudomorphs, or unprocessed ash were identified. * The Metropolitan Museum of Art; ** Hispanic Society of America; *** Fordham University.

Artist	**Painting (inv. no.)**	**Date**	**City**	**Ground preparation**	
				Leached ash, rich in calcite pseudormophs	Unprocessed ash, with soil
Diego Velázquez	*Philip IV, King of Spain* (14.40.639)*	*c.*1624	Madrid	✓	
Diego Velázquez	*Portrait of a Young Girl* (A108)**	*c.*1640	Madrid	✓	
Diego Velázquez	*Peasant Girl* (private collection)	*c.*1649–50	Rome?	✓	
Diego Velázquez	*Juan de Pareja* (1971.86)*	1650	Rome	✓	
Possibly Diego Velázquez	*Portrait of a Man* (89.15.29)*	*c.*1650	Rome?	✓	
Diego Velázquez	*Cardinal Camillo Astalli-Pamphili* (A101)**	*c.*1650	Rome	✓	
Luca Giordano	*The Annunciation* (1973.311.2)*	1672	Naples		
Luca Giordano	*The Flight into Egypt* (61.50)*	*c.*1700	Madrid	✓	
Cristóbal de Villalpando	*The Adoration of the Magi****	1683	Puebla?	✓	
José Sánchez	*The Marriage of the Virgin* (2016.553)*	*c.*1690	Mexico City?	✓	
Attributed to Melchor Pérez Holguín	*Saint Christopher* (2018.652.2)*	*c.*1710–20	Potosi		✓
Unknown Peruvian	*Our Lady of Mercy* (2018.652.4)*	*c.*1730–40	Cuzco		✓
Unknown Peruvian	*Our Lady of Cocharcas* (2019.14)*	1759	Cuzco		✓
Unknown Peruvian	*Christ Carrying the Cross* (2018.652.5)*	*c.*1770–75	Cuzco		✓
Unknown Peruvian	*Our Lady of Valvanera* (2018.652.3)*	*c.*1770–80	Cuzco?		✓
Unknown Peruvian	*The Soul of the Virgin* (2018.836.3)*	18th century	Cuzco		

with plant ash in natural, industrial and archaeological contexts.[10] The abundant calcite found in plant ashes derives primarily from the initial thermal decomposition of calcium oxalates, whewellite or weddellite, originally present in the plant's tissues. The calcium oxalate crystals have distinguishing shapes, the most common being various types of prismatic crystals and druses, but elongated fibrous crystals and aggregates of submicrometric crystallites, called 'crystal sand,' may also be present.[11] Hydrated calcium oxalates may form calcite ($CaCO_3$) and/or lime (CaO) depending on the temperature reached during the combustion, with calcite formation occurring around 420–510 °C, and decomposition to CaO starting when the temperature exceeds 600 °C and completing at around 850 °C. The CaO crystals are organised in chains of submicrometric particles that preserve the shape of the oxalates. These small CaO particles are extremely unstable and can react to form $CaCO_3$ in the presence of moisture in the environment. Full transformation of CaO to calcite occurs after long-term weathering or mixing with water to produce lye. The formation of calcite by carbonation of CaO takes place without an apparent change in crystal morphology, so these calcite crystals are referred to as pseudomorphs. The calcite pseudomorphs become the dominant constituents after the ash is leached as the result of the dissolution of carbonates and hydroxides of sodium and potassium, and because of the particle separation by floatation that removes charcoal fragments, for example when water is added to leach it. In ash, calcite pseudomorphs with polygonal shapes, commonly with four or five sides, generally range in size between 10 and 30 μm.[12]

Even after the transformations that occur during burning, the calcite crystals retain the shapes of the oxalate crystals. However, the pseudomorphs crystal faces have cavities and embayments that differ substantially from the smooth oxalate crystal faces.[13] These unique morphological features of calcite pseudomorphs – the crystal shapes and skeletal structure – are important markers for the unambiguous identification of ash in the ground layers of paintings. This is particularly important when only small amounts of sample are available and/or when the heterogeneity of the elemental composition of the ground layers makes it difficult to firmly assign an ash origin to the components.[14]

Recently, and in addition to the paintings executed in Madrid during the baroque period that were found to have leached ash in their ground preparations,[15] it was discovered that Diego Velázquez (1599–1660) used leached ash while he was in Rome.[16] For the present study, we extended our investigation to four paintings by Velázquez: two painted in Madrid, one painted in Rome and the fourth one possibly painted in Rome.

An anonymous manuscript, written in the Toulouse region of France and dated to *c.*1580–1600, mentions the use of ashes for the first layer in a two-layer preparation for panels:

> 'common ashes' (probably burnt wood) mixed with oil and chalk, or with the colours that have accumulated at the bottom of the rinsing jar for brushes. This mixture

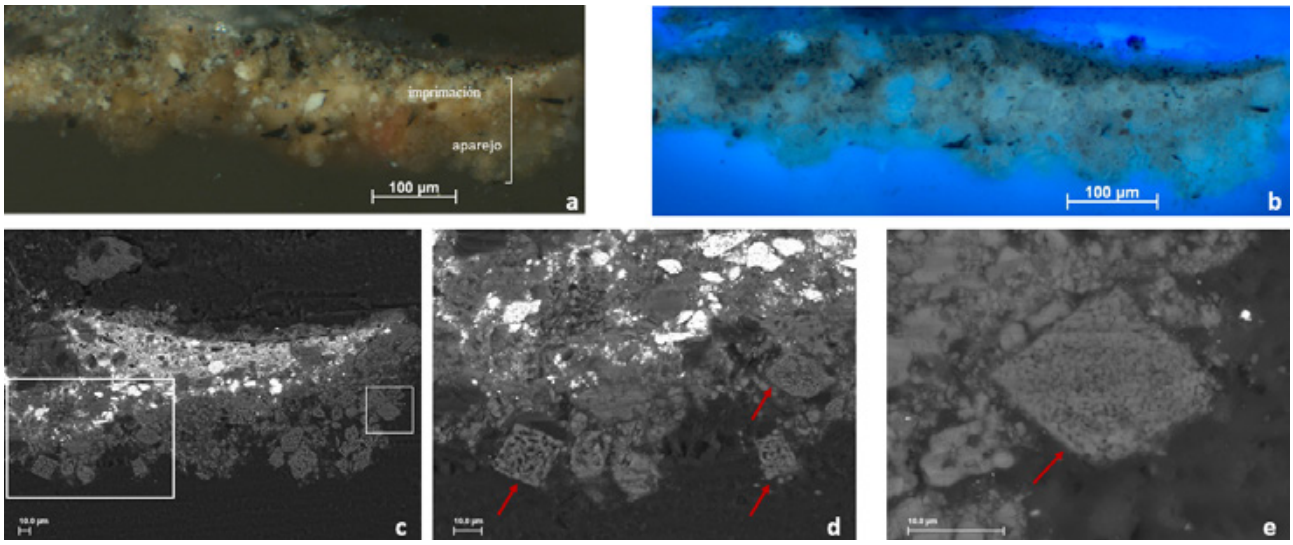

Fig. 1 *Cardinal Camillo Astalli-Pamphili (1616/19–1663)*, Hispanic Society of America Collection, New York. Cross-section sampled from the left edge, photographed at ×200 with visible (a) and ultraviolet (UV) (b) illumination; (c) ×400 BSE image; (d) ×768 BSE image; (e) ×2650 BSE image. In (c) details are indicated by white rectangles and in (d) and (e) calcite crystals with the characteristic morphology of ash origin are indicated by red arrows.

> is applied as a first layer, and covered by a second layer containing ceruse or 'mixed colours'.[17]

But, so far, no scientific evidence of this practice has been reported for works by non-Spanish artists working outside Spain. To investigate if the custom extended to non-Spanish painters working in Europe outside Spain and to artists in Colonial Latin America, we examined and analysed paintings by the Italian painter Luca Giordano (1632–1705), who worked in both Naples and Madrid, Cristóbal de Villalpando (*c.*1649–1714) and José Sánchez (active 1686–95), who worked in the Viceroyalty of New Spain, and by a group of artists in 18th-century Colonial South America.

Methods

All the cross-sections were studied and analysed by means of optical microscopy and SEM-EDX, complemented with Raman spectroscopy. The morphology and texture of the calcite particles were investigated by optical microscopy and SEM. The cross-sections were photographed with a Zeiss light microscope under visible and UV illuminations using AxioVision4.X.X software. SEM-EDX was performed with a FE-SEM Zeiss Σigma HD, equipped with an Oxford Instrument X-MaxN 80 SDD detector. Backscattered electron (BSE) images, EDX and X-ray mapping were carried out with an accelerating voltage of 20 kV on carbon-coated cross-sections. Raman spectroscopy measurements were done on the cross-sections using a Renishaw System 1000 coupled to a Leica DM LM microscope. All the spectra were acquired using a 785 nm laser excitation focused on the sample using a ×50 objective lens, with integration times between 10 and 120 s. A 1200 lines/mm grating and a thermoelectrically cooled CCD detector were used. Powers at the sample were set between 0.5 and 5 mW using neutral density filters.

Results

The results for the paintings studied are summarised in Table 1.

Paintings executed by Diego Velázquez during his Madrid and Rome periods

The previous identification of leached ash in the ground of Velázquez's *Portrait of a Man*[18] added to the list of 17th-century Spanish paintings executed in Madrid in which this material was used in the preparatory layers.[19] In the same article, the identification of calcite crystals with the characteristic morphology of ash origin in the ground of the well-documented *Portrait of Juan de Pareja* was reported.[20] Velázquez painted the portrait while in Rome, confirming that the use of leached ashes was not limited to paintings executed in Madrid and that this artist maintained his traditional practice and may have travelled with his preferred materials.

For the present work, we examined and analysed the ground preparations in four other paintings by Velázquez: *Cardinal Camillo Astalli-Pamphili (1616/19–1663), c.*1650 (New York, Hispanic Society of America) (Fig. 1); *Portrait of a Young Girl, c.*1640 (New York, Hispanic Society of America); *Peasant Girl, c.*1649–50 (private collection); and *Phillip IV (1605–1665), King of Spain*, probably dating to 1624 (New York, The Metropolitan Museum of Art). *Portrait of a Young Girl* and *Phillip IV* were painted in Madrid[21] while *Cardinal Camillo Astalli-Pamphili* is from Velázquez's second Rome period[22] and so possibly is *Peasant Girl*.[23] Calcite crystals derived from plant ash were identified unequivocally in the ground preparation of these four paintings.

A cross-section of a paint sample from the dark background, in the right edge of *Cardinal Camillo Astalli Pamphili* is presented in Fig. 1. In this painting, the grey ground consists of an *aparejo* containing calcite crystals with the typical

Fig. 2 Luca Giordano, (a) *The Annunciation*, 1672, oil on canvas, 236.5 × 169.9 cm. (b) *The Flight into Egypt, c.*1700, oil on canvas, 61.5 × 48.9 cm. The Metropolitan Museum of Art, New York, inv. nos. 1973.311.2 (Gift of Mr and Mrs Charles Wrightsman, 1973) and 61.50 (Gift of Mr and Mrs Harold Morton Landon, 1961). (Photos: Imaging Department, The Metropolitan Museum of Art, New York.)

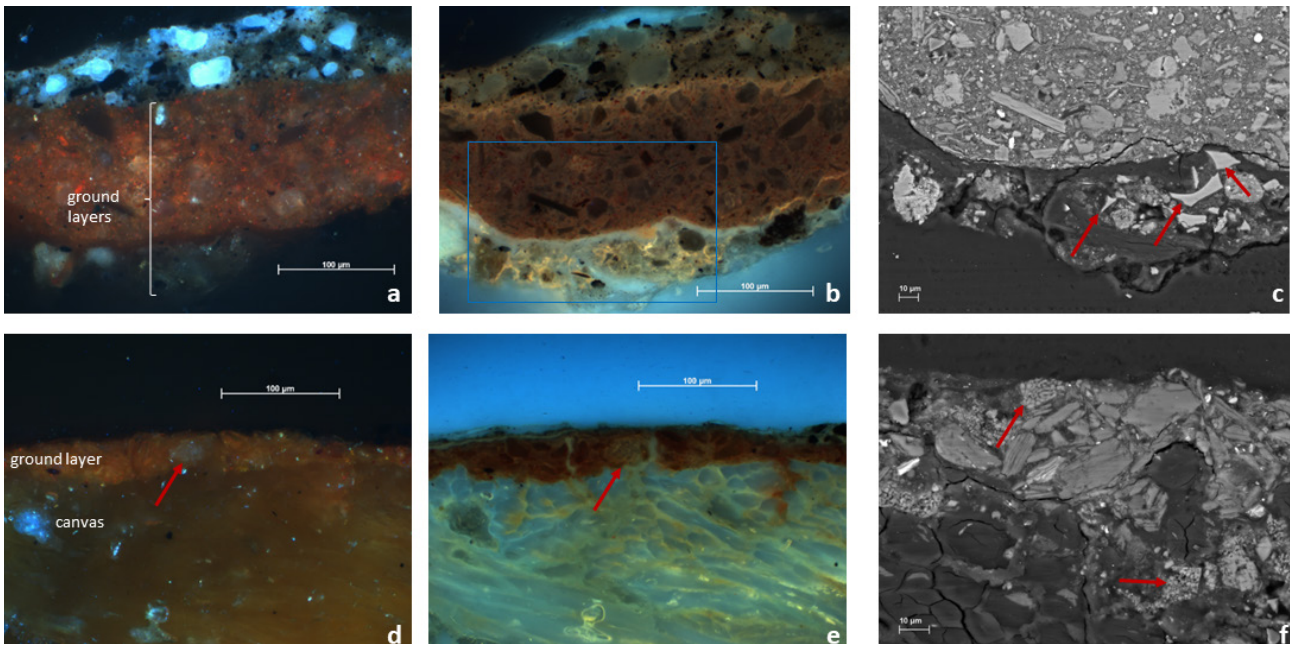

Fig. 3 (a) and (b) Cross-section sampled from *The Annunciation* (Fig. 2a) photographed at ×400 with visible and UV illumination; (c) BSE image of the area marked with a blue rectangle in (b); (d) and (e) cross-section sampled from *The Flight into Egypt* (Fig. 2b) photographed at ×400 with visible and UV illumination; (f) BSE detail of the sample shown in (d) and (e). In (c) the red arrows indicate angular glassy particles composed of Si, Al, K, Ca, Na and Fe, in the bottom layer of the ground, while in (d), (e) and (f) the arrows point to calcite pseudomorphs.

morphology of ash origin and an *imprimación* composed of lead white, an ochre and a carbon-based black. Details showing calcite pseudomorphs in the *aparejo* at two magnifications are shown in Fig. 1d and e. The layer above the *imprimación* in this sample is the paint mixture that Velázquez used for the background, containing mainly an ochre, a carbon-based black and a relatively smaller amount of lead white when compared to the *imprimación*.

Fig. 4 Paintings by artists working in the Viceroyalty of New Spain. (a) Cristóbal de Villalpando, *Adoration of the Magi*, 1683, oil on canvas, 248.9 × 195.6 cm, Fordham University, New York; (b) *José Sánchez, The Marriage of the Virgin, c.*1690, oil on canvas, 127.6 × 182.9 cm, The Metropolitan Museum of Art, New York, inv. no. 2016.553 (Maria DeWitt Jesup Fund, 2016.) (Photos: Juan Trujillo, Imaging Department, The Metropolitan Museum of Art, New York.)

The Annunciation and *The Flight into Egypt* by Luca Giordano

To determine whether or not leached ashes have been used in the ground layers of paintings by non-Spanish artists, we compared the compositions of the grounds in two works by the Italian painter Luca Giordano (1632–1705), active in Naples in the 17th century, who was summoned to the Spanish court in 1692.[24] We selected two well-documented paintings by this artist in the collection of the Metropolitan Museum of Art, New York: *The Annunciation* (Fig. 2a), painted in Naples in 1672,[25] and *The Flight into Egypt* (Fig. 2b), commissioned by the Bourbon king, Philip V, while Giordano was in Madrid working for the Spanish court, and dating approximately from 1700.[26]

The Annunciation is painted on a canvas prepared with a dark red ground. In a paint sample from the grey tile to the right of Mary's foot, two ground layers are observed (Fig. 3a–c). No calcite particles that can be associated with ash-derived material were found in any of these two layers. The bottom layer is mainly composed of silicates as well as angular, glassy particles (Fig. 3c) containing Si, Al, K, Ca, Na and Fe. These angular particles may originate in volcanic soil or rock, such as pumice, or may be associated with high temperature zones in wood fire, where glass can form in the presence of abundant amounts of alkaline salts that act as fluxes.[27] The top layer in the ground is composed of a coarsely ground red ochre. Some calcite and dolomite particles are present in this upper layer but, as mentioned above, they do not have the skeletal morphology typical of calcite derived from ash.

The Flight into Egypt is also painted on a canvas support prepared with a dark red ground. However, this ground differs in its stratigraphy and composition from that in *The Annunciation*. A cross-section from the primed tacking edge in *The Flight into Egypt* is shown in Fig. 3d–f. Analysis of this cross-section, which includes the canvas support, in the scanning electron microscope with energy dispersive X-ray (SEM-EDX) analysis, showed that the ground consists of a single layer rich in silicates including quartz, feldspars and mica, clay minerals and possibly an ochre pigment. It also contains a few calcite particles with a shape and skeletal morphology typical of calcite originating from plant ash (Fig. 3f). This finding is consistent with those of Jover de Celis and Gayo who reported the presence of leached ash in the ground layer of several paintings by Luca Giordano dating from 1692–1700, all painted in Madrid.[28] The heterogeneous composition of the ground in *The Flight into Egypt*, with its relatively low abundance of calcite pseudomorphs, indicates the use of unprocessed ash. However, it is possible that what appears visually as an orange-brown ochre in this layer is in fact soil associated with the unprocessed ash. While the appearances of the dark red ground layers in *The Annunciation* and *The Flight into Egypt* are similar, the analytical comparison of the components highlights the use of locally sourced materials and practices as Giordano relocated from Naples to Madrid.

The Adoration of the Magi by Cristóbal de Villalpando and *The Marriage of the Virgin* by José Sánchez

The Adoration of the Magi by Cristóbal de Villalpando (*c.*1649–1714) (Fig. 4a), in the collection of Fordham University, New York, was examined, cleaned and restored in preparation for an in-focus exhibition on the Mexican painter that took place at the Metropolitan Museum of Art in 2017.[29] Probably painted for the cathedral of Puebla in 1683, this painting was acquired in the mid-19th century during a Jesuit mission to Mexico City and has been held in the collection of Fordham

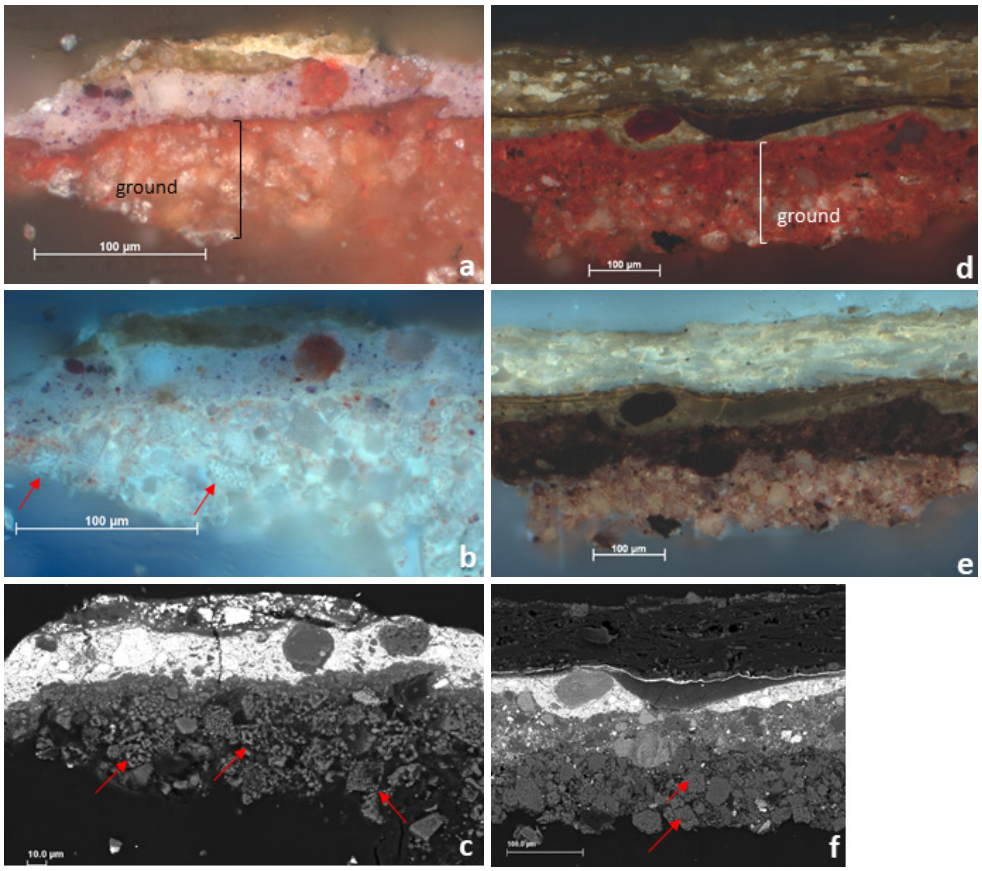

Fig. 5 (a–c) Cross-sections sampled from *The Adoration of the Magi* (Fig. 4a), photographed at ×500: (a): visible light; (b) UV; (c) BSE image; (d–f) cross-sections sampled from *The Marriage of the Virgin* (Fig. 4b), photographed at ×500, in visible light (d), UV (e) and BSE image (f). The red arrows indicate calcite pseudomorphs in the ground preparation.

University since then. *The Marriage of the Virgin*, *c.*1690, by José Sánchez (active 1686–95) (Fig. 4b) was acquired in 2016. The painting represents one scene from a pictorial series for an altarpiece dedicated to the life of the Virgin Mary, a theme frequently explored by painters in Spanish America.

Villalpando, the most recognised and prolific New Spanish painter of his time, was born in Mexico City and most likely never travelled to Spain.[30] He, along with Sánchez, formed part of a group of artists descended from Spaniards who revived Mexico City's Painters' and Gilders' Guild. Villalpando's expertise in painting and Sanchez's knowledge of both painting and gilding made them the perfect complementary candidates to become authorities in the guild. In 1686, between the creations of the paintings, Villalpando and Sánchez were elected judges to examine aspiring master painters entering the newly re-established institution. Their examination included a hands-on component in which artists primed canvases and completed a painting under the watchful eyes of the examiners.[31] As such, during the two years that their tenures overlapped they exerted a powerful influence over many artists, ultimately being responsible for shaping Mexican artistic practices well into the 18th century.

In the *Adoration*, the support comprised two vertical strips of canvas with the seam placed just left of centre. The seam was reinforced with a long narrow piece of paper, a technique popular in New Spain.[32] In a paint sample removed from the seam at the top perimeter (photomicrograph not shown), it was observed that the ground consists of three layers composed of a red earth mixed with abundant calcite derived from leached ash, and a little carbon-based black: one layer sits below the paper and two above. The bottom layer is relatively thicker and contains a larger amount of calcite while the final layer, which is thinner, consists of a higher proportion of red iron earth that served to homogenise the overall colour. In a second paint sample taken from a lavender cloak from one of the background figures in the *Adoration*, the calcite crystals from leached ash are large enough to be visible at ×500 magnification with an optical microscope (Fig. 5a–c). In this second sample, only the upper portion of the thickly applied ground structure is present.

A cross-section, sampled from the gilded left edge of Sánchez's *The Marriage*, which includes the complete stratigraphy and a paper fragment on top of the paint layers, is presented in Fig. 5d and e. In this sample, the ground consists of two layers, with the bottom layer composed of red earth mixed with calcite from ash and some carbon-based black, and the second layer containing mainly a red earth. In both paintings, the relatively high, predominant abundance of calcite pseudomorphs in the ground layers indicates that the ashes used were most likely refined by leaching and sieving. The few technical studies of works by Villalpando that have so far been reported are not sufficient to establish a pattern

Fig. 6 Paintings by artists working in Colonial South America. (a) Unknown Cuzco artist, *The Soul of the Virgin Mary*, 18th century, oil on canvas, 65 × 54 cm; (b) Unknown Cuzco artist, *Christ Carrying the Cross, c.*1770–75, oil on canvas, 165.1 × 121.9 cm; (c) Melchor Pérez de Holguín (attributed to), *Saint Christopher, c.*1710–20, oil on canvas, 164.5 × 99.5 cm; (d) Unknown Cuzco artist, *Our Lady of Mercy, c.*1730–40, oil on canvas, 125.1 × 155 cm; (e) Unknown Cuzco artist, *Virgin of Valvanera, c.*1770–80, oil on canvas, 203.4 × 243.5 cm; (f) Unknown Cuzco artist, *Our Lady of Cocharcas*, 1759, oil on canvas, 153.2 × 112.1 cm, The Metropolitan Museum of Art, New York, inv. nos. 2018.836.3 (Gift of James Ming Bo Li and He Xiaoyuli, São Paulo, in honor of James Kung Wei Li, 2018.), 2018.652.5, 2018.652.2, 2018.652.4, 2018.652.3 (all gifts of James Kung Wei Li in memory of Ambassador and Mme Ti-Tsun Li, Republic of China) and 2019.14 (Gift of John Ming Li in honor of James Kung Wei Li and Julie Chu Lu Li, 2019). (Photos: Juan Trujillo, Imaging Department, The Metropolitan Museum of Art, New York.)

of how the artist worked throughout his career. The question remains: were there specialised canvas primers in Mexico City as was the case in Madrid according to Palomino?[33] The large format of Villalpando's paintings, some measuring up to 8.5 m in height, suggests the contribution of assistants or commercial primers in the preparation of the canvases. Only systematic studies of the ground layers used by painters in New Spain, such as Villalpando and Sánchez, will shed further light on their use of leached ashes.

Paintings from Colonial South America

In 2018, the Metropolitan Museum of Art received a transformative donation of 10 paintings from South America, mostly painted in the Viceroyalty of Peru and with stylistic similarities to paintings of the Cuzco School.[34] To determine if Colonial South American artists were using ash by-products in their grounds, as identified in the works executed in the Viceroyalty of New Spain by Villalpando and Sánchez, we selected a group of six paintings dating to the 18th century (shown in Fig. 6a–f) for analysis. Of these six works, five were painted in the Viceroyalty of Peru by unknown artists, while *Saint Christopher* (Fig. 6c) has been attributed to Melchor Pérez de Holguín (*c.*1660– after 1732), an important artist working in Potosí (today in Bolivia).

The grounds in these six paintings vary in colour from red and dark brown to black. Regarding their composition, *The Soul of the Virgin Mary* (Fig. 6a) differs from the rest. In this painting, the dark reddish-brown ground consists of two layers: the bottom layer is mainly composed of gypsum and the second layer contains a red ochre, carbon-based black and lead white (Fig. 7a–c). The other five paintings have single layer grounds that are somewhat heterogeneous from the compositional point of view, made predominantly of fine silicate particles of variable morphology and composition. Some of these grounds are also composed of larger silicate particles, including quartz and feldspars, in a matrix of finely divided particles containing Si, Ca, K, Al, P, S, Fe, Mg, Na, Cl and Sr. Some of the grounds, such as that in *Christ Carrying the Cross* (Fig. 7d–f), contain silica-rich particles, as well as Ca, K and Na, with fluidal to spherical shapes and spherical porosity (Fig. 7f). The morphology and composition of these particles are consistent with glassy fragments formed during mid-to-high temperature firing of wood in the presence of fine-grained silicates and alkaline salts that act as fluxes.[35] The presence of carbon particles may corroborate this interpretation although glassy particles might also have a volcanic origin.

Few calcite particles are present in the grounds of these five paintings, but only two of them have calcite particles with the typical morphology of plant ash origin: *Our Lady of Mercy* (Fig.

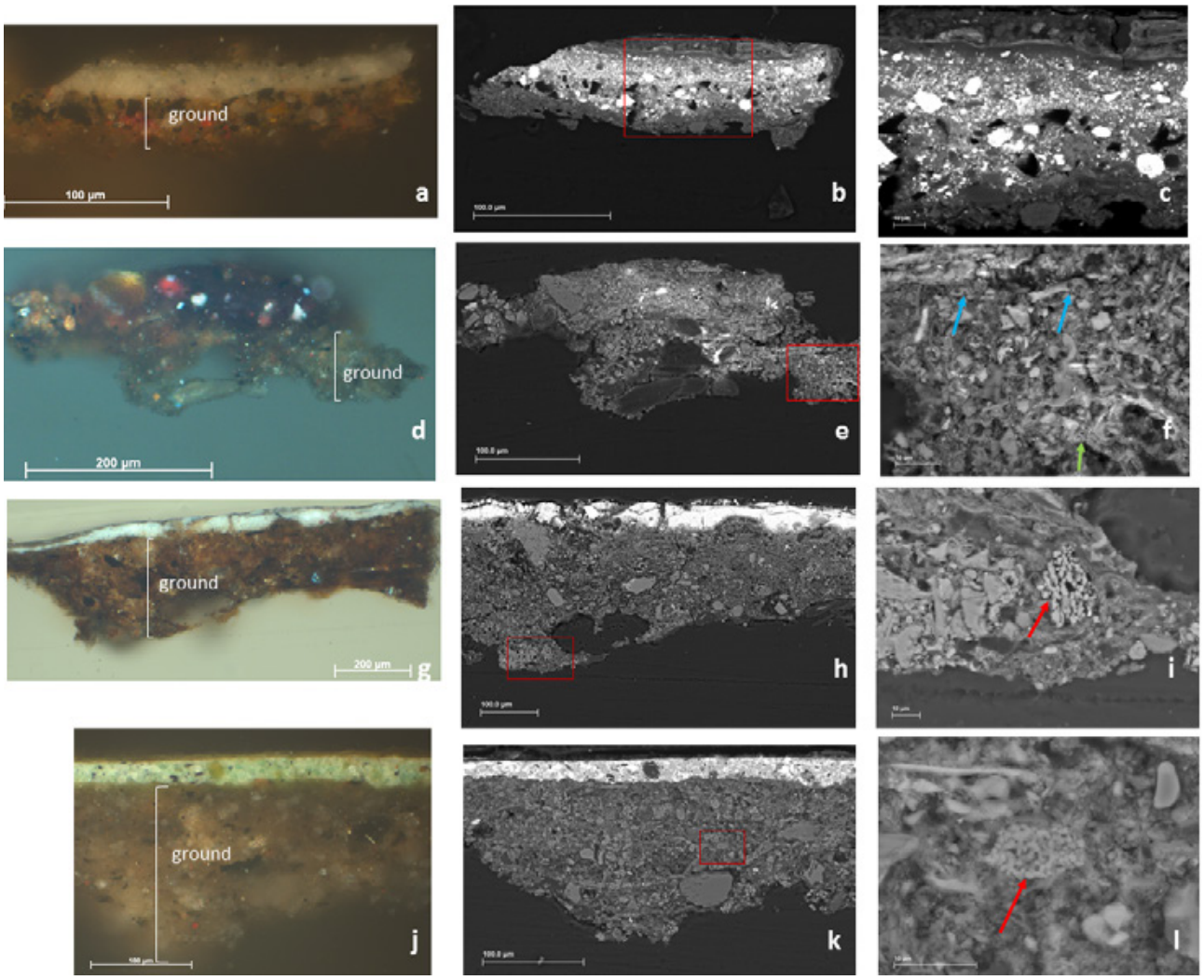

Fig. 7 Cross-sections photographed in visible illumination (a, d, g, j) and BSE images (b, c, e, f, h, i, k, l): *The Soul of the Virgin Mary* (Fig. 6a) (a at ×400, b and c); *Christ Carrying the Cross* (Fig. 6b) (d at ×200, e and f); *Our Lady of Mercy* (Fig. 6d) (g at ×100, h and i); *Saint Christopher* (Fig. 6c) (j at ×400, k and l). The red rectangles in (b), (e), (h) and (k) indicate the areas where, respectively, the details (c), (f), (i) and (l) were taken. Red arrows indicate calcite pseudomorphs, blue arrows glassy particles, and the green arrow the location of amorphous Si-rich particles.

6d) and *Saint Christopher* (Fig. 6c). In *Our Lady of Mercy*, the dark reddish ground comprises a single application containing carbon-based black particles. This ground contains fine- to medium-sized grain silicates, including quartz, feldspar and clay minerals, and very fine grain, poorly crystalline or amorphous particles rich in Si, Ca, K and Al that are predominant over the calcite pseudomorphs (Fig. 7g–i). In the dark brown ground in *Saint Cristopher* (Fig. 7j–l), the calcite particles from ash are more abundant than in the rest of the paintings from South America, but still in less quantity compared with the grounds of the paintings by Villalpando and Sánchez discussed above. Summarising, the characteristics of the grounds in these five paintings from South America are consistent with the use of unprocessed ash rich in soil that may have been ground and sieved, but not leached as described in the Spanish treatises. As a consequence, calcite pseudomorphs are less abundant in the unprocessed ash than in leached ash. Higher amounts of Si and Al, as observed in the five paintings from Colonial South America and in Luca Giordano's *The Annunciation*, may originate in the presence of soil carried in some plant parts, particularly roots and bark, as well as amorphous particles formed at mid-to-high temperatures.[36]

Conclusions

As mentioned above, a French treatise dated *c*.1580–1600 of unknown authorship cites the use of ashes for a ground preparation.[37] However, to our knowledge, no physical evidence of this practice in France has so far been reported. Our study indicates that the practice of using ash in ground layers also occurred outside Spain, under the influence of the Spanish School. The results obtained from the relatively small number of paintings studied here indicate that ashes may have been used in different ways by Spanish and Latin American artists, but this will need to be corroborated by the study of a larger number of works, with more diverse geographical origins and executed across a broader time span.

As an increasing number of paintings produced in Latin America, Spain and other European countries are investigated, we hope that emerging patterns will help us to better understand how the practice of using ashes may have extended beyond Spain.

Acknowledgements

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Notes

1. M. Jover de Celis and M.D. Gayo,'*This they use in Madrid*: the ground layer in paintings on canvas in 17th-century Madrid', in H. Dubois, J.H. Townsend, S. Eyb-Green, J. Nadolny, S. Neven and S. Kroustallis (eds), *Making and Transforming Art: Technology and Interpretation*, London, Archetype Publications, 2014, pp. 40–46.
2. B. Bassegoda i Hugas, *Arte de la pintura*, Francisco Pacheco (1564–1644), Madrid, Cátedra, 1990; A. Palomino de Castro y Velasco, 1724, *El museo pictórico y escala óptica. Tomo Segundo*, Madrid, Imprenta de Sancha, 1797; Z. Véliz, *Artists' Techniques in Golden Age Spain: Six Treatises in Translation*, Cambridge, Cambridge University Press, 1986, pp. 68, 153.
3. Jover de Celis and Gayo 2014 (cited in note 1).
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EUROPEAN ART IN ARGENTINA: THE GROUND OF A PAINTING ATTRIBUTED TO SALVATOR ROSA

Mariana Aurora Calderón Mejía, Dolores González Pondal, Damasia Gallegos, Fernando Marte and Marcos Tascón

ABSTRACT This paper discusses the ground of a large painting attributed to the Italian painter Salvator Rosa currently held in the Castagnino Museum in Rosario. During conservation treatment, the painting's history and materials were investigated.

Introduction

In 2016, the Astengo family donated *Paesaggio* (Fig. 1), a large painting (2.52 × 4.6 m) attributed to Salvator Rosa, to the Castagnino Museum in Rosario, Argentina. It had been in the collection of Enrique Astengo, one of the most notable collectors in the city of Rosario,[1] but there is little other information on provenance or attribution. On the reverse the inscription '*Secondo*' (second) at the middle right (Fig. 2) suggests that the painting was part of a series of three or more paintings. In addition to its artistic value, this painting is a typical example of private art collecting in Argentina during the late 19th and early 20th century, which has formed a significant part of Argentinian public collections.

On the left side, a cluster of trees dominates the foreground. There are rural dwellings and peasants resting in the shade, cattle are grazing and a companion animal wanders freely in the lower left side of the composition. It is evident

Fig. 1 Salvator Rosa (attributed to), *Paesaggio*, oil on canvas, 252 × 460 cm, Museo Castagnino, Rosario, Argentina, inv. no. R. 3481, after treatment. Acquired in Italy in 1913 from the Gallery Palazzo Strozzi, allegedly from the collection of Count Camillo Della Gherardesca according to documentation at the time of purchase. Bequest of María Antonia Astengo, 2009. (Photo: Sergio Redondo, IIPC-TAREA.)

Table 1 Representative cross-sections showing the preparatory layers.

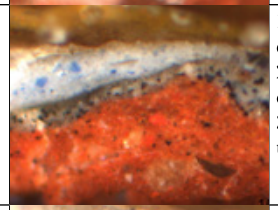
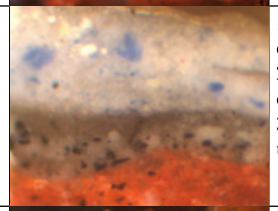
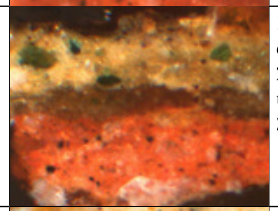
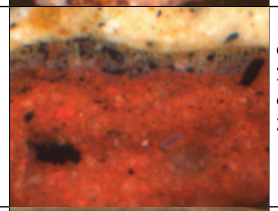
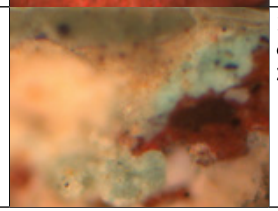
Area	Stratigraphy	Width of image	PLM photograph	Pigments	Particle size for coloured pigments	Compounds/chemical formula	Analysis
Sky (upper left)	1.Reddish-earth ground with black and white/ translucent particles. 2.Thin pale grey layer (not visible in the painting). 3.Original paint layer with white and dispersed blue particles. 4.Varnish. 5.Overpaint.	100 µm		1.Lead white, red earth, carbon black. 2.Lead white, carbon black. 3.Natural ultramarine.	Range of sizes in all layers except those overlying the varnish	1.Hematite (Fe_2O_3), goethite ($FeO(OH)$), cerussite ($PbCO_3$), carbon black (C), calcite ($CaCO_3$). 2.Cerussite, carbon black. 3.Ultramarine $(Na,Ca)_8[(S,Cl,SO_4,OH)_2](Al_6Si_6O_{24})]$.	PLM Raman spectroscopy
Sky (upper right)	1.Reddish-earth ground with black and white/ translucent particles. 2.Thin medium grey layer (not visible in the painting). 3.Original paint layer with white and dispersed blue particles. 4.Varnish. 5.Overpaint.	100 µm		1.Lead white, red earth, carbon black. 2.Lead white, carbon black. 3.Natural ultramarine.	Range of sizes in all layers except those overlying the varnish	1.Hematite, goethite, cerussite, carbon black, calcite. 2.Cerussite, carbon black. 3.Ultramarine $(Na,Ca)_8[(S,Cl,SO_4,OH)_2](Al_6Si_6O_{24})]$.	PLM Raman spectroscopy
Sky (upper centre)	1.Reddish-earth ground with black and white/ translucent particles. 2.Thin pale grey layer (not visible in the painting). 3.Original paint layer with white and dispersed blue particles. 4.Varnish.	50 µm		1.Lead white, red earth, carbon black. 2.Lead white, carbon black. 3.Natural ultramarine.	Range of sizes in all layers	1.Hematite, goethite, cerussite, carbon black, calcite. 2.Cerussite, carbon black. 3.Ultramarine	PLM Raman spectroscopy
Foliage (lower left)	1.Reddish-earth ground with black and white/ translucent particles. 2.Dark grey layer (not visible in the painting). 3.Original paint layer with white and dispersed green particles. 4.Varnish.	50 µm		1.Lead white, red earth, carbon black. 2.Carbon black, umber? 3.Copper resinate?	Range of sizes in all layers	1.Hematite, goethite, cerussite, carbon black, calcite. 2.Cerussite, carbon black, ferric oxide? (Fe_2O_3). 3.Copper resinate? $(Cu(C_{19}H_{29}COO)_2)$.	PLM
Mast of boat (lower centre towards the right)	1.Reddish-earth ground with black and white/ translucent particles. 2.Dark grey layer (not visible in the painting). 3.Original paint layer with white and dispersed blue particles.	50 µm		1.Lead white, red earth, carbon black. 2.Lead white, carbon black. 3.Mars yellow.	Range of sizes in all layers	1.Hematite, goethite, cerussite, carbon black, calcite. 2.Cerussite, carbon black. 3.Goethite, cerussite.	PLM Raman spectroscopy
Sky (overpaint from upper right patch)	1.Reddish-earth ground with black and white/ translucent particles. 2.Varnish. 3.Overpaint filling lacunae of original layers.	100 µm		1.Lead white, red earth, carbon black. 3. Ultramarine.	Range of sizes in the ground; very fine and uniform in the overpaint layers	1.Hematite, goethite, cerussite, carbon black, calcite. 3.Ultramarine.	PLM Raman spectroscopy

Fig. 2 Inscription on the reverse. (Photo: Sergio Redondo, IIPC-TAREA.)

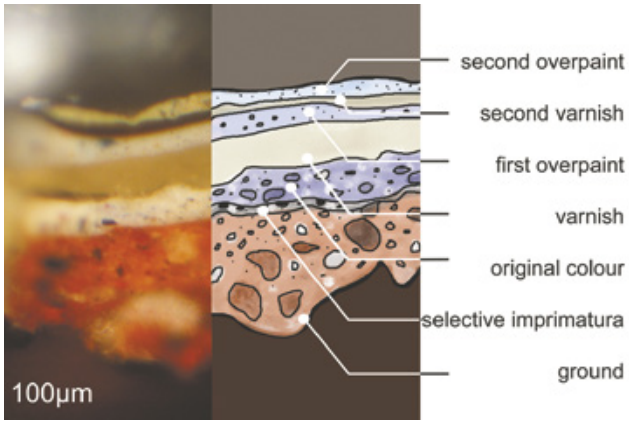


Fig. 3 Cross-section of paint sample from the light blue sky showing at least two campaigns of overpaint and varnish. (Sample and imaging: Noemí Mastrangelo, IIPC-TAREA.)

that the focal elements are concentrated in the upper middle. Visual examination did not reveal any inscriptions that could link the painting with Rosa.

Technical study

During its conservation treatment at the Instituto de Investigaciones sobre el Patrimonio Cultural-Taller Tarea (IIPC-TAREA) studio at the Universidad de San Martín, Buenos Aires, the painting was investigated in terms of its history and materials. Thirty-four microscopic samples were taken from different colours and analysed with polarised light microscopy (PLM) and Raman spectroscopy. Materials analysis focused on the preparatory layers. The most relevant samples are summarised in Table 1.

The colour, particle morphology and chemical composition of the dark brownish-red grounds, as well as the grey layer present below the original blue sky and other light coloured elements of the composition, show a technical affinity with paintings made in the second half of the 17th century. These features also correspond with practice from the first half of the 18th century. The painting techniques, assessed visually after removal of two campaigns of varnishing and overpainting (Fig. 3), also correlate with those used predominantly in southern Europe in these periods. Furthermore, there is no evidence from the original materials to imply a date later than the first half of the 18th century. By examining the format, motifs and painting technique, the technical study did not disprove a relationship between this work and decorative and idealised landscape painting from the first half of the 18th century, which was strongly influenced by the Rococo style, coeval tapestries and Italian landscapes by Claude Lorrain, Salvator Rosa and Dutch artists.

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Note

1. M.P. López Carbajal and P. Montini. 2016. 'París en el horizonte. La colección de Enrique Astengo', *Ediciones Digitales #6.* Rosario: Ediciones Museo Castagnino+Macro.

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COLOURED GROUNDS AND TRANSFER TECHNIQUES IN 17TH-CENTURY SPANISH ROYAL PORTRAITURE: THE CASE OF PANTOJA DE LA CRUZ'S PORTRAIT OF PHILIP III AT THE HARVARD ART MUSEUMS

Cristina Morilla, Narayan Khandekar, Kate Smith and Anne Schaffer

ABSTRACT This paper examines the role of coloured grounds in the development of Golden Age Spanish portraiture and its relation to the techniques used to transfer drawn images to a prepared canvas through the work of the 17th-century royal painter Pantoja de la Cruz and his version of the portrait of Philip III belonging to Harvard Art Museums, Cambridge, MA. The results of a recent technical examination of the portrait by the Straus Center for Conservation and Technical Studies were compared with two other versions at the Royal Monastery of El Escorial and the BBVA Foundation, both in Madrid, Spain. All three paintings were produced at the same time in Pantoja's atelier and are identical in size and composition as demonstrated by comparison using traced outlines processed in Adobe Photoshop. Underdrawing was detected in cross-sections from the Harvard Art Museums version showing particles of calcium sulphate over the dark brown ground as evidence of the transfer process. This practice was found in 17th-century treatises, which explain the use of a white medium over a dark ground similar to the technique used decades earlier with carbon paper on top of a white ground. Additional investigation on the transfer methods involved mockups, X-radiography and infrared reflectography in order to help with reconstructing the working methods in Pantoja's workshop and his followers.

Pantoja de la Cruz and the portrait of the king

In 1596 the court painter Juan Pantoja de la Cruz (1553–1608) was honoured with the title of chamber painter by King Philip III of Spain (1578–1621), a major step in the career of a painter in terms of prestige and achievements. Pantoja was already a familiar face at the Spanish court, as he had painted the young prince when still an apprentice in the atelier of Alonso Sánchez Coello (1531–1588), a preeminent court portraitist and chamber painter himself since 1560.

Pantoja left Sánchez Coello's workshop and opened his own studio around 1587/1588. Eight years later his new responsibility as a chamber painter brought a frantic activity for the remainder of his life, keeping him fully engaged with commissions from the royal family. A chamber painter in Spain at this time was the only artist authorised to paint a portrait of the king from life. Pantoja also oversaw portraiture of other members of the royal family in his atelier; paintings that were sent as presents to other European courts during this golden age of Spanish diplomacy. This is the first time in history that portraits of members of the Spanish royal family were painted several times throughout their lifetimes, from childhood through to adulthood.[1]

Pantoja made a detailed drawing of the king every few years, which allow us to follow subtle changes in the king's physiognomy during his lifetime. After the artist's death his drawings and probably the prototypes of the king's portrait made in oil colours, remained in his workshop and continued to be used by his followers, as argued in this paper. The young Prince Philip was portrayed by Pantoja in 1582, 1586,

1590, 1591, 1592 and 1594, the frequency illustrating King Philip II's eagerness to document the fragile but successful development of his son and future heir, particularly after the tragic deaths of his other sons Don Carlos (d.1568), Fernando (d.1578), Carlos Lorenzo (d.1575) and Diego Félix (d.1582).

The image of the king followed certain rules of representation established two generations earlier when Titian (*c.*1485/90–1575) created a particular typology for portraits of Charles I (1500–1558) that became official for the male members of the Habsburg family.[2] As was the case with his father and grandfather, the young Prince Philip was depicted full-length: his body, dressed in armour, turned at a three-quarter angle and his face looking firmly at the viewer. His hands are consistently depicted with one placed on the hilt of the sword, the other holding a baton. The Golden Fleece pendant hangs from a gold chain intertwined with red silk ribbons.[3]

Pantoja developed distinct elements of the royal portrait that had been settled by his predecessors. His portrait of the king has arguably been defined as stiff or as 'abstract linear design' because of the 'mask-like' appearance of the royal features and the lack of shadows in his face, among other characteristics.[4] According to this view, Pantoja's style detaches him from his predecessors who portrayed the king in a more 'naturalistic' way. This paper argues that Pantoja's portraits of Philip III are the result of the development of a certain style in a specific workshop practice, which served to quickly fulfil the diplomatic needs of the court and thus have to be appreciated under different terms. Because of the high demand for royal portraits, Pantoja's workshop produced numerous paintings of the royal couple at a very fast pace.[5] The replication process was extremely accurate, assuring a high quality in the portraits that may well have been the result of a collaboration between several artists. Pantoja's 1608 estate inventory lists the presence of eight easels and eight palettes in his workshop.[6] In that same year, at least six painters – Jerónimo de Cabrera, Pedro de León, Juan Francisco de Alcántara, Pedro de Salazar, Pedro Navarro and Juan Bautista Espinosa – were employed in Pantoja's atelier, while Rodrigo de Villandrando and Pedro Gutiérrez are documented as his apprentices.[7] Finally, three other painters – Andrés López Polanco, Pedro Antonio Vidal and Bartolomé González – were also active in the workshop, painting portraits both before and after Pantoja's death.[8]

Despite the large number of collaborators, the features of the king and queen in portraits produced in Pantoja's atelier remained close to unchanged. This circumstance provided Pantoja's paintings with a distinct authority over unauthorised court portraits of dubious quality distributed in the market. In fact, the lack of quality and similarity to the king's likeness in royal portraits produced by painters with no direct access to the royal image became a problem during the reigns of both Philip II and Philip IV. It is documented that Vicente Carducho (1585–1638) and Diego Velázquez (1599–1660), while serving as court painters of King Philip IV in 1633, were asked to investigate the accuracy of the king's portraits displayed in public spaces and streets. As a result, only 12 out of the 84 royal family portraits examined were retained while the rest was required to be painted again.[9] This may also have been the case during the reign of Philip III.

Fig. 1 Juan Pantoja de la Cruz, *Philip III of Spain, c.*1605, oil on canvas, 205.5 x 101.6 cm, Harvard Art Museums, Cambridge, MA, inv. no. 1922.73. (Photo © Harvard Art Museums.)

In 1605, after the 1604 Treaty of London, Pantoja started to portray the king in a different pose from previous portraits, which became his most frequently reproduced version of the adult monarch. In the weeks following the treaty, Pantoja's atelier overflowed with commissions for state portraits of King Philip III, of which at least one was to be sent to England.[10] In this portrait, the king no longer pointed to the battlefield as in the first large portrait from 1601, today in Vienna.[11] Instead, his left hand was resting on his sword while his right hand was holding the baton of commander-in-chief, wearing the original armour today preserved at the Royal Palace of Madrid. Pantoja completed these series of portraits during a short time period of 35 days, from June to August 1605, setting the official diplomatic representation of the monarch during a period of negotiated peace.[12] To achieve

Fig. 2 Juan Pantoja de la Cruz, *Philip III of Spain*, (a) 1601, oil on canvas, 192 × 130 cm (photo © Kunsthistorisches Museum Vienna, inv. no. GG 9490); (b) 1604, oil on canvas, 184.4 × 118.5 cm (photo Royal Collection Trust, inv. no. RCIN 404969/ © Her Majesty Queen Elizabeth II 2019); (c) 1606, oil on canvas, 204 × 122 cm (photo © Museo del Prado, Madrid, inv. no. P002562).

Fig. 3 Juan Pantoja de la Cruz, *Philip III of Spain*, (a) 1605, oil on canvas, 204 × 122 cm (photo © Patrimonio Nacional, Royal Monastery of El Escorial, Madrid. inv. no. 10034481); (b) c.1605, oil on canvas, 205.5 × 101.6 cm (photo © Harvard Art Museums, Cambridge, MA, inv. no. 1922.73); (c) 1605, oil on canvas, 204.8 × 101.5 cm (photo © BBVA Collection, Madrid, inv. no. 417).

this high demand at a fast pace, Pantoja's atelier developed an efficient method to replicate the royal portrait accurately, which employed the application of a dark ground and a particular method of transferring the design.

Transfer from life to paper to canvas

As chamber painter, only Pantoja was allowed to draw the king's likeness from life and he used the king's actual measurements to apply the physical height to the canvas. Starting with the 1601 painting, the height of the king's figure remained at 165 cm regardless of the size of the canvas. In the words of Jean L'Hermite, Philip III's royal instructor: '[the prince], after he turned twenty … did not grow anymore, for he had well-built shoulders and began to blunt his moustache and beard.'[13] The measurements of the painting, completed when the monarch was 26 years old, match testimonies of other witnesses who commented on the small but well-proportioned king.[14] The life drawing would be copied for use in the workshop. Little is known about the standard sizes of paper sheets in Spain at this

Fig. 4 Comparing the outlines of Harvard's portrait to (a) the El Escorial version by Juan Pantoja de la Cruz and (b) the El Pardo Palace version by Bartolomé González.

time,[15] but it seems likely that the drawing of a life-size figure would have been composed of multiple sheets fixed together. This, however, cannot yet be confirmed.

Pantoja and his atelier used dark brown grounds to prepare their canvases,[16] which differentiates him from his master Alonso Sánchez Coello, who applied grounds of a light grey colour. The artists working after Coello at El Escorial Monastery, the most important Spanish artistic enterprise at the time, initiated the use of red grounds in Spanish painting practice.[17] A canvas prepared with a dark coloured ground increased the efficiency in the painting process of large-scale paintings. The monarch would often be represented situated in a dark room with light falling on his face, hands, ruff and stockings. Light areas would constitute less than 25% of the painted surface, giving the dark ground an active role in the final appearance of the painting. The clays employed in the preparation of the canvases also rendered the paintings more flexible when rolled up for transportation compared with the traditional, more brittle white gesso ground.[18]

The method by which the drawing was transferred to the canvas was adapted in response to the change in ground colour. By placing the drawing on top of a paper covered with powdered pigment, the design could be pressed onto the primed canvas surface with a stylus.[19] Pigments such as gypsum or lead white substituted the traditional carbon, used as a drawing material on light coloured grounds, in order to achieve the necessary contrast. The drawing, transferred with either powdered gypsum or lead white, was reinforced with lines of white oil paint to fix the design on the dark ground. Most often these outlines were covered during the process of painting, making it difficult today to detect the drawing by means of technical examination.[20]

Versions and replications

This study focuses on one version of a royal portrait of Philip III at the Harvard Art Museums in Cambridge, MA (Fig. 1). The painting is not included in the comprehensive catalogue on Pantoja and is presented here for the first time. The painting is exceptional for its quality and unique state of preservation when compared with other portraits of the king made around the same time period.[21] In order to place the Harvard portrait in context, other paintings depicting the king as an adult, dating from 1601 to 1606, were also studied. In this period Pantoja produced at least six portraits varying only in the depiction of the background (Fig. 2). This research focuses on the portraits from 1605 in the Library in the Royal Monastery of El Escorial and in the BBVA Foundation in Madrid, which are closely related to the Harvard portrait (Fig. 3). These versions have been compared with a later portrait at the Museo Nacional del Prado in Madrid, and all three set against later portraits dating after 1610 by Pantoja's followers Bartolomé González (1564–1627) and Andrés López Polanco (d.1641) in order to observe the development of the copied portraits (Fig. 4).

Comparing outlines in different versions

The relation between dark brown grounds and the transfer methods has not been fully addressed in the technical literature, partly because of the difficulty in distinguishing between the drawing and the paint layer. Furthermore, the use of a white drawing medium on a dark coloured ground layer was introduced during a period in which copying methods began to play an important role in the production of multiple copies of the same portrait. One method to identify and understand this process of transfer is by comparing the traced outlines of portraits completed within a specific period. Comparing a group of similar portraits makes it possible to identify potential primary versions and propose theories as to the sequence of production. A comparison of the outlines of Pantoja's Harvard portrait was made with two groups of Philip III portraits: those by Pantoja de la Cruz executed in 1605 (Escorial, BBVA and Harvard, see Fig. 3) and a second group of portraits painted after Pantoja's death (Las Huelgas Monastery in Burgos, La Encarnación Monastery, Madrid, El Pardo Palace, Madrid, El Escorial Monastery's Sala de Reyes, Madrid) (Fig. 4). The two groups illustrate the development of the royal image in their shifting fidelity to the established models of the king's likeness.[22]

Despite a difference in canvas size, the outlines of the three 1605 figures are almost identical in shape and height. The El Escorial and the Harvard paintings are identical,[23] followed closely by the BBVA painting where the upper part of the figures align but the legs differ slightly (Figs 5 and 6). The 1606 Prado version is slightly smaller in scale than the three 1605 versions; the king is 1 cm shorter and his hands are a few millimetres smaller than in the Harvard portrait. Portraits that are close in production date are the most similar. This may relate to the sheets of paper attached together to transfer the full-size drawing of the figure: if this assembly was redone or modified at a later stage, small differences could occur.

The measurements of the king's figure varied in portraits made by Pantoja followers. In paintings by Bartolomé González, signed in 1621, now in La Encarnación Monastery (Madrid) and in El Pardo Palace (Madrid) respectively, and in

Fig. 5 Outlines of the three 1605 versions.

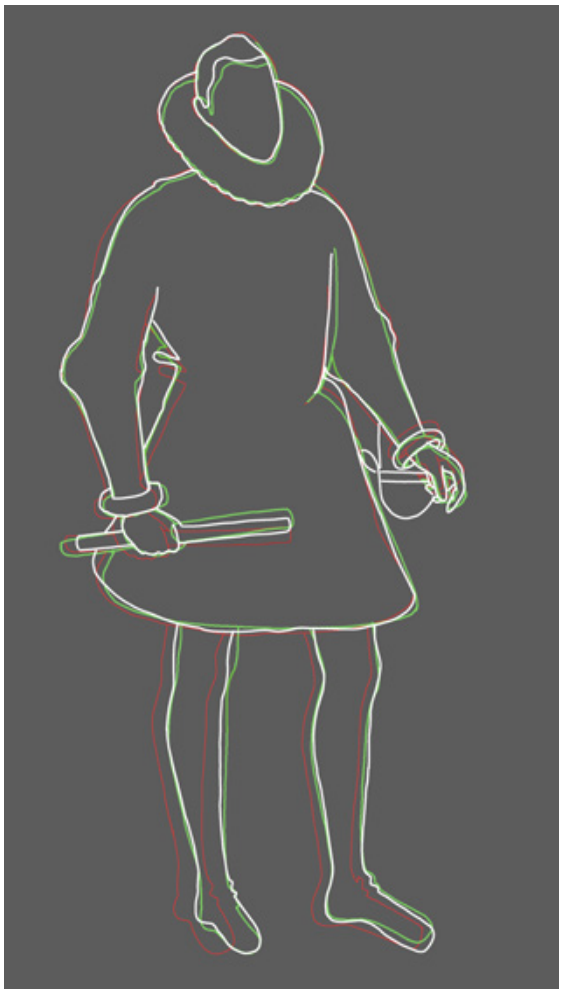

Fig. 6 Outlines of the three 1605 versions overlapped.

Polanco's portrait in Las Huelgas Monastery (Burgos) close to that date, the dimensions of the king's body vary in height by 1–1.5 cm. The king depicted by González in the painting in La Encarnación Monastery is 6 cm larger in height compared with the figure in Pantoja's portrait. This change occurred only a few years after Pantoja's death. The outline of the face was transferred unchanged for a longer period of time, possibly because the cartoon of the face was reserved on a single sheet of paper, limiting dimensional changes.

The first portrait of the king after Pantoja's death was painted by his most gifted follower Bartolomé González, probably around 1616, and represents the earliest documented portrait by this artist.[24] His portraits reflect a more tired-looking and round-faced, armour-wearing monarch, quite different from Pantoja's rendering, and from 1616 onwards this was the most frequently reproduced portrait of the king. González used the sketches available in Pantoja's workshop, only updating Philip III's countenance by lowering the position of his eyes but otherwise keeping his outlines unaltered. This process illustrates not only the rigidity and fidelity in transferring the royal image but also the availability of the original versions to later painters. This may serve to identify later copies of the king by painters unrelated to Pantoja's atelier.

Reconstruction of transfer techniques described in Spanish written sources

Copying and transferring processes are not extensively described in Spanish technical literature. Among the

Fig. 7 Outlines of portraits of Philip III by Pantoja's followers compared to the Harvard Art Museum's version. From left to right: Harvard Art Museums (by Juan Pantoja de la Cruz), El Pardo Palace, Madrid (by Bartolomé González) and Las Huelgas Monastery, Burgos (by Andrés López Polanco).

contemporary treatises included in this study, only a few explain the mechanisms of transferring images onto a dark ground, including an anonymous Castilian workshop booklet entitled *Reglas para pintar*, today in the University Library of Santiago de Compostela and Volpato's *Modo da tener nel dipinger*.[25] The workshop process of copying a finished painting, described as *contrahacer lienzos* in the written sources, was replicated in order to gain hands-on experience of the technique.[26] The outlines of a 1:1 photographic detail from the Harvard portrait was highlighted in order to render the drawing visible through the oiled translucent paper before tracing it with a pen following the instructions in the manuscripts. A thin paper was brushed with any oil on one side, the excess being cleaned with a piece of cloth, and finally placed over the painting: 'And placing the paper over the painting, you will go over the outlines, visible because of the transparency of the paper, and with pen and ink you will draw the outlines without changing anything from them'.[27]

The next step was to transfer the tracing onto a canvas primed with a dark brown ground. A second sheet of paper was rubbed with powdered gypsum and placed between the tracing and the primed canvas. The outlines were traced with a stylus, producing a white drawing on the dark ground layer:

> A leaf of paper is covered with dry white lead or gesso, which, being placed between the tracing paper and the canvas, where it is oiled, the outlines of these figures are pressed with a needle of bone, and the coloured paper, which is placed between the two, leaves impressed all those marks which you have indented with the needle, and thus you will remove in regular order this coloured paper, having, however, fixed the tracing paper in two places that it may not move.[28]

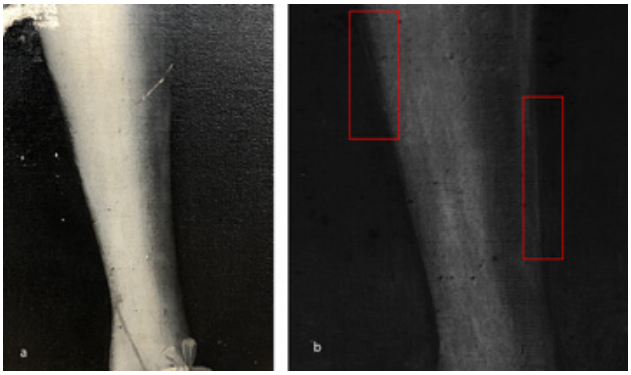

Fig. 8 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): (a) photograph and (b) X-radiograph detail of the legs. The X-radiograph shows a subtle white line (inside the rectangles).

The transferred drawing with unbound lead white or gesso was reinforced with lead white paint in order to create a permanent outline, referred to as *perfiles ciertos* or 'definitive outlines' in the written source.[29] During the painting process, these contours would disappear when covered by the oil paint. This process is referred to as *contrahacer por perfiles perdidos*, 'copying with lost outlines', in contemporary sources.[30]

The reinforced lines applied with lead white paint can sometimes be identified using X-radiography revealing the high-density lead white paint against a low-density clay-rich

Fig. 9 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): (a) detail of the face and (b) X-radiograph of the same detail.

Fig. 10 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): detail of the cracks following the outlines of the face, ×8 (left) and ×20 (right).

Fig. 11 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): cross-section taken from the armour of the sitter's proper right elbow showing the canvas and ground layering.

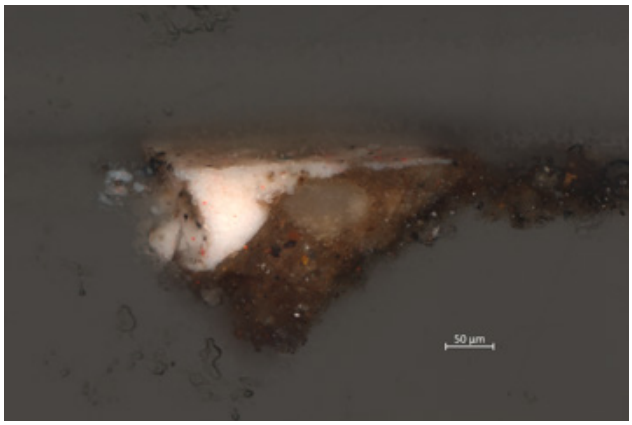

Fig. 12 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): cross-section of the proper right hand from an area assumed to have a drawn line transferred using gypsum paper.

ground.[31] In the Harvard version, a small passage of the 'definitive outline' was detected in the X-radiograph in the form of a subtle white line, among other locations, next to the painted edge of the right leg (Fig. 8); in the Prado version these lines are more visible. The X-radiograph of the Harvard version also reveals dark areas of reserve where the figure was to be painted, suggesting a planned drawing even without visible evidence of the lines (Fig. 9). The dark line seen around the cheek is a gap in the high-density paint of flesh and ruff left to keep track of the transferred outlines, eventually leaving the dark ground exposed in the final painting.

Microscopic examination of the well-preserved surface of the Harvard portrait in raking light provides further evidence of the transfer process, illustrating a brushstroke carefully following the now invisible drawing outlining the figure. The distinct undulating pattern of the craquelure that follows the form of the cheek illustrates a careful underdrawing that affected the way in which craquelure would naturally develop over the centuries (Fig. 10).

Sampling and materials analysis

In order to understand the construction of the Harvard portrait and to compare it with other examples, samples were taken to identify the pigment composition, the build-up of the ground, and if possible, confirm evidence of the transfer process.[32] The palette is rather simple – applied to enhance the king's face, hands and ruff with bright whites and pinks – while receding areas are painted with ochres and black. No colours other than those used in the king's flesh could compete in brightness and depicting his attire with saturated colours such as bright green, was not permitted.[33] The pigments identified in the portrait match those encountered in the studio inventory drawn up after Pantoja's death, which included lead white, lead-tin yellow, vermilion, red lake, copper-based green, copper-based blue, bone black and ochre pigments.[34] The dark ground in the Harvard portrait is similar to the grounds found in paintings studied at the Prado[35] (Fig. 11): a thin layer of glue sizing covering the texture of the canvas, followed by a dark brown ground layer made from clays containing small amounts of red iron oxides, black manganese minerals, barium-containing minerals and quartz with the occasional addition of coal, charcoal and copper-based blue. No lead-containing pigments were detected in the ground layers.[36] The paint layers were applied in a thin and economical way with almost the same thickness as the ground, consistent with the characteristics of a carefully planned and transferred design. In these cases, corrections or *arrepentimientos* that would produce thicker paint films by adding paint to obscure or change an initial design are rarely found.

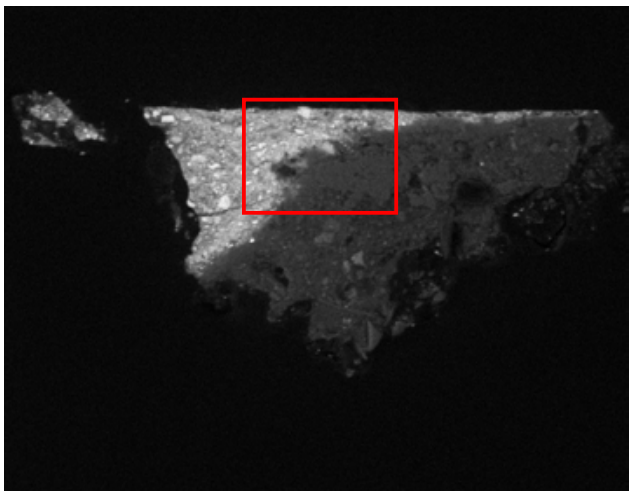

Fig. 13 Juan Pantoja de la Cruz, *Philip III of Spain* (Fig. 1): backscattered SEM image of the cross-section in Fig. 12.

One cross-section was sampled from the proper right hand of the king in an area presumed to contain a transferred line (Fig. 12). The flesh tones, composed of lead white and vermilion, fill an indentation in the ground layer, which is the result of the transfer technique where the force of the stylus pressed into the paper rubbed with gypsum compressed the malleable clay ground. In addition, energy dispersive X-ray (EDX) analysis revealed residues from the transfer technique in the form of gypsum particles between the ground and the paint layer. Furthermore, the cross-section shows half of the curved indentation shape made by the tool used to press the lines into the ground layer. The shape found implies that the ground was still flexible at this stage; the complete shape of the tool employed to transfer the lines was approximately 0.15 mm wide (Fig. 13).

Conclusions

The relation between dark grounds and transfer techniques in Spanish royal portraiture was developed in Pantoja's workshop and by his immediate predecessors. Pantoja and his atelier found an extraordinarily efficient method to replicate portraits: the sharpness of the outlines of the faces and the characteristic lack of shadows in the features are the result of the precise transfer method used to reproduce the king's image. Portraits by Pantoja de la Cruz of other members of the court do not exhibit the same characteristics, probably because they were not subject to replication to the same extent. New evidence related to style, function and efficiency in the production process sheds light on Pantoja's royal portraits, not as copies of an original but as simultaneous versions made and/or supervised by the artist in his workshop. The term 'synchronic' seems appropriate as a way to describe these series of paintings occurring or existing at the same time and with the same purpose. Pantoja and his atelier painted the monarch's portrait one after the other, all of which can be considered as high-quality originals following a unique and fixed iconography as a replacement for the presence of the king.

The drawing taken from life of the king's face by Pantoja produced a prototype to be transferred in his large atelier. Evidence of the procedure that followed to produce the Harvard portrait has, for the first time, been presented here as the 'gypsum paper technique'. Both the identification of calcium sulphate (gypsum) between the dark ground and the paint layer, and the indentation into the ground, suggest a transfer technique using a dry, white drawing medium. Brushstrokes made with lead white and reserved areas rendered visible with X-radiography illustrate the process of transfer, while the distinctive craquelure along the outlines of the flesh reveals the working methods of the painter in question.

The production of portraits of Philip III in 1605 can be placed into a fairly accurate sequence by comparing their outlines. Closest to the signed El Escorial prototype is the version in the Harvard Art Museums. After Pantoja's death, the copies of royal portraits produced in his atelier exhibit slight variations in scale and in the facial contours. The particularly accurate depiction of the face of the monarch by Polanco and González suggests that they owned the drawings or had access to the originals remaining in the atelier.

We can refer to Pantoja's portraits of Philip III as 'synchronic portraiture'. The evidence presented in this article shows that these paintings were made to be multiplied as needed. This however did not imply any detriment in their quality or changes in the body, posture or countenance of the king: on the contrary, the method was developed to maintain an equal iconography while meeting the same high standard of quality. In fact, similar portraits of the king executed in the following years and after Pantoja's death in 1603, such as Polanco's version in Las Huelgas Monastery in Burgos, were probably transferred after originals from Pantoja's workshop, making use of drawings or sketches left in his atelier. This later step of the portrait production remains to be investigated.

Acknowledgements

This article would not have been possible without the expertise and patience of individuals from different institutions who helped us to investigate Pantoja de la Cruz's portraits of Philip III and Margaret of Austria: we thank Angel Aterido (Universidad Complutense de Madrid) for his support, and Felipe Pereda (Harvard University) for his vision and expertise. We also extend our appreciation to: Anne Driesse, Kathy Eremin, Georgina Rainer and Julie Wertz (Straus Center for Conservation and Technical Studies); Jose Luis Díez García, Ángel Balao, Carmen García Frías and Leticia Ruiz (Patrimonio Nacional, Royal Monastery of El Escorial); Enrique Quintana, Dolores Gayo, Jaime García Máiquez, Laura Alba and Inmaculada Echeverría (Museo Nacional del Prado); María Jesús López Verdejo and María Luisa Barrio Mestre (BBVA Foundation); Julie A. Simek and Kim Muir (Art Institute of Chicago); Sony Bomford (Museum of Fine Arts Houston). Last but not least, we thank Lola Sánchez Jáuregui (Hunterian Museum & Art Gallery, Glasgow) who, during her period as a curatorial fellow at Harvard Art Museums in 2018, brought to our attention the portrait of Philip III, by then in storage and never exhibited on the museum walls.

Notes

1. G. Cobo Delgado, 'Retratos infantiles en el reinado de Felipe III y Margarita de Austria, entre el afecto y la política', *Anuario del Departamento de Historia y Teoría del Arte* 25, 2013, pp. 23–42.
2. For this particular issue see: M. Duncan Jenkins, *The State Portrait: Its Origin and Evolution*, Monographs on Archaeology and Fine Arts 3, New York, College Art Association of America/ Art Bulletin, 1947.
3. The only portrait of Philip III as an adult that differs slightly is a portrait held by the Kunsthistorisches Museum in Vienna, in which the monarch is pointing to the battlefield of the Ostend Siege (1601–1604): Juan Pantoja de la Cruz, *Portrait of Philip III King of Spain*, *Portrait in Full Figure as General of Infantry* (inv. no. GG 9490). The following versions show a more peaceful depiction of the king who is no longer pointing to the battlefield, but resting his hand on the hilt of the sword.
4. Pantoja's style has previously been mischaracterised as stiff and archaic-like, particularly after the work of Carl Justi who unfairly described Pantoja's work as 'soulless and lifeless': C. Justi, *Diego Velázquez and his Times*, London, 1889, p. 90. Maria Kusche's work has introduced a more accurate and documented point of view that sets Pantoja's work in context: M. Kusche, *Juan Pantoja de la Cruz y sus seguidores. Bartolomé González, Rodrigo Villandrando y Antonio López Polanco*, Madrid, Fundación de Apoyo a la Historia del Arte Hispánico, 2007, pp. 493–499. Our terms are borrowed from S. Schroth, who also discusses the validity of the words used to define Pantoja's work: S. Schroth, 'Re-presenting Philip III and his favorite: changes in court portraiture 1598–1621', *Boletín del Museo del Prado* 18, 2000, p. 39.
5. Philip III married Margaret of Austria in 1599. The portraits of the king were often presented as a pair along with portraits of the queen. For the purpose of this study, we analysed not only a large group of the king's portraits by Pantoja de la Cruz and his followers, but also three portraits of Queen Margaret of Austria (1584–1611): two by Pantoja de la Cruz: one at the Museo Nacional del Prado and another in the Museum of Fine Arts in Houston; and one by Andrés López Polanco in the Art Institute of Chicago. The conclusions drawn by the present research project regarding rules of representation and transfer techniques in relation to the king's portraits also apply to those of the queen.
6. The state inventory of Pantoja de La Cruz made after his death was published by F.J. Sánchez Cantón, 'Sobre la vida y las obras de Juan Pantoja de la Cruz', *Archivo Español de Arte* 20, 1947, pp. 95–120. For the most complete study of the painter see Kusche 2007 (cited in note 4).
7. L. Varela Merino, 'Muerte de Villandrando, ¿fortuna de Velázquez?', *Anuario del Departamento de Historia y Teoría del Arte*, Madrid, Universidad Autónoma, Facultad de Filosofía y Letras, 11, 1999, pp. 185–210.
8. Regarding the collaboration of Bartolomé González, Andrés López Polanco and Rodrigo Villandrando with Pantoja see Kusche 2007 (cited in note 4), pp. 255–435.
9. See *Informe de Vicente Carducho y de Velázquez sobre la calidad de diversos retratos de la familia real* (October 1st, 1633) Madrid, Archivo Histórico Nacional. Consejos, libros de gobierno de la Sala de Alcaldes de Casa y Corte, 1633, f.467, https://www.ceeh.es/velazquez/informe-de-vicente-carducho-y-de-velazquez-sobre-la-calidad-de-diversos-retratos-de-la-familia-real/. We thank Angel Aterido for this reference.
10. G. Ungerer, 'Juan Pantoja de la Cruz and the circulation of gifts between the English and Spanish courts in 1604/5', *Shakespeare Studies* 9, 1998, pp. 159–162.
11. This portrait is the same as mentioned in note 3.
12. R. de Aguirre, 'Documentos relativos a la historia del arte en España. Juan Pantoja de la Cruz, pintor de Cámara', *Boletín de la Sociedad Española de Excursiones* 30, 1922, pp. 17–22. See also Kusche 2007 (cited in note 4), pp. 480–485. The published documents #11 and #12 relate to the canvases painted by Pantoja in 1603 and 1608.
13. J. L'Hermite, *Le passetemps*, publié d'après le manuscrit original, Antwerp, 1896, pp. 113–114: https://archive.org/details/lepassetempsdej00lhgoog/page/n2/mode/2up. The height of the monarch was 5.8 Castilian feet as stated by L'Hermite, which is equivalent to approximately 165 cm.
14. For more testimonies regarding the appearance of the king see C. Perez Bustamante, *Felipe III: semblanza de un monarca y perfiles de una privanza*, Madrid, Real Academia de la Historia, Estades, 1950.
15. It might have been possible for Pantoja's atelier to have large sheets of paper available according to the Arab tradition, but so far this has not been documented. See E.J. Labarre, *Dictionary and Encyclopedia of Paper and Papermaking*, Amsterdam, Zwets & Zeitlinger, 1952, pp. 246ff. For more information see also D. Hunter, *Papermaking: The History and Technique of an Ancient Craft*, New York, Dover, 1987.
16. The term 'ground' is used rather than 'priming' when referring to the single layer used by Pantoja de la Cruz to prepare his canvases. The layer is thinly applied over a very thin animal glue sizing.
17. M.D. Gayo and M. Jover de Celis, 'Evolución de las preparaciones en la pintura sobre lienzo de los siglos XVI y XVII en España', *Boletín del Museo del Prado* 28, 2010, pp. 39–59. The recent book by Maartje Stols-Witlox offers an overview of coloured grounds in Europe, showing the scarce use of dark brown grounds between the years 1600 and 1699 in comparison to red, beige, grey or cream: M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900*, London, Archetype Publications, 2017.
18. Our technical results coincide with those mentioned in note 17. This generation of artists, including Pantoja de la Cruz, started using clays to prepare their canvases.
19. The most common method for copying images on white-primed panels and canvases around 1510, a generation before Pantoja, was the technique of pouncing powdered carbon through a pricked cartoon (*spolvero*). This method was gradually substituted by use of carbon paper and a stylus (*calco*), probably a more suitable practice for working on canvas. Dark carbon-based drawing on a white ground can be detected with infrared imaging in a finished painting due to the characteristic transmission of coloured pigments, reflectance of the ground, and absorption of the drawing under infrared illumination. For the displacement of *spolvero* by *calco* between 1510 and 1520 see C. Bambach, *Drawing and Painting in the Italian Renaissance Workshop: Theory and Practice, 1300–1600*, Cambridge, Cambridge University Press, 1999, pp. 63 and 334.
20. The challenge of tracking the use of the carbon paper technique and the process of copying has been addressed by García Maíquez in relation to Velázquez, and by Rega Castro in relation to Murillo: J. García Máiquez, 'La cuadratura del círculo: calco y originalidad en la pintura del primer Velázquez', in *The Young Velázquez: Studies on the Education of the Virgin at Yale*, International Symposium held in Seville by the Instituto de la Cultura y las Artes de Sevilla (ICAS), 15–17 October 2014, pp. 574–593; I. Rega Castro, 'El calco en Murillo. Las copias y el procedimiento de copia mediante calco en las series de Ecce Homo', in *On Copying: Copies of Paintings from Renaissance to Baroque*, *Revista de Historia da Arte* 7, 2018, pp. 104–114.

21. The canvas remains unlined on its original stretcher and with its original frame, serving as an exceptional case for technical analysis presented in this research study. The portrait entered the Harvard Art Museums' collection in 1922 through a donation from Denman Ross, a painting professor at Harvard and a great collector who had bought the painting in Milan. According to a letter dated June 20, 1921 (from his travel book dated April 26, Fez, to July 6, Paris at Somerville Archives, Harvard Art Museums), Ross already owned the Pantoja painting in 1921. No further evidence was found on the provenance of the painting. We thank Cassandra Albison and Jessie Park for this reference. Rafael Agapito Crespo had already attributed the painting to Pantoja de la Cruz in 1973 when studying at Harvard University. His study was never published and remains in Harvard Art Museums' Curatorial files.
22. The outlines of Harvard's portrait were taken over a sheet of Mylar and placed over the other portraits for comparison. The outlines were processed through Adobe Photoshop. We used the Harvard Art Museums' tracings on eight portraits in order to reach conclusions about the 1605 versions as well as a second group of portraits painted by Pantoja's followers after his death.
23. El Escorial is the first documented portrait of 1605 and belongs to The Gallery of Kings at the Royal Library, El Escorial Monastery, Madrid.
24. The portrait is mentioned as *retrato original* (original portrait,) which meant that he portrayed the king from life: see 'Memoria de los retratos de B. González para Felipe III (1617–1621)', in Kusche 2007 (cited in note 4), p. 510.
25. R. Bruquetas Galán, *'Reglas para pintar*, Un manuscrito anónimo del siglo XVI', *PH: Boletín del Instituto Andaluz del Patrimonio Histórico* 24, 1998, pp. 33–44. M.P. Merrifield published the 'Volpato Manuscript' for the first time in 1849. Our reference is to M.P. Merrifield, *Original Treatises on the Arts of Painting*, vol II, New York, Dover Publications, 1967, pp. 721–759. See also M.M. Virginia Sanz, 'Un breve tratado de pintura anónimo y manuscrito del siglo XVIII', *Goya: Revista de arte* 145, 1978, pp. 23–27.
26. F. Pacheco, *Arte de la pintura, su antigüedad y grandezas*, Seville, Simon Faxardo, 1649. Libro I, cap. XII, p. 159: https://archive.org/details/HArteR03T09/page/n165: 'Por evitar la infelicidad de nuestro tiempo, i la miserable servidumbre de los aprendizes del. Atados a *contrahacer lienzos* ordinarios por perfiles perdidos.'
27. Bruquetas Galán 1998 (cited in note 25), p. 5: 'puniedo el dicho papel encima de la pintu- ra q[ue]/ as de sacar se señalarán los perfiles della por/ causa de la transpareçia del papel y con pluma/ sotil y tinta señalarás en el papel los dichos/ perfiles sin mudar cosa alguna dellos'. It is interesting to note that on the El Escorial portrait, the contours of the king's face and legs have been outlined several times, which supports the theory that this is the primary version of the three paintings. Examination with UV light suggests that these outlines do not relate to previous restoration campaigns but rather to the replication process, more specifically to the step of highlighting the contours of the original to improve visibility through the oiled paper that would serve for the transfer.
28. Merrifield 1967 (cited in note 25), p. 737: 'Si tinge un foglio di carta con biaca suta ovvero giesso, qual posta tra il lucido e la tella ove sarà ogliato e con un ago di osso si calca li contorni di quelle figure, e quella carta tinta che fra posti, lascia impressi tutti quei segni, che haverai calcato con l' ago, e cosi trasporterai per orline quella carta tinta havendo però saldata da due parti il lucido aciò non si mova; e questa la facio ancor io, benchè non son pittore, die in ciò non vi entra artificio di pittura, ma è una pura operatione nostra'.
29. Pacheco 1649 (cited in note 26), Libro I, cap XIV, p. 158.
30. Ibid., Libro Tercero, p. 386.
31. Brushstrokes applied with lead white paint have been reported in Velázquez copies: García Maíquez 2014 (cited in note 20), p. 7.
32. Microscopic samples, collected and prepared as cross-sections, were analysed by visible and UV light microscopy, followed by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX) to identify elements in the pigment particles.
33. I*nforme de Vicente Carducho y de Velázquez sobre la calidad de diversos retratos de la familia real* (October 1st, 1633) Madrid, Archivo Histórico Nacional. Consejos, libros de gobierno de la Sala de Alcaldes de Casa y Corte, 1633, f.467, https://www.ceeh.es/velazquez/informe-de-vicente-carducho-y-de-velazquez-sobre-la-calidad-de-diversos-retratos-de-la-familia-real/, 'Y uno de los dichos retratos grandes, del Rey Nuestro Señor, que está con calzones y medias verdes, se ha de borrar el color del vestido, y hacerle decente.'
34. Sanchez Cantón 1947 (cited in note 6), p. 103. See also M. Kusche, *Juan Pantoja de la Cruz*, Madrid, Editorial Castalia, 1963, pp. 258–267.
35. Gayo and Jover de Celis 2010 (cited in note 17), pp. 44–45.
36. Pantoja's grounds are very different from at least one of his followers: López Polanco. In the portrait of Queen Margaret of Austria at the Art Institute of Chicago (where Polanco is carefully transferring Pantoja's painting), paint samples show a remarkably different more reddish and thicker ground. The palette also differs in the use of yellow pigments. We thank our colleagues Kim Muir and Julie Simek for sharing this information. Analysis of the Art Institute of Chicago samples made use of the EPIC facility of Northwestern University's NUANCE Center, which has received support from the Soft and Hybrid Nanotechnology Experimental (SHyNE) Resource (NSF ECCS-1542205); the MRSEC program (NSF DMR-1121262) at the Materials Research Center; the International Institute for Nanotechnology (IIN); the Keck Foundation; and the State of Illinois, through the IIN.

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VELÁZQUEZ AND HIS CHOICE OF PREPARATORY LAYERS: DIFFERENT PLACE, DIFFERENT COLOUR?

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ABSTRACT This article originates from a large research project concerning paintings by Diego Velázquez (1599–1660) in the collection of the Museo Nacional del Prado in Madrid. This project includes the updating of technical documentation and the material analysis of a group of more than 60 paintings by Velázquez, plus some others attributed to his workshop or close contemporary painters. Velázquez had a long and fruitful career that involved some changes in his place of residence. From his hometown Seville, he moved to the court in Madrid in 1623, where, apart from two travels to Italy in 1629–1631 and 1649–1651, he would remain until his death in 1660. These different stages in his career show different stylistic features as well as more or less important changes in his artistic practice. Regarding the use of preparatory layers, the changes correspond to a combination of his personal choice and the local habits of the successive artistic environments in which he worked, varying in colour from brown to red and then grey as his career developed. This paper proposes a first general outline of Velázquez's choice of colours and materials for his preparatory layers over the course of time, which may establish a basis for future studies on the artist.

Introduction

Diego Velázquez (1599–1660) is one of the most important representatives of Spanish baroque art. In 2019, the Museo Nacional del Prado in Madrid, which preserves the vast majority of his works, celebrated the bicentenary of its inauguration and, among many other events, a large research project was initiated involving the curator in charge of the Velázquez collection, Javier Portús, and the museum's scientific staff. The project includes the study of around 60 paintings by Velázquez, mostly from the Prado collection as well as some others from his circle[1] and will conclude with the publication of a *catalogue raisonné* for the artist.[2] The Prado collection includes, for the main part, the paintings Velázquez executed during the 37 years he worked in the service of King Philip IV of Spain – works he produced for other private collectors or religious institutions have since been added to the collection. It includes examples from almost every stage in the life of the painter,[3] allowing an evaluation of the evolution of his technique. One of the subjects being studied is his choice of different colours and compositions for the preparatory layers over the course of his artistic life.

This paper investigates Velázquez's preparations in the different stages of his career in various locations (Seville, Madrid and Italy), in order to establish an overview of his choice of ground colour. In the 1990s, Carmen Garrido studied the painter's technique[4] and the present research has mainly re-analysed her old samples, yielding updated results that broaden the previous information, adding new and interesting data concerning the materials used. Future research involving a more precise study on specific paintings or periods, as well as the relationship between the selection of preparation colour and stylistic features, will be tackled in the context of the aforementioned *catalogue raisonné*.[5]

Diego Velázquez was born in Seville where he trained as a painter with one of the best-known and well-connected artists in the city, Francisco Pacheco (1564–1644). Pacheco was part of the generation in Seville from the last third of the 16th century, whose style and artistic aims would be rapidly replaced by the next generation of younger and more modern painters. Pacheco is probably better known as the author of the treatise *El arte de la pintura* (*The Art of Painting*),[6] published in 1649, which contains detailed practical information on painting techniques. His descriptions and remarks are highly valuable for the study of Spanish Golden Age painting, especially from the point of view of artistic materials and workshop practices.

Pacheco considered the process of preparation a crucial step in ensuring the future preservation of the painting, and it was therefore carefully explained. He describes two different layers for the preparation of canvases:

- the ground layer (*aparejo*), applied directly over the lightly sized canvas. This layer is composed of a water-based paste with glue or flour as binder with or without an inert extender.
- the priming layer (*imprimación*, *imprimadura*) on top of the ground layer, bound in oil, whose colour could vary (red, brown or grey).

Pacheco's descriptions of different preparation options for canvases is based on his own experience and is therefore limited. Nevertheless, the information is highly reliable and the procedures described have been found in his paintings as well as those by other artists with a remarkable match in colour and composition. Pacheco died in 1644 (his treatise was published posthumously), but he had been compiling information and writing for many years; his treatise therefore includes some already outdated practices no longer in use by 1644.

Seville (1599–1623)[7]

In 1618, Velázquez married Pacheco's daughter Juana thereby becoming his son-in-law. This direct relationship meant that, in the beginning of his career, Velázquez profited from Pacheco's network in Seville, receiving several important commissions in the city. The works painted by Velázquez in Seville follow the style of local painters and include mainly genre paintings, religious scenes and some interesting portraits, such as *The Nun Jerónima de la Fuente* (Fig. 1), which depicts a nun about to leave for missions in the Philippines from Seville harbour. The preparatory layers in this painting reflect the description given by Pacheco for the Sevillian workshops: 'The best and smoother priming is this mud that is used in Seville, powdered and bound with linseed oil.'[8] Scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis of samples from these first paintings in Seville confirms the composition described by Pacheco: a mixture of natural clays with calcium carbonate and minor components such as pyrite bound in linseed oil. It was used over a thick layer of animal glue applied to seal the canvas surface (the *aparejo*) (Fig. 2).

The clay-based brown priming in Velázquez's *The Nun Jerónima de la Fuente* is comparable to preparatory layers used both by him and other painters in Seville, including Bartolomé Esteban Murillo, Juan de Valdés Leal, Francisco de Zurbarán, Alonso Cano and Francisco Herrera the Elder.[9] As a natural product, the colour of the clay mixtures can vary slightly, being either more or less reddish or yellowish and, in some cases, small quantities of lead white can be detected. As Pacheco states 'you can add a little lead white to give more body, or use the mud alone.'[10]

Fig. 1 Diego Velázquez, *The Nun Jerónima de la Fuente*, 1620, oil on canvas, 160 × 110 cm, Museo Nacional del Prado, Madrid, inv. no. P002873. (Photo © Museo Nacional del Prado.)

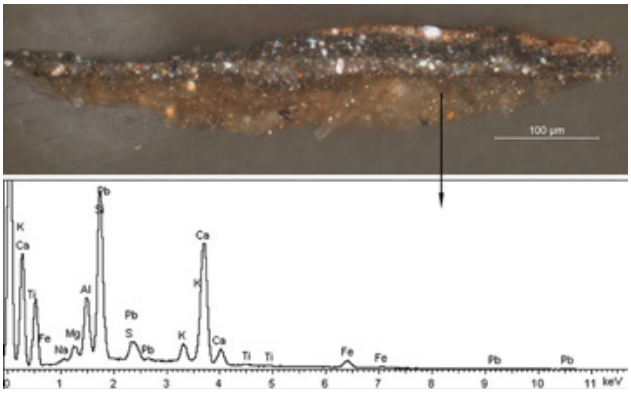

Fig. 2 Diego Velázquez, *The Nun Jerónima de la Fuente* (Fig. 1): cross-section from the orange letters near the nun's habit, with the typical brown clay-based priming layer used in Seville and the SEM-EDX spectrum for this layer. Painting layers above correspond in turn to a slight *pentimento* for the habit, the background, and the reddish letters on top of it.

Madrid (1623–1629)

Soon after his arrival in Madrid in 1623, Velázquez was appointed court painter to the Spanish king, Philip IV, a post he held until his death in 1660. In Madrid, he had access to the large collection of paintings kept by the king in his palace, including paintings by Titian and Tintoretto, among others.

Fig. 3 Diego Velázquez, *Infante Don Carlos*, 1626–27, oil on canvas, 209 × 125 cm, Museo Nacional del Prado, Madrid, inv. no. P001188: detail and cross-section from the greyish background. The red priming is visible with the naked eye. The cross-section shows the usual structure for paintings made in Madrid during the 17th century.

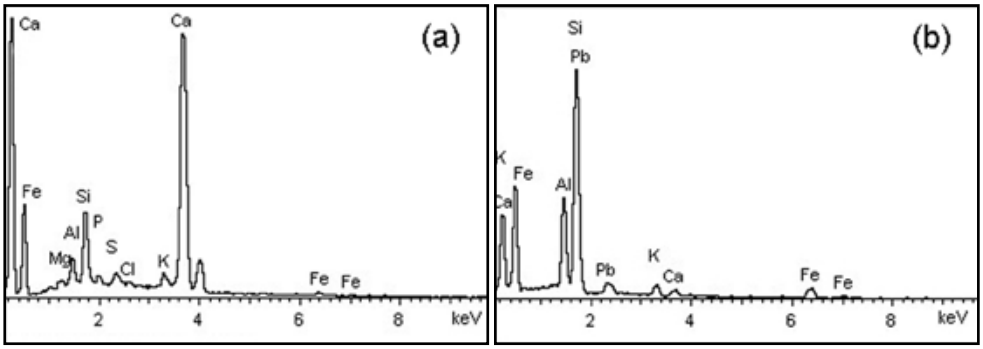

Fig. 4 Diego Velázquez, *Infante Don Carlos* (Fig. 3): SEM-EDX spectra corresponding to a sample from the background. (a) Ground layer containing calcite, traces of aluminosilicates and the presence of phosphorus and sulphur; (b) priming layer with red and non-coloured clays and a very small amount of lead white.

This had a great impact on the young painter. Alongside his stylistic transformation, Velázquez also changed the colour of his preparatory layers, adopting the red priming used by Madrilenian painters, which Pacheco describes as follows:

> Others ground with sifted ashes … making sure to make it even with brush and knife; and once dry and rubbed with pumice stone, they prime it solely with common red earth ground up with linseed oil; this they use in Madrid.[11]

This red colour – evident all over the surface and giving an overall red tone even in open-air scenes – was left visible in some of Velázquez's works from this early Madrilenian period as, for example, in the portrait of Philip IV's brother, *Infante Don Carlos* (Fig. 3). In the cross-sections from Velázquez's paintings from this period, including the *Infante Don Carlos*, a double layer structure can be seen, showing a greyish translucent colour covered with an intense red.[12] Analysis of these two layers confirms the description given by Pacheco: a lower layer with large calcite particles,[13] aluminosilicates and detectable phosphorus and sulphur bound in animal glue, and an upper layer of red and non-coloured clays where occasionally a very small amount of lead white can be detected in a binder of linseed oil (Fig. 4).

In 2014, the Museo Nacional del Prado laboratory identified the composition of this lower layer with one of the materials cited by Pacheco for the preparation of canvases: burnt wood ashes.[14] An experimental reconstruction of the glue paste described by Pacheco was carried out: when comparing the composition of such ashes in glue paste with the ground layer found in samples by using EDX, the spectra were identical except for a high potassium content in the ashes. This resulted in the hypothesis that some processing of the raw material was needed in order to eliminate the potassium content, although this was not mentioned by Pacheco.[15]

The calcite particles in the ground have a polyhedral shape and a rough spotted surface, clearly identified in SEM images. This specific structure was described by the laboratory of the Metropolitan Museum of Art, New York, as pseudomorphs of calcite formed during the combustion of wood due to the calcite oxalates present in plants.[16] The general texture of the layer when viewed in the SEM is highly porous, not at all compact, and the pseudomorph fragments are easy to recognise within the glue matrix.

Further research elucidated this discrepancy to some extent. Pacheco used the term 'sifted ashes' (*ceniza cernida*) to describe the main ingredient for the preparation paste, but Antonio Palomino, in his treatise published in 1724, mentions the same ground made of ashes but refers to *cernada* instead of *cernida* (sifted).[17] The different meaning of both terms perfectly explain the results of the analysis. The word *cernada* is defined by the *Royal Academy Dictionary of Spanish Language*, published at the same time as Palomino's treatise, as 'the part of ash not dissolved, which was left on the *cernadero* [cloth strainer] after lye had been put on clothes'.[18] This suggests a relationship between the ashes used for preparing canvases and a byproduct obtained in the process of lye manufacture. In laundry processes, wood ashes were spread on a thick canvas stretched over a container. Boiling water was poured over them so the salts in the ashes, mainly potash, were leached. After several repetitions of the pouring process, the ashes would remain inert: this is the material used for grounding the canvases, the *cernada*. As lye extraction from ashes was a common process, this material was generally inexpensive and easy to obtain. Although currently it has only been identified mainly in paintings produced in Madrid and the central part of Spain, its utilisation in other parts of Europe is plausible but requires further research.

Throughout his early years in Madrid, Velázquez used this red-over-ashes preparation but, at the end of 1628, an event occurred that had a profound effect on his future choices: the visit of Peter Paul Rubens (1577–1640) to the court of Madrid. The Flemish master arrived in Madrid as part of a diplomatic mission and remained for eight months during which time he painted portraits of the royal family, copied several of Titian's works in the royal collection and worked on some private commissions. Rubens also made substantial changes to his *Adoration of the Magi*;[19] this work was originally painted in 1609 for the Antwerp city council but became part of Philip IV's collection several years later. It is likely that Velázquez saw Rubens working on one or more of these paintings and perhaps even witnessed him preparing grounds. It is also possible that he discussed Rubens' ground compositions with him.[20]

Around the time of Rubens' visit, Velázquez executed one painting that exhibits a peculiar internal structure which demonstrates the impact of Rubens' method of painting over grey primings. In the portrait of *Maria Anna of Spain, Queen of Hungary*,[21] a double priming layer can be found: a light grey one on top of the traditional red clay layer over ashes. As there would be no reason for using so many layers for preparation, this might indicate the reuse of an already prepared red canvas, covering this colour with a light grey layer of paint.[22]

Fig. 5 Diego Velázquez, *View of the Gardens of the Villa Medici, Rome, with a Statue of Ariadne*, *c.*1630, oil on canvas, 44 × 38 cm, Museo Nacional del Prado, Madrid, inv. no. P001211. (Photo © Museo Nacional del Prado.)

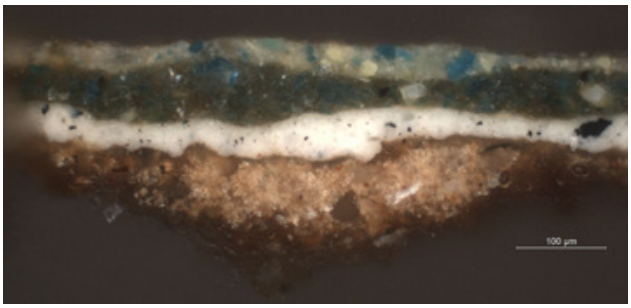

Fig. 6 Diego Velázquez, *View of the Gardens of the Villa Medici* (Fig. 5). Cross-section from a green leaf at the lower right showing the double preparation: the lower brown clay-based layer commonly used in Rome and, above, an additional priming in a light grey tone comprising lead white and charcoal black.

Italy (August 1629–January 1631)

Immediately following Rubens' visit, and probably influenced by the Flemish painter's opinion, Velázquez requested the king's permission to travel to Italy in order to complete his training. Sponsored by the king, he remained in Italy for two years to allow him to study and copy the Renaissance masters' paintings, returning to Spain with a different and more complex style. Velázquez visited Genoa, Venice, Ferrara, Bologna and Rome, passing through Naples on his way back to Spain. However, he settled and stayed in Rome for the longest period of time, where most of his known paintings were executed.

Few paintings are preserved from this first Italian period but analysis of two small open-air views of the gardens of the Villa Medici in Rome (Fig. 5) and *Joseph's Tunic* shows a similar brown priming clay in oil on top of the canvas.[23] The

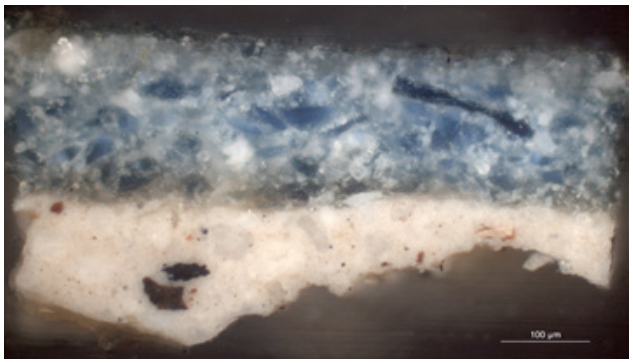

Fig. 7 Diego Velázquez, *Philip III on Horseback*, *c.*1635, oil on canvas, 300 × 212 cm, Museo Nacional del Prado, Madrid, inv. no. P1176: cross-section from the sky showing a very light grey priming containing a mixture of lead white with a small amount of charcoal black and brown earths over a very thin layer of animal glue.

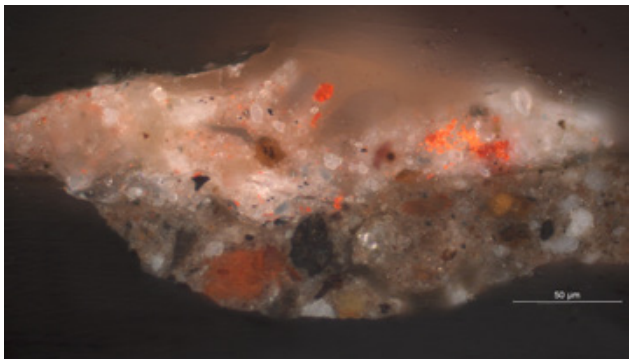

Fig. 8 Diego Velázquez, *The Buffoon Calabacillas*, 1635–39, oil on canvas, 106 × 83 cm, Museo Nacional del Prado, Madrid, inv. no. P001205: cross-section from the right hand. A combination of dark brown pigments was used in the priming containing a high proportion of lead white mixed with manganese black, umber, brown and red earths.

composition of this layer reveals a mixture of natural clays with and without iron, some calcium carbonate, umber pigments and the occasional grain of pyrite. This composition and the colour of the layer resemble the priming used by Velázquez in his early career at Pacheco's workshop in Seville, but it was also common in several Italian cities at that time, Rome and Naples among them.[24]

The three paintings also exhibit differences in the structure of the preparation. In the case of *Joseph's Tunic*, a large-format scene measuring 233 × 250 cm, Velázquez only utilised the brown priming – perhaps he had purchased the canvas pre-primed from another workshop. He did not have a workshop and the infrastructure to prepare his canvases and allow them to dry properly. Furthermore, he was familiar with the use of brown priming through his Sevillian training. But the case of the two small open-air landscapes portraying the gardens of the Villa Medici is different: for these canvases, Velázquez chose to re-prime the surface in light grey by applying a second layer of lead white and charcoal black over the brown layer (Fig. 6). Due to the small size of these two scenes (44 × 38 cm), this was a simple operation that allowed Velázquez to use a grey background – much more convenient for experimenting with the effects of light in open-air scenes. These two cases are analogous to the already mentioned examples of the grey-over-red preparations used in the last few months in Madrid before his departure to Italy.[25]

Madrid (January 1631–January 1649)

The next stage in Velázquez's career took place during the two decades he spent in Madrid before embarking on his second journey to Italy. This is the longest period under study during which he resumed his responsibilities as royal portrait painter. He was also involved in some decorative projects for royal buildings, including the two large ones in the Buen Retiro Palace, a new palace built in Madrid, and Torre de la Parada, the hunting lodge in the countryside near Madrid. Within these projects, Velázquez was responsible not only for some of the paintings but also for many other practical tasks related to the furnishing projects, which kept him extremely busy. Nevertheless, at that time he managed to produce some of the most important paintings of his career.

Buen Retiro Palace, conceived as a royal retreat and a pleasure palace, was built between 1630 and 1633 – a very short period for such an ambitious project.[26] It included the so-called Hall of Realms, where ambassadors' receptions took place: the walls were covered with a series of large-format paintings depicting military victories of the Spanish army, commissioned from several Spanish painters, Velázquez among them. He was also responsible for the equestrian portraits of the family on the main wall, where the throne was located, as well as on the opposite wall.[27] For this whole group of paintings, in the Hall of Realms as well as in other spaces of the palace, Velázquez chose the same type of preparation for his canvases: a very light grey priming containing a mixture of lead white with a small amount of charcoal black and brown earths over a very thin layer of animal glue (Fig. 7). This colour is especially appropriate for open-air scenes in which a large proportion of the painting is devoted to depicting sky and clouds, such as the equestrian portraits of the royal family or *The Surrender of Breda*,[28] but it was also employed for interior scenes.

Just as the Buen Retiro Palace project reached an end, a second began: the decoration of Torre de la Parada. This was a less important palace, a smaller already extant building used only for hunting activities with no significant official role. Nevertheless, the king took a great interest in its decoration and awarded a huge commission to Rubens' workshop in Antwerp which, for a large part, is still preserved in the collection of the Museo Nacional del Prado. The paintings were partially designed by Rubens and executed by his workshop and other Flemish painters, including Cornelis de Vos (1585–1651), Jacob Peeter Gowy (1615–1661), Erasmus Quellinus (1607–1678), Jacob Jordaens (1593–1678), Peeter Symons (active 1629–1636), Jan Cossiers (1600–1671) and Theodoor van Thulden (1606–1669).[29] Velázquez's contribution included the portraits of the royal family in hunting outfits and paintings depicting mythological gods and court jesters.

The paintings by Velázquez for Torre de la Parada share the same choice of priming colour. For this series he selected a

dark brown colour with some slight tonal differences between them: from reddish to greyish nuances. This choice resembles his original Sevillian priming colour but there is one important difference: instead of the natural brown clay used in Seville, a combination of pigments was chosen containing a high proportion of lead white mixed with manganese black, umber, brown and red earths (Fig. 8). In this group of paintings by Velazquez, all the canvases share the same colour and most have a layer containing ashes beneath.

In addition to these two large commissions for the king, Velázquez created paintings for other customers, mainly religious images or civil portraits, such as *The Crucified Christ* and the portraits of Antonia de Ipeñarrieta and her husband Diego del Corral y Arellano.[30] For these canvases he chose a warm light grey colour priming containing a mixture of lead white, charcoal black, umber and poorly coloured particles of smalt over animal glue, when detected. The tone once again is grey, similar to but warmer and slightly darker than that used for the Buen Retiro Palace paintings.

During this long period, Velázquez barely moved from Madrid except for one short journey when he accompanied the king on a military campaign in Fraga, near Zaragoza, in 1644. He painted at least two portraits there: one of the king dressed in the silver-and-rose costume he wore during the campaign (now in the Frick Collection, New York) and, surprisingly, one of a dwarf in the king's service, *The Buffoon El Primo*.[31] A sample taken from this painting reveals an internal structure slightly different from his works in Madrid: underneath, instead of ashes or simply an animal glue ground layer, a thick layer of light brown clay (without a high iron content) is found. Above this, a simple grey layer of lead white and charcoal black was applied. This example is analogous to the re-primed canvases discussed above used in Madrid just before and during Velázquez's first trip to Italy, and in which he added to an existing prepared support a grey coloured layer as a final priming.[32] Given the circumstances in which this painting was created, without his own studio and materials, it would make sense for Velázquez to buy pre-primed canvases from a local painter and modify the colour if necessary, as he did in the two paintings of the Villa Medici.[33]

Italy (January 1649–June 1651)

In 1649, at the king's request, Velázquez returned to Italy, where he stayed for more than two years. He was ordered to purchase antiquities and works of art to decorate the king's palaces. The royal assignment involved travelling to all the principal Italian cities but again he stayed for the longest time in Rome until departing from Naples. This second Italian period was very fruitful for Velázquez who, as the leading court artist to Philip IV, had by now become an internationally famous master, receiving important commissions such as the *Portrait of Pope Innocent X* (now in the Galleria Doria Pamphilj, Rome). He travelled in the company of his servant, Juan de Pareja (*c.*1606–1670), who was portrayed by Velázquez in Rome; this portrait depicted De Pareja as a gentleman. As in Madrid, De Pareja was probably in charge of preparing the artist's canvases but this time Velázquez was no longer the young painter in Rome at the beginning of his career, forced to use locally available materials – now he could select the colour and nature of the preparatory layers for his portraits.

Few of the paintings dating from this period have been studied with respect to the materials used for preparation – most remained in Rome when Velázquez returned to Madrid and are now held in different collections. The Prado's collection includes only one example of a painting executed in Rome during this period: the *Portrait of Ferdinando Brandani* (Fig. 9). Nevertheless, the Prado's laboratory has studied two more examples from this period belonging to other collections: the portraits of two cardinals, *Camillo Astalli* (Hispanic Society of America, New York) and *Camillo Massimo* (Bankes Collection, Kingston Lacy, UK). In addition, analysis of the preparatory layers of the *Portrait of Juan de Pareja* at the Metropolitan Museum of Art in New York was published in 2018 including comparable data.[34]

In these four examples from the second Roman period, the priming layer shows common characteristics. It is a grey priming, but unlike the paintings from the first Roman period, there is no layer of brown clay beneath.[35] However, the texture and the composition of this layer is quite different from the other grey primings described above: it is a complex mixture that includes lead white, gypsum, calcite, charcoal black, some grains of iron aluminosilicates and, occasionally, some grains of smalt (Fig. 10).

Examined closely, parts of this mixture strongly resemble the composition of washed ashes: calcite, charcoal black and iron aluminosilicates. When the calcite particles were observed using SEM, their shape and texture reflected the described characteristics of calcite pseudomorphs, mentioned above for the Madrilenian *aparejo* (Fig. 10). A possible explanation for this layer is that the same material was used bound in oil and mixed with other ingredients to modify the colour and improve the drying: lead white, gypsum and, in some cases, smalt.[36] This mixture was not common in Rome in this period[37] nor is it found in Velázquez's paintings in the 1630s,[38] but it is very similar to the one widely used by his son-in-law Juan Bautista Martinez del Mazo (*c.*1611–1667) and other painters in Madrid.[39] Perhaps De Pareja was preparing the canvases in a way that was customary in Madrid using materials with which he was familiar, cheap and easy to obtain, ashes being a ubiquitous domestic product.

A mixture containing ashes plus lead white in oil would be a slightly warm grey colour, its darkness depending on the amount of lead white added. In a recent project devoted to the reproduction of old recipes from art treatises as well as real sample information, the Prado's laboratory used this mixture to prepare pieces of canvas in order to observe the final colour as well as other aspects such as the texture of the paste and drying properties.[40] The result of the combination of ashes with lead white in oil varied from a dark anthracite grey tone to a light grey colour, with a slightly warm nuance due to the presence of some iron aluminosilicates in the composition of

Fig. 9 Diego Velázquez, *Portrait of Ferdinando Brandani*, 1650, oil on canvas, 50.5 × 47 cm, Museo Nacional del Prado, Madrid, inv. no. P007858. (Photo © Museo Nacional del Prado.)

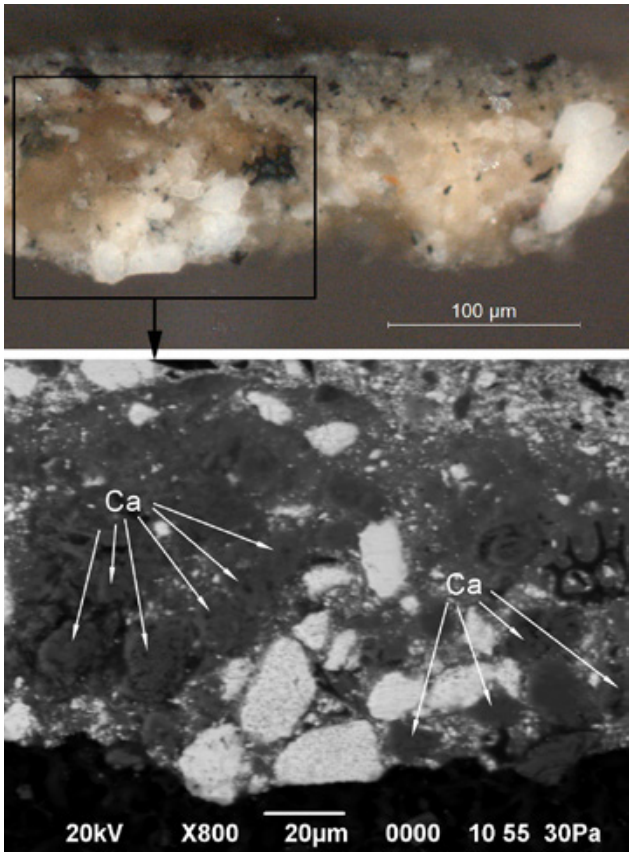

Fig. 10 Diego Velázquez, *Portrait of Ferdinando Brandani* (Fig. 9): cross-section from the greyish background showing a grey priming. The mixture includes washed ashes (calcite pseudomorphs visible in the SEM image detail), lead white, gypsum, some grains of iron aluminium silicates and some smalt particles.

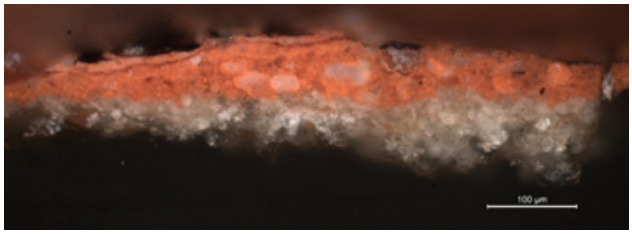

Fig. 11 Juan de Pareja, *The Calling of Saint Matthew*, 1661, oil on canvas, 225 × 325 cm, Museo Nacional del Prado, Madrid, inv. no. P001041: cross-section from the red drapery. A light warm grey priming layer was used comprising a mixture of washed ashes with lead white, manganese black and umber.

the ashes – this could be a possible reason to add some blue smalt to the mixture to achieve a colder grey.

Juan de Pareja himself became an independent painter after their arrival back in Madrid. From very humble origins, he was a Moorish slave assigned to Velázquez who developed a great fondness for him. He appreciated De Pareja's skills as a painter and freed him from slavery following their return to Madrid in 1654. Nevertheless, De Pareja stayed close to his former master's circle, collaborating with Velázquez's son-in-law Martinez del Mazo. Analysis of one of De Parejas's paintings, *The Calling of Saint Matthew*, painted in 1661, shows a preparation of similar colour and composition to that described for Velázquez's second Roman period paintings: ashes and lead white (Fig. 11). In this case there is neither smalt nor gypsum in the mixture, as in the other examples already mentioned by other painters in Madrid such as Martinez del Mazo, Francisco Rizzi (1608–1685) and Juan Antonio de Frías y Escalante (1633–1669).

Fig. 12 Diego Velázquez, *The Spinners, or the Fable of Arachne*, 1655–60, oil on canvas, 220 × 289 cm, Museo Nacional del Prado, Madrid, inv. no. P1173. (Photo © Museo Nacional del Prado.)

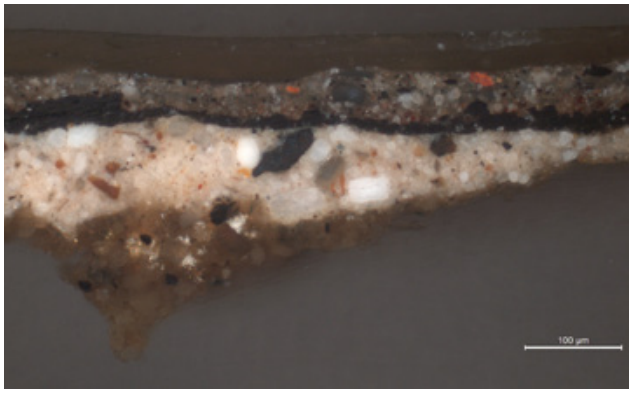

Fig. 13 Diego Velázquez, *The Spinners* (Fig. 12). Cross-section from the grey wall: the light warm grey priming has been identified as a combination of lead white, manganese black and umber. The layer beneath is composed of washed ashes bound in glue ground.

Madrid (1651–1660)

On his arrival in Madrid in 1651, Velázquez resumed his position at the court of Philip IV and started decorating the royal palaces with the works of art that he had bought in Italy. He was less active as a painter in this period. His paintings included portraits of the new Queen Mariana of Austria and her daughters, and two of his masterpieces, *Las Meninas* and *The Spinners, or the Fable of Arachne* (Fig. 12).

Regarding the composition of the preparatory layers in this period, the mixture of ashes and lead white that Velázquez used in Rome has been found just once – in the portrait of Philip IV[41] – but it did not include gypsum or smalt. As Juan de Pareja became a free professional master artist in 1654, perhaps someone else was preparing the canvases for Velázquez according to another recipe. The paintings from this period that have been analysed display the same light warm grey priming that Velázquez used before his second period in Italy: a combination of lead white, charcoal or manganese black and umber but, in this instance, without the addition of smalt (Fig. 13). Underneath this grey priming, there is a ground layer of ashes in glue in all the samples studied.

Conclusions

After studying a large group of paintings by Velázquez and his circle, some clear trends can be identified regarding his choice of preparatory layers. The successive stages of his career are quite well defined and the changes in the colour and composition of his preparatory layers seem to follow a pattern, with just a few slight variations: these range from a dark brown clay-based priming in Seville and red priming in his first years in Madrid to grey colours throughout the rest of his career.

As for the selection of the ground colour, Velázquez's choices seem quite unusual: throughout their entire careers, painters would typically use similar preparatory layers to other artists active in the same geographical area with only minor changes if they remained in that same location. However, Velázquez exercised deliberate choice when he decided to move from brown or red clay-based primings to grey ones containing lead white. This shift seems to have been made as a consequence of his contact with Rubens in 1628, and which he maintained, with slight variations in tone or composition, throughout his career. It has to be borne in mind that this was not the colour generally used in Madrid or elsewhere in Spain: in other Madrilenian workshops, red-primed canvases were in use without interruption until the end of the century and beyond[42] while brown backgrounds can be found in paintings made in Seville and other Andalusian cities. From this point of view, Velázquez and part of his circle (mainly Martinez del Mazo but also some other painters already mentioned) represent an exception in the national panorama.

Furthermore, Velázquez's preference for greyish preparatory layers can be demonstrated by the three paintings in which a re-priming process has been detected: in Madrid just before his first journey to Rome (grey over red), in his first Roman period (grey over brown) and in the short period in Fraga when he accompanied the king (grey over light brown). In these three situations, his preference for grey backgrounds led him to modify pre-prepared canvases before using them for his own purpose.

With reference to the use of water-based ground layers (*aparejos*) under the priming, two methods have been found, both described in Pacheco's treatise: glue alone and glue mixed to a paste with washed ashes (*cernada*). This last material was detected over the canvas in all the paintings with red primings, and in combination with the dark brown primings in his works produced for Torre de la Parada. In some paintings, the possible use of glue alone or glue with ashes in the ground (or flour paste also described by Pacheco but rarely found) cannot be assessed as often the samples are incomplete and lack these lowest layers.

There is no evident correlation between the different types of ground layers and priming layers. This suggests that the choice of the ground layer material could be a decision for the workshop to make, not the master. It is possible that different people working as assistants in the workshop or smaller workshops hired for this task would prefer different materials. However, other possible reasons for one or other choice can be related to other factors, such as the weave of the canvas or its coarseness, or even the size of the painting. All these possibilities remain to be investigated as the project continues.

This research has demonstrated that canvases used for large projects shared a common colour and composition in grounds and primings, independent of the subject to be represented, the exhibition location (e.g. different rooms in the same palace) or the various formats. This could also be related to the fact that these large groups of canvases may have been commissioned from external workshops with specific instructions.[43] At the current time, no archival documentation related to this subject has been found, but more research is needed.

In conclusion, the study of such a large group of paintings has allowed a classification over a prolonged period that shows enough consistency to consider colour and composition of the preparation as a diagnostic feature in the chronology of the artist's work.[44] The specific study of those cases that raise doubts as to the place or time of execution will be approached in collaboration with the curator responsible for the collection and in the general context of the forthcoming *catalogue raisonné*. Although, this characteristic will not be the only criterion used, the remarkable coherence that Velázquez shows in the use of different preparations gives important weight to this feature, in combination with his stylistic and documentary study. In general and beyond the collection of the Museo Nacional del Prado, the classification presented here can be regarded as a very useful tool for the study of Velázquez's work in its entirety, including distinguishing between originals and copies or studio works.

Acknowledgements

The authors wish to thank Javier Portús and Jaime García-Maiquez for their collaboration in this project and for sharing their expertise in the history of art. We acknowledge Jaime García-Maiquez particularly for his encouragement and his comments on this article.

Notes

1. The paintings studied in this article belong to the collection of the Museo Nacional del Prado, Madrid, unless otherwise indicated.
2. The *catalogue raisonné* is expected to be published in 2021–22.
3. The only period not represented in the Prado's collection is the decade of 1640.
4. C. Garrido, *Velázquez, técnica y evolución*, Madrid, Museo Nacional del Prado, 1992.
5. Other scholars have proposed that Velázquez's stylistic evolution relates to the colour of the preparatory layers, suggesting different motivations for the changes he made and its consequences. For a general overview, see L. Keith, 'Velázquez's painting technique', in D. Carr (ed.), *Velázquez*, London, National Gallery, 2006, pp. 70–89.
6. F. Pacheco, *El arte de la pintura*, ed. B. Bassegoda i Hugas, Madrid, Editorial Cátedra, 1990. For a slightly simplified English translation, see Z. Véliz, 'Francisco Pacheco's comments on painting in oil', *Studies in Conservation* 27(2), 1982, pp. 49–57.
7. Velázquez's biography is well known and many studies on the different aspects of his career have been published over the years. No specific references are given in this paper as this is not the focus of the research presented here. For a general context see, J. Brown, *Velázquez: Painter and Courtier*, New Haven, Yale University Press, 1986; J.M. Cruz Valdovinos, *Velázquez: Vida y obra de un pintor cortesano*, Zaragoza, Caja de Ahorros de la Inmaculada, 2011.
8. 'La mejor emprimación y más suave es este barro que se usa en Sevilla, molido en polvo y templado en la losa con aceite de linaza', Pacheco 1990 (cited in note 6), p. 481 [authors' translation].

9. Several paintings by these Sevillian painters have been studied in the laboratory of the Museo Nacional del Prado, some of which are included in M.D. Gayo and M. Jover de Celis, 'Evolución de las preparaciones en la pintura sobre lienzo de los siglos XVI y XVII en España', *Boletín del Museo del Prado* 28(46), 2010, p. 55. See also A. Illán, R. Romero and A. Sáenz de Tejada, 'Características de las preparaciones sevillanas en pintura de caballete entre 1600 y 1700: implicaciones en el campo de la restauración y de la historia del arte', in Grupo español IIC (ed.), *Investigación en conservación y restauración*, Barcelona, 2004, pp. 197–205; M.V. Muñoz and F. Paz, 'Murillo joven: aportaciones al conocimiento de su técnica', in Museo de Bellas Artes de Bilbao, Junta de Andalucia (eds), *El joven Murillo*, Bilbao, Museo de Bellas Artes de Bilbao/Seville, Consejería de Cultura, 2009, pp. 157–185; H. Tomlinson, H. Howard, D. Peggie, P. Ackroyd and D. Carr, 'Murillo's *Christ Healing the Paralytic at the Pool of Bethesda*: an introduction to the artist's late painting technique', in M. Spring (ed.), *Studying Old Master Paintings: Technology and Practice*, London, Archetype Publications, 2011, pp. 173–179.
10. 'pueden añadir al barro un poco de albayalde, para darle más cuerpo, o usar de solo el barro', Pacheco 1990 (cited in note 6), p. 481 [authors' translation].
11. 'Otros aparejan los lienzos con cola de guantes y ceniza cernida, en lugar de yeso y … empriman con sola almagra común molida con aceite de linaza; esto usan en Madrid', Pacheco 1990 (cited in note 6), p. 481 [authors' translation].
12. Several examples are included in M. Jover de Celis and M.D. Gayo García, '*This they use in Madrid*: the ground layer in paintings on canvas in 17th-century Madrid', in H. Dubois, J. Townsend, J. Nadolny, S. Eyb-Green, S. Kroustallis and S. Neven (eds), *Making and Transforming Art: Technology and Interpretation*, London, Archetype Publications, 2014, p. 44.
13. Calcite particles confirmed by means of XRD analysis by the authors.
14. Jover de Celis and Gayo García 2014 (cited in note 12).
15. At the end of his life, Pacheco visited his son-in-law in Madrid and tried, unsuccessfully, to make a living as a painter in the city. Although he would have seen the use of the ashes ground by painters in Madrid, he did not provide detailed information on the preparation method.
16. F. Carò, S. Centeno and D. Mahon, 'Painting with recycled materials: on the morphology of calcite pseudomorphs as evidence of the use of wood ash residues in Baroque paintings', *Heritage Science* 6(3) 2018, doi: https://doi.org/10.1186/s40494-018-0166-5.
17. See A. Palomino de Castro y Velasco, *El museo pictórico y escala óptica: práctica de la pintura,* Madrid, Aguilar, 1988, p. 134
18. Real Academia Española, *Nuevo Diccionario Histórico del Español. Diccionario de Autoridades*, 1729, T. II. Available at: http://web.frl.es/DA.html (accessed 1 April 2020).
19. Museo Nacional del Prado, Madrid, inv. no. P001638.
20. That Velázquez was close to Rubens and probably witnessed his fruitful activity is actually described by Pacheco who, after listing all the paintings that the Flemish master produced in Madrid, states 'Parece cosa increible haber pintado tanto en tan poco tiempo, y en tantas ocupaciones. Con pintores comunicó poco, solo con mi yerno … hizo amistad, y favoreció mucho sus obras por su modestia, y fueron juntos a ver el Escorial' ['It seems incredible that he painted so much in such a short time while being so busy. He rarely talked with painters, just with my son-in-law … he established a friendship, and praised his works for its modesty, and they went together to see El Escorial'], Pacheco 1990 (cited in note 6), p. 202 [authors' translation].
21. Museo Nacional del Prado, Madrid, inv. no. P001187.
22. A canvas painted by Rubens during his stay at the Spanish court, studied in 2013 by the Prado's scientific department, showed a similar internal structure: a light grey layer over the typical Madrilenian red priming. As the painting has been transferred to a new canvas in recent times, the ground layer (probably ashes) no longer exists. Surprisingly, the results of this study revealed a portrait of the king's brother, Don Carlos, under the image of an unknown gentleman: A. Vergara, L. Alba and M.D. Gayo, 'Rubens in Madrid (1628–29): new technical evidence concerning his copies after Titian, and a new portrait', *Boletín del Museo del Prado* 31(49), 2013, p. 30.
23. *View of the Gardens of the Villa Medici, Rome* (Museo Nacional del Prado, Madrid, inv. no. P001210); *View of the Gardens of the Villa Medici, Rome, with a Statue of Ariadne* (Museo Nacional del Prado, Madrid, inv. no. P1211); *Joseph's Tunic* (National Heritage Collection, Monastery of El Escorial, inv. no. 10014694). No other material was detected under the brown layer in any of the samples.
24. Several paintings produced in Italy in the 17th century from the Prado's collection have been studied by its laboratory including in Naples: Jusepe de Ribera, *The Raising of Lazarus* (inv. no. P007768), *The Martyrdom of Saint Philip* (inv. no. P001101), Giovanni di Stefano Lanfranco, *Funeral Rites for a Roman Emperor* (inv. no. P000234) and Massimo Stanzione, *Sacrifice to Bacchus* (inv. no. P000259); in Rome: Nicolas Poussin, *Landscape with Saint Paul the Hermit* (inv. no. P002304), Jan Both, *Landscape with Carmelites* (inv. no. P002058), *The Baptism of Queen Candace's Eunuch* (inv. no. P002060), *Taking the Cattle Out* (inv. no. P002061), *Landscape with Fishermen and Shepherds on a Riverbank* (inv. no. P002066) and Herman van Swanevelt, *Mountain Landscape with Hut and Vegetables* (inv. no. P002057), *Landscape with Saint Rosalia of Palermo* (inv. no. P002063), *Landscape with a Carthusian (Saint Bruno?)* (inv. no. P002064), *Landscape with Saint Benedict of Nursia* (inv. no. P002065), *Landscape with Wayfarers, Boy and Dog* (inv. no. P002140), *Landscape with Fisherman Family at Dusk* (inv. no. P002141), *Landscape with Travellers and a Shepherd* (inv. no. P003223), *Landscape with Hermit Preaching* (inv. no. P005121). See also M. Álvarez- Garcillán, 'La restauración de Venus, Adonis y Cupido', in A. Úbeda de los Cobos (ed.), *Annibale Carracci: Venus, Adonis y Cupido*, Madrid, Museo Nacional del Prado, 2005, pp. 55–70; A. Sánchez Ledesma, 'Material analysis', in S. Pérez, A. Sánchez Ledesma and U. Sedano, *Discovering Caravaggio. 'Saint Catherine of Alexandria': Technical Study and Restoration*, Madrid, Museum Thyssen-Bornemisza, 2018, pp. 47–51; L. Keith, 'Three paintings by Caravaggio', *National Gallery Technical Bulletin* 19, 1998, pp. 37–51; H. Glanville, H. Rousselière, L. de Viguerie and Ph. Walter, '*Mens Agitat Molem*: new insights into Nicolas Poussin's painting technique by X-ray diffraction and fluorescence analyses', in B.G. Brunetti, A. Sgamellotti and C. Miliani (eds), *Science and Art: The Painted Surface*, Cambridge and London, Royal Society of Chemistry, 2014, pp. 314–335.
25. There is some discussion among scholars about the dates of creation of these two small landscapes, placing them either during the first or second period in Rome. For the time being, according to the data on preparatory layers obtained, an early date seems more plausible, but the complete discussion will be included in the forthcoming *catalogue raisonné*.
26. Today, Buen Retiro Palace no longer exists: only one of the wings of the building has survived, now part of the Museo Nacional del Prado campus.
27. Detailed descriptions of this hall and the paintings, as well as information on the construction of the palace, can be found in J. Brown and J. Elliott, *A Palace for a King: The Buen Retiro and the Court of Philip IV*, New Haven and London, Yale University Press, 2003.

28. Museo Nacional del Prado, Madrid, inv. no. P001172.
29. Details of this commission are studied in S. Alpers, *The Decoration of the Torre de la Parada*, London, Phaidon Press, 1971.
30. Museo Nacional del Prado, Madrid: *The Crucified Christ* (inv. no. P001167), *Portrait of Antonia de Ipeñarrieta y Galdós and her Son, Luis* (inv. no. P001196) and *Portrait of Diego del Corral y Arellano* (inv. no. P001195).
31. Museo Nacional del Prado, Madrid, inv. no. P001202.
32. The portrait of Philip IV in the Frick collection was studied some years ago. Research using the canvas thread counting automation system resulted in the information that both this portrait and *The Buffoon El Primo* was painted on supports made from the same canvas roll. See P. D'Ors and M. Gallagher, 'New information on Velázquez's portrait of Philip IV at Fraga in The Frick Collection, New York', *The Burlington Magazine* 152(1291), 2010, pp. 652–659 (note: no information on preparatory layers is included).
33. An identical situation is found in another work by Martinez del Mazo, painted in Zaragoza in 1647: over a light brown coloured clay layer, a grey priming is used (see J. Portús, J. García-Máiquez and M. Álvarez-Garcillán, 'La *Visita de Zaragoza*, de Juan Bautista Martínez del Mazo. Notas al hilo de su restauración', *Boletín del Museo del Prado* 33(51), 2015, pp. 62. No published information has been found on the colour and composition of the preparatory layers in paintings produced in this area in the 17th century as lesser known regional schools have not been the subject of studies. In a future project, the Museo Nacional del Prado will study other geographical areas in order to gain a better understanding of the preparatory layers used by the different 17th-century Spanish schools.
34. See Carò *et al*. 2018 (cited in note 16), pp. 5–6.
35. However, an important exception to this affirmation may exist: the already mentioned *Portrait of Pope Innocent X* (Galleria Doria Pamphilj, Rome, inv. no. FC289). In 1996, while this painting was on exhibition at the Prado, some technical studies were carried out including radiography and infrared reflectography but no samples were taken. Based on her observations of the surface and the characteristics of the radiography, Garrido suggested that the ground layer could be a brown earth, typically used in Rome at that time; see C. Garrido, 'Un sevillano retratista de un papa', in Junta de Andalucia (ed.), *Actas del Symposium Internacional de Velázquez*, Seville, 2004, pp. 201–206.
36. The presence of gypsum could be related to the use of a low quality lead white or perhaps to give more body to the mixture.
37. See note 22.
38. Unfortunately, the Prado collection does not include works by Velázquez painted in the 1640s, immediately before his second visit to Italy. No published technical information has been found about this period either, therefore we do not know whether Velázquez had already used this mixture in Madrid before his departure.
39. Several examples of the use of this mixture in paintings made in Madrid between 1640 and 1670 were studied in the Prado's laboratory, not only by Francisco Martínez del Mazo but also by Juan Antonio de Frías Escalante, Francisco Rizzi, Sebastián Herrera Barnuevo and others; unpublished results and Gayo and Jover de Celis 2010 (cited in note 9), p. 59.
40. The results of this experimental project, including ground and priming layers of different colours and compositions, have not yet been published.
41. Museo Nacional del Prado, Madrid, inv. no. P001185.
42. Red primings have been identified in works by painters active in Madrid between 1630 and 1660, such as Juan Fernandez "El Labrador" (*Vase of Flowers* inv. no. P002888; *Four Bunches of Hanging Grapes* inv. no. P007903; *Still Life with Four Bunches of Grapes* inv. no. P007904), Juan de Espinosa (*Still Life with Grapes, Apples and Plums* inv. no. P00702; *Octagonal Still Life with Bunches of Grapes* inv. no. P007942) and Pedro Núñez del Valle (*The Adoration of the Magi* inv. no. P03531). For more examples by other artists such as Miguel de Pret, Antonio Ponce and José de Arellano, see R. Romero, *El bodegón español en el siglo XVII: desvelando su naturaleza oculta*, I & R Restauración y Estudios Técnicos de pintura de caballete, Madrid, 2009, pp. 141–146, 147–159, 101–115, 323–332.
43. This is a common feature that has been described for other painting decorative series: see Lidwien Speleers, Margriet van Eikema Hommes, Ineke Joosten, Suzan de Groot and Annelies van Loon, 'The effect of ground colour on the appearance of two paintings by Thomas Willeboirts Bosschaert in the Oranjezaal, Huis Ten Bosch', in this volume, pp. 93–106.
44. The study of Velázquez's preparation colour has already been used for diagnostic purposes: *Christ after the Flagellation* painted in Madrid (L. Keith and D. Carr, 'Velázquez's *Christ after the Flagellation*: technique in context', *National Gallery Technical Bulletin* 30, 1988, pp. 52–70) and the two versions of the portrait of *The Nun Jerónima de la Fuente*, one painted in Seville and the other in Madrid (C. Garrido and T. Gómez Espinosa, 'Estudio técnico comparativo de los dos retratos de la *Venerable Madre Sor Jerónima de la Fuente*', *Boletín del Museo del Prado* 9(25–27), 1988, pp. 66–76).

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TO REACH THE ORIGINAL: TECHNIQUE AND MATERIALS OF THE LATE 17TH-CENTURY ITALIAN PAINTER OF LARGE-SCALE BATTLE SCENES, MARTINO ALTOMONTE

Joanna Szpor, Katarzyna Górecka and Marcin Kozarzewski

ABSTRACT The conservation treatment of the large-scale canvas paintings by Martino Altomonte, *Battle of Párkány* and *Battle of Vienna* from St Lawrence Collegiate Church in Zhovkva (today in western Ukraine), was completed in 2011. Both paintings were in very poor condition. Many layers of browned varnishes, darkened overpaint and excessive fills were removed during the conservation treatment in order to reach and expose the original paint. Analysis of Altomonte's technique and materials revealed that he had used a specific reddish ground, composed of chalk and lead white coloured with minium – an unusual combination for a painter who was educated at the Academy of St Luke in Rome. The ground structure of both paintings also showed considerable lead soap formation.

Introduction

Battle of Párkány and *Battle of Vienna* are the largest 17th-century battle scenes painted on canvas in Europe, measuring 886 × 782 cm and 806 × 833 cm, respectively (Figs 1 and 2). Completed in 1695 by Martino Altomonte (1657/59–1745), the paintings depict, in a realistic way, two victorious battles of the Holy League against the Ottoman Empire, Vienna and Párkány. The paintings were commissioned by the Polish king, Jan III Sobieski, for St Lawrence Collegiate Church in Zhovkva (also known as Nesterov), near Lviv, which is today in western Ukraine (Fig. 3). In the 17th century, the Renaissance town belonged to Poland. St Lawrence was not only the parish church, but a monument both to the town's founder Stanisław Żółkiewski (Commander-in-Chief of the Polish army and great-grandfather of King Jan III Sobieski) and the Sobieski royal family. The king wanted to commemorate these enormous battles with enormous paintings.

Altomonte, born in 1657 or 1659, hailed from Naples. After apprenticeships to Giovanni Battista Gaulli (1639–1709) and Carlo Maratta (1625–1713) in Rome, he completed his studies at the Accademia di San Luca (Academy of St Luke). Appointed court painter to Jan III Sobieski in 1684, *Battle of Párkány* and *Battle of Vienna* were the most important works he made for the Polish king. Altomonte lived in Poland for nearly 20 years during which time he also received commissions from local monasteries and the nobility, exemplified by portraits for Commander Jabłonowski and the Wodzicki family, and his cycle of religious paintings in the Jesuit monastery in Holy Linden (Święta Lipka), Poland. In 1703, Altomonto moved to Vienna. He remained in Austria for the rest of his life and executed, among others, the ceiling paintings in the archbishop's residence at Salzburg and the frescoes in Lower Belvedere Palace in Vienna. In 1707, Altomonte was selected as a teaching member at Vienna's Akademie der bildenden Künste. He also worked for the monastery of the Holy Cross in Linz where, towards the end of his life, he would become a brother and eventually die in 1745.[1]

Conservation treatment as an opportunity to reach the original

Battle of Párkány and *Battle of Vienna*, now owned by the Lviv National Gallery, Ukraine, were treated in Poland

Fig. 1 Martino Altomonte, *Battle of Párkány*, 1695, oil on canvas, 886 × 782 cm, Zolochiv Castle, Lviv National Art Gallery: after conservation. (Photo: C. Delgado Martin, Monument Service.)

Fig. 2 Martino Altomonte, *Battle of Vienna*, 1695, oil on canvas, 806 × 833 cm, Olesko Castle, Lviv National Art Gallery: after conservation. (Photo: C. Delgado Martin, Monument Service.)

Fig. 3 Joseph Engert, *Interior of the Collegiate Church in Zhovkva*, 1827, oil on canvas, 70 × 50 cm, Lviv National Art Gallery.

between 2008 and 2011. The paintings' large scale and poor condition presented significant logistic and technical challenges (Fig. 4), but the treatment made it possible to 'reach the original', both literally and figuratively: the original colours were discovered under several layers of brown varnish and overpainting. The expression 'reaching the original' encompasses an analytical aspect in terms of the work carried out on the binders and pigments in the ground and paint layers. Comprehensive documentation and research included photographing the paintings in ultraviolet (UV) and visible light, examining embedded paint samples for their stratigraphy, microchemical and microbiological analyses, Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis and high-performance liquid chromatography (HPLC). Researchers then used this analytical investigation of the Zhovkva paintings to create a database describing the technique and methods used by the Italian painter in the second half of the 17th century.[2]

Technique and materials of the coloured ground and its optical role

Altomonte's ground preparation in *Battle of Párkány* and *Battle of Vienna* is presumably a characteristic feature of his painting technique. He used a distinctive coloured ground to build up colour in the paintings (Fig. 5). Produced on a two-layered oil or oil-emulsion ground,[3] the paintings have a reddish lower ground containing lead white with chalk and orange minium. The upper layer or priming is thinner and orange-grey, comprising orange, white and colourless particles. Minor additions of Naples yellow, ochre and iron oxide red, as well as charcoal black, were also found in both layers.[4]

Altomonte's preparatory layers are unlike the grounds employed by other painters associated with the Academy of St Luke in Rome. Until the end of the 17th century, Italian artists usually painted on dark red bole grounds:[5] in their works, the dark red colour of grounds was treated as an initial colour for the shadow parts to create a contrast with the strong lights. It is possible that Altomonte's ground also differs from that used by other artists at the court of Jan III Sobieski. Research has been conducted on paintings by

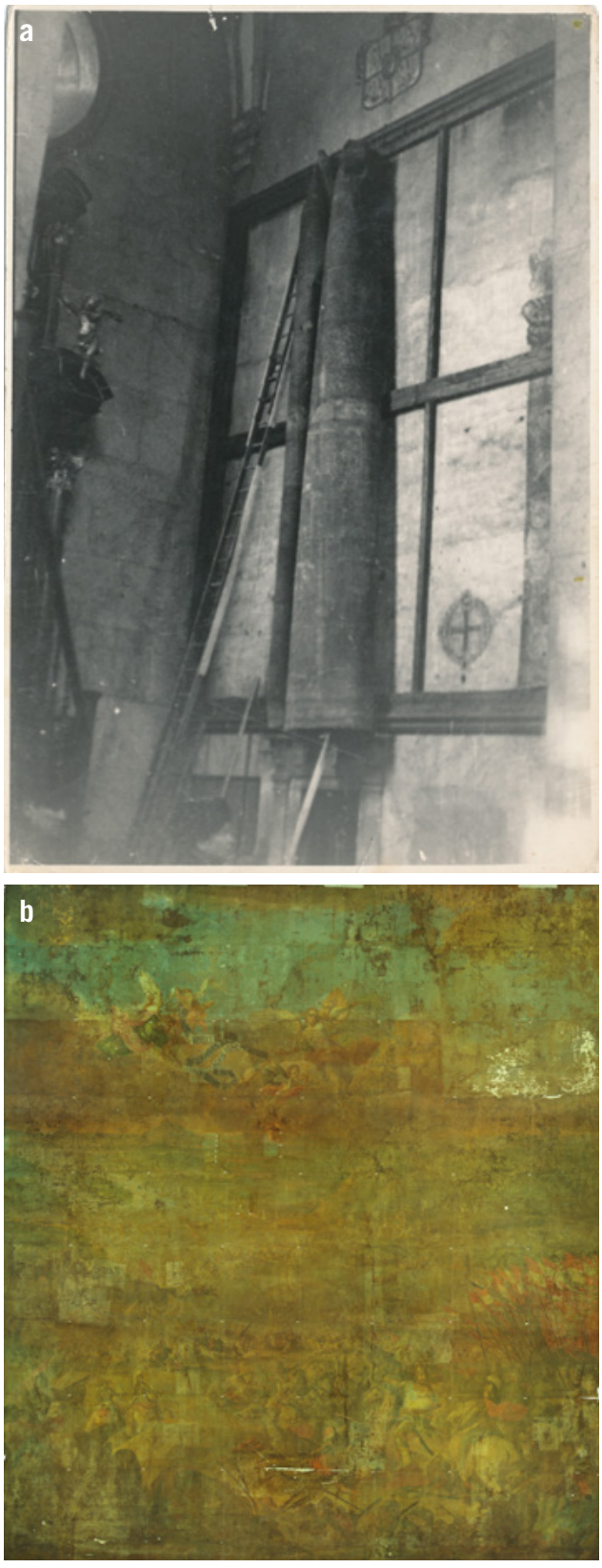

Fig. 4 Martino Altomonte, *Battle of Párkány* (Fig. 1), then in St Lawrence Collegiate Church in Zhovkva, Lviv National Art Gallery (archival photo): (a) removal of the painting from the church wall in the 1970s and (b) before conservation in Warsaw in 2008. (Photo: M. Morańda, Geometric.)

Fig. 5 Martino Altomonte, *Battle of Vienna* (Fig. 2): (a) King Jan III Sobieski and the location of sample W.38 – military armlet; (b) stratigraphy: 1,2 – two-layer ground, 3 – warm grey background, 4 – underpainting layer with indigo, 5 – final colour painted with azurite.

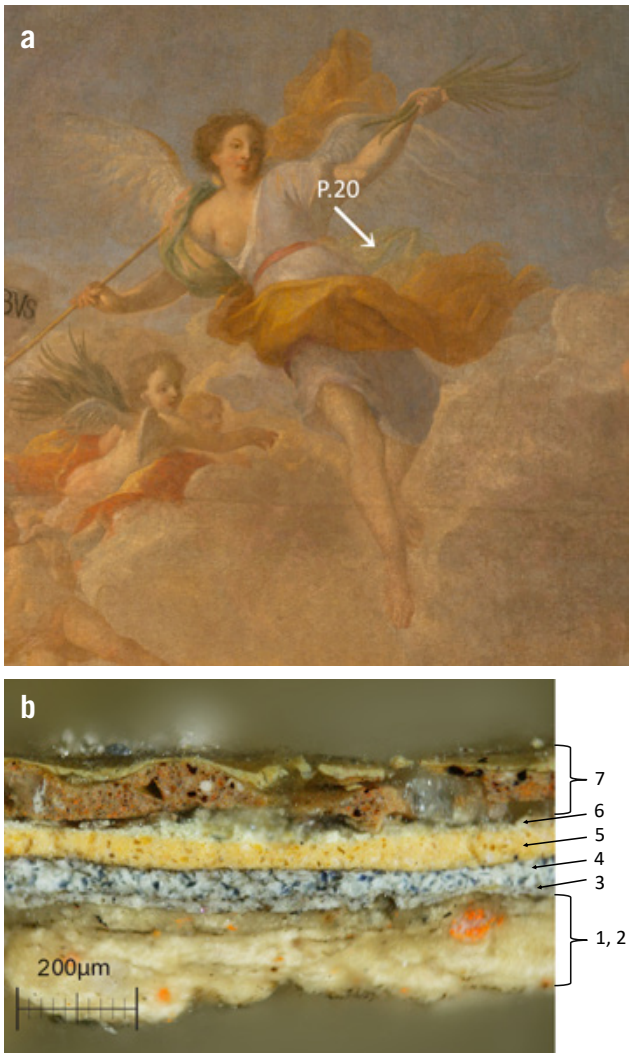

Fig. 6 Martino Altomonte, *Battle of Párkány* (Fig. 1): (a) The Personification of Fame and the location of sample P.20 – green coat; (b) stratigraphy: 1,2 – two-layer ground, 3 – blue background painted with fine-grained smalt, 4 – final blue colour painted with large-grained smalt, 5 – yellow painting layer, 6 – green earth (addition of lead white, chalk and lead-tin yellow, 7 – non-original layers.

Jerzy Eleuter Szymonowicz Siemiginowski (1660–1711), a Polish artist appointed to the royal court who, like Altomonte, was educated at the Academy of St Luke in Rome. Siemiginowski executed the large ceiling paintings in Wilanów Palace in Warsaw. The preparatory layers in these works consisted of two layers of red ground containing red earth, white lead, charcoal black, and chalk mixed with oil.[6] The royal portraits attributed to Siemiginowski were also painted on dark red grounds. Tests of their elemental composition revealed the presence of iron, calcium and lead ions, confirming the use of red earth, chalk and probably lead white; however, the presence of minium cannot be excluded.[7] We do not know if both artists consistently used the same recipes for ground layers in their later works – only analyses of a larger number of the grounds would allow a comparison to be made. Research on the technology of the grounds employed by artists at the court of King Jan III Sobieski is ongoing.[8]

Certainly, the colour of the ground used by Altomonte was not accidental – in a corner of the *Battle of Párkány*, he experimented with different ground colours in order to decide on its final tone. Analyses of the collected samples indicate that his palette was limited to around 13 pigments. The artist used a fatty tempera binder (linseed oil with the addition of egg yolks) and the colour was locally deepened with a coloured glaze in an oil and resin (sandarac) binder. There is evidence that Altomonte tried to economise in this work: for the first paint layer, he used the cheapest earth pigments, such as ochre, iron oxide red and green earth. The more expensive pigments, including vermilion and lead-tin yellow (Fig. 6), were reserved for the final layers. Azurite was used for the most important details of the composition, applied to an underpainting made from the cheaper indigo pigment (Fig. 3).[9] Presumably, the artist acquired his painting knowledge not only from masters, but also from popular manuals such as *Il riposo* by Raffaello Borghini (Florence, 1584).[10]

The enormous battle scenes required Altomonte to use a composition of many planes. To create the impression of

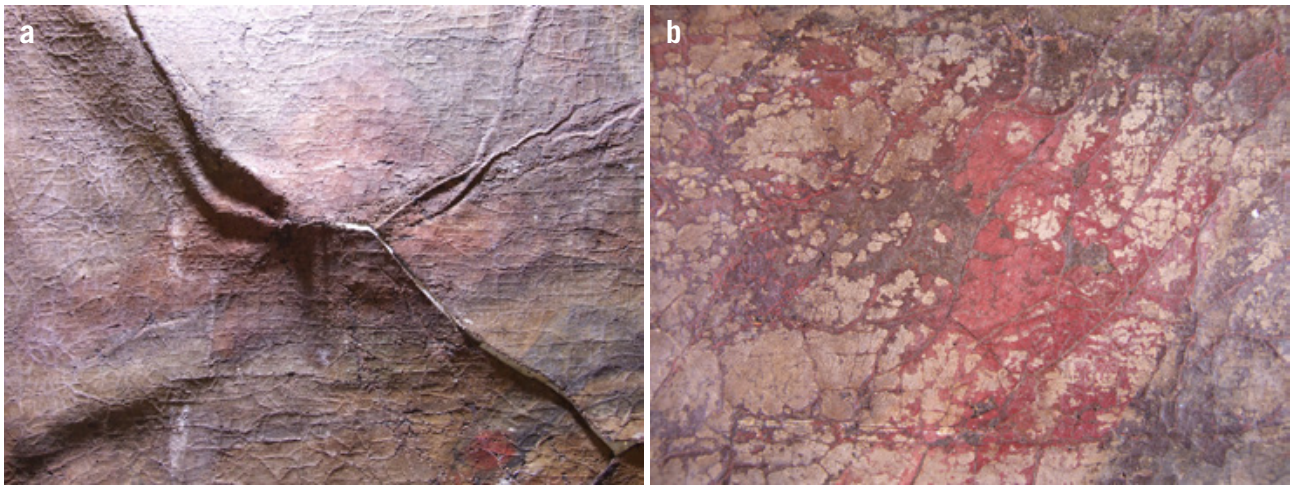

Fig. 7 Martino Altomonte, *Battle of Párkány* (Fig. 1): before conservation. (a) Deformation of the canvas support and (b) degradation of the painting binder.

depth, he depicted the foreground, middle and farthest distances in separate colour bands. The illusion of distance is enhanced by the controlled use of colour. Only the foreground is dark – the middle distance is colourful, while the farthest distance gradually becomes bluish and pale. This effect could only be achieved on a light coloured ground. In the case of large-format compositions, the proper saturation of the paint layers by varnish was equally important: uneven saturation would distort the appearance. Correct colour saturation and avoidance of a matte appearance were discussed by the 17th-century Italian painter Filippo Baldinucci, author of *Il lustrato* (Florence 1691).[11] It was known at that time that bole grounds were characterised by high absorption. The Italian term *prosciugato* ('sinking in' of the colour) describes the phenomenon of over-absorbency of the ground.[12] Altomonte may have deliberately tried to avoid this effect by using a less absorbent oil ground, tinted with minium in place of iron oxide red pigments.

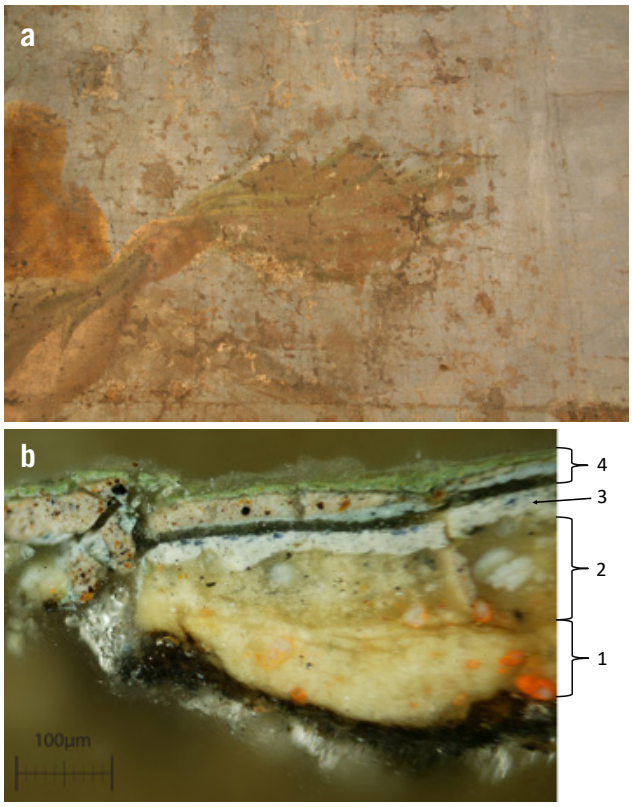

Fig. 8 Martino Altomonte, *Battle of Párkány* (Fig. 1): (a) the laurel branch held by the Personification of Fame, showing the paint surface covered with old fills; (b) stratigraphy of sample P.11: 1, 2, 3 – original layers, 4 – non-original layers.

Condition of the paintings

Altomonte's paintings and St Lawrence Collegiate Church in Zhovkva have a dramatic history. After the Second World War, Soviet authorities closed the church. Later the building was turned into a warehouse and finally fell into ruin. Roof leaks nearly destroyed both paintings and in the 1970s they were removed from the church walls (Fig. 4a), rolled up, and transported to Olesko Castle in Ukraine.[13] The *Battle of Vienna* was exhibited in one of the castle rooms but because the ceiling was too low the painting was folded and only its lower part was displayed. The *Battle of Párkány* remained rolled on a tube made from a wooden pillar and stored in a museum warehouse for 30 years (Figs 7 and 8).

In 2007, both paintings, rolled on tubes, were transported from Ukraine to Poland. They were in very poor condition (Fig. 4b): attacked by microorganisms, their canvas supports were deformed (Fig. 7a), badly distorted and fragile, while the damaged paint layers showed numerous cracks and traces of recurrent overpainting (Figs 6 and 8): only about 60 per cent of the paint layer of the *Battle of Párkány* was preserved. This remainder demonstrates weakened adhesion to the support (Fig. 5b), and extensive filling and retouching (Fig. 9).

The ground in both paintings was physically and chemically degraded. Characteristic white aggregates of lead carboxylate, surrounded by minium grains, were observed

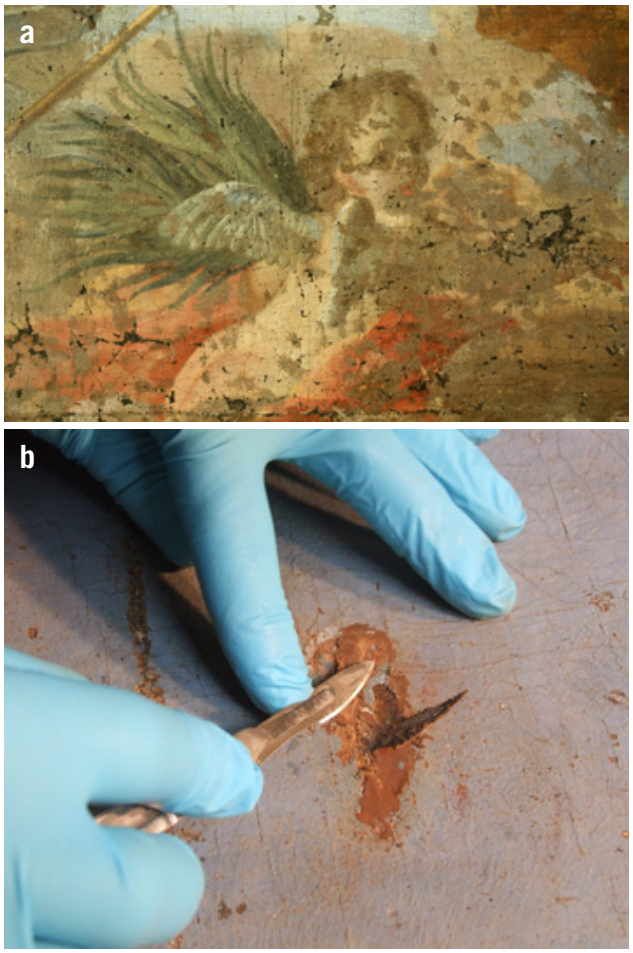

Fig. 9 Martino Altomonte, *Battle of Párkány* (Fig. 1): (a) the paint surface covered with old fills and (b) their mechanical removal.

in cross-sections made from paint samples (Fig. 10). The aggregates range in size from 0.075 to 0.1 mm. These changes are associated with the formation of crystalline lead soaps in the ground structure. This type of degradation results from the reaction of fatty acids (derived from the oil binder or waxes) with lead ions from lead-containing pigments or additives. The lead soap aggregates formed within the ground and the paint layers that caused their delamination protrude through the paint surface, giving it a granular appearance. The literature on the subject attributes the presence of remineralised minium grains around white crystalline aggregates to a later stage in the alteration of lead white.[14] Although minium itself was added to the ground, it cannot be ruled out that this type of reaction has also occurred in the Altomonte paintings, as evidenced by the numerous orange particles of minimum that are present in, but not encircling, the lead soap aggregates. The painter's addition of minium to the ground could have catalysed or accelerated the changes. High relative humidity and bioinfestation also contributed to the paintings' degradation. Imaging FTIR is a vital analytical method for the identification of metal soaps in paint cross-sections, thus enabling the detection and localisation of carbonyl group stretches characteristic of carboxylate-metal bond systems in soaps.[15] Studies on the grounds are ongoing.

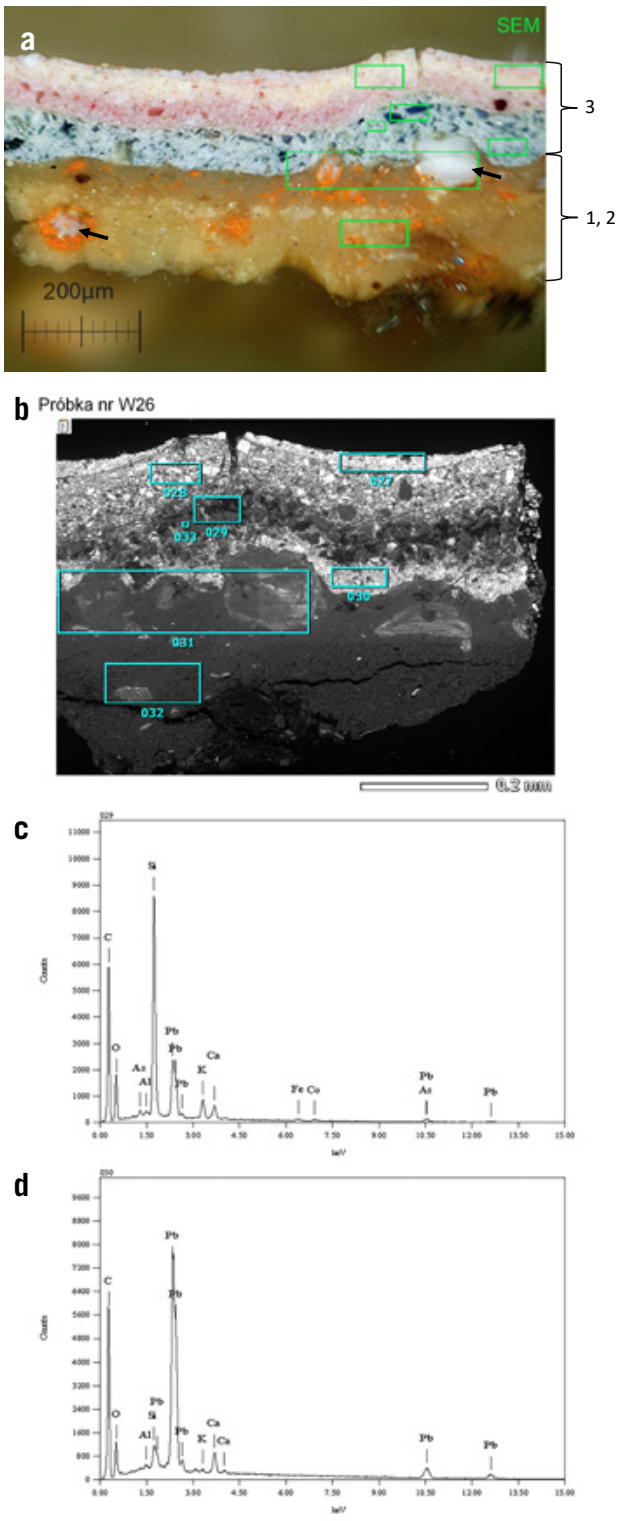

Fig. 10 Martino Altomonte, *Battle of Vienna* (Fig. 2), Zolochiv Castle: (a) stratigraphy of the sample taken from the *Battle of Vienna* W.26. 1,2 – two-layer ground, 3 – original painting layers, aggregates surrounded by minium particles can be seen; (b) SEM image; (c) EDX analysis marked '29' for the top of the blue layer; (d) EDX analysis marked '30' for the bottom of the same layer.

Conservation process 2008–2011

In 2008, both paintings were transported to Warsaw where the mould growth was treated and removed. The starch glue and animal glue used for lining during previous treatments

Fig. 11 Preparation for the exhibition of Altomonte's paintings at the Museum of Architecture in Wroclaw. (Photos: C. Delgado Martin, Monument Service.)

were carefully removed from the reverse using steam and mechanical cleaning. During this operation, the canvas deformations were almost entirely eliminated. The consolidation of paint layers was executed by reactivation of the remains of old animal glue and additional impregnation of synthetic resin in a low concentration solution. Laborious repairs of the canvas and strengthening with non-woven fabric were carried out. Next, the paint surfaces were cleaned. Huge quantities of yellowed varnish and vast overpainted areas were removed using solvents. Old, very hard fills covering parts of the original layers were removed mechanically (Fig. 9). Losses in the paint and priming were filled with a more flexible material then the paintings were lined with new soft linen canvas and BEVA-371 solution,[16] applied by spraying. Finally, the works were retouched. Areas where the painting layer was lost were integrated with local colour (using watercolours and resin-oil colours) and missing fragments of the composition were then reconstructed after 19th-century lithographs.[17] Due to its optical properties, dammar was used for varnishing.[18] After treatment, the paintings were exhibited on new lightweight wood–aluminium stretchers[19] at the Theatre Museum of the National Opera in Warsaw in 2011, and at the Museum of Architecture in Wrocław in 2012 (Fig. 11). In 2012, *Battle of Vienna* and *Battle of Párkány* returned to Ukraine, where they were provisionally exhibited at Olesko and Zolochiv. Unfortunately, despite the ongoing efforts of the Polish government, Altomonte's paintings have not been returned to St Lawrence Collegiate Church in Zhovkva, their place of origin.

Conclusions

The enormous works *Battle of Vienna* and *Battle of Párkány* were painted by Martino Altomonte for St Lawrence Collegiate Church in Zhovkva. For both works, the artist used a reddish colour ground containing mainly lead white and chalk, supplemented by minium to achieve specific painterly effects: it harmonised the colour of the entire composition and was used locally as an underpainting layer for some fragments of the scenes. The grounds of the two paintings have degraded both chemically and physically; the formation of lead soap aggregates has led to the creation of remineralised minium grains around the crystalline structures. The original addition of the minium pigment probably accelerated the formation of lead soaps and the process of remineralisation. Consequently, the paint on the entire surface has become granular and porous. Very few studies have been made on the artist and his oeuvre and it remains unclear if Altomonte used this type of ground in other works, and whether those works have undergone similar degradation.

Acknowledgements

The Polish-Ukrainian restoration project was financed by the Polish Ministry of Culture and National Heritage. The project was managed by Paweł Sadlej (Croaton Ltd) and Marcin Kozarzewski (Monument Service), in cooperation with Larissa Voznicka (Lviv National Art Gallery). The painting technique and technical research were supervised by Prof. Joanna Szpor (Academy of Fine Arts in Warsaw). Materials analysis was performed by Prof. Maria Poksińska (Nicolaus Copernicus University, Toruń), with additional analyses carried out by: J. Czelej (Academy of Fine Arts in Warsaw), W. Grzesik (Nicolaus Copernicus University, Laboratory PKZLAB, Toruń), D. Jarmińska (Academy of Fine Arts in Warsaw), E. Jeżewska (Academy of Fine Arts in Warsaw), J. Karbowska-Berent PhD (Nicolaus Copernicus University, Toruń), K. Królikowska-Pataraja (Academy of Fine Arts in Warsaw), A. Nowicka (Academy of Fine Arts in Warsaw), E. Orłowska (Nicolaus Copernicus University, Laboratory PKZLAB, Toruń), G. Trykowski (Nicolaus Copernicus University, Toruń), M. Wróbel (Warsaw University), I. Zadrożna (Warsaw University of Technology). Karol Klata and Katarzyna Górecka led the international conservation teams: *Vienna* and *Párkány*. The authors wish to express their thanks to Petria Noble (Head of Paintings Conservation, Rijksmuseum, Amsterdam) for comments regarding the formation of lead soaps in grounds. We also thank Janka Hradilová and David Hradil for scientific discussion that allowed us to better understand the chemical processes taking place in the grounds containing lead white. We are also grateful to Joanna Czernichowska (Academy of Fine Arts in Warsaw) and Agnieszka Pawlak (Museum of King Jan III's Palace at Wilanów) for their information and comments on Siemiginowski's painting technology.

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19. Designed and produced by the company Al Portico Telai.

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WHITE, RED, GREY AND BROWN: COLOUR IN GENOESE GROUNDS FROM THE MID-16TH TO THE 18TH CENTURY

Michela Fasce

ABSTRACT This paper discusses the investigation, using various analytical techniques, of the ground colours and *imprimatura* of over 100 paintings by Genoese artists covering the period from the mid-16th to the 18th century. It describes the colours found in preparatory layers observed during their conservation treatments and technical examinations.

Introduction

This study investigates the colours found in preparatory layers in works by Genoese artists painted between the mid-16th and the 18th century, observed during their conservation treatments and technical examinations by the author and the University of Genoa. Materials identification for more than 100 paintings was obtained by scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis, optical microscopy for the examination of cross-sections and fibre identification for the canvas. This paper discusses the colour of their ground and *imprimatura* if present.

Technical study

From this study, the first Genoese works to show a variation in the colour of the preparation layer were attributed to the mid-16th century. Working chronologically from *c.*1525, paintings by Flemish artists working in Genoa demonstrated such changes: these preparations consisted of two layers of beige including orange, either as a direct result of preparation carried out in the region of Genoa or on supports brought in by the artists. Furthermore, the presence of foreign masters in Genoa with experience in using coloured grounds may have contributed to the spread of pigmented preparations among Genoese artists.

During the 16th century, important developments in painting affected the whole of Italy and such changes had repercussions on the use of supports, preparations and the constituents of paint. It is evident that innovations in painting techniques can be seen in the work of Luca Cambiaso (1527–1585). Cambiaso began his career working on panels utilising a white preparation, but by 1555, during the transition to canvas, his preparations became brown, progressing to red, with a very thin and 'dry' appearance. From this time, with a few exceptions, painters would use a textile support rather than a solid support. Within the same period, the Bergamasco, Giovanni Battista Castello (1509–1569), used a grey preparation, similar to that used by Bernardo Castello (1557–1629), who varied the colour of his local preparatory layers beneath areas of light and shadow.

From the 16th into the 17th century, artists in Genoa started to use a grey-white and/or reddish layer over the ground (an *imprimatura*) and some included calcium carbonate as opposed to the more common calcium sulphate used in Italy at this period. At the commencement of the 17th century, works by Bernardo Strozzi (1581–1644) demonstrate a particular brown-beige preparation sometimes formed by two separate layers. Elemental analysis indicated that the earth pigment used has a relatively low iron content compared to the proportion of magnesium, aluminium and silicon present, while manganese is completely absent, making it an ochre rather than an umber. This is in contrast to Venetian paintings which show a tendency towards a dark red preparation. Except for Strozzi, Genoese painters at this time used similar

ARTIST	TITLE (COLLECTION)	PREPARATION							*IMPRIMATURA* OR UNDERMODELLING							
		WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	BLACK
Anonimo Fiammingo	*Sacra Famiglia con San Giuseppe al lavoro* (Convento dei Frati Cappuccini di Portoria, Genova)															
Anonimo Fiammingo	*Sacra Famiglia con San Giuseppe al lavoro* (Museo Diocesano Genova)															
Giovanni Battista Castello il Bergamasco (1509–1569)	*Cattura di Cristo* (Palazzo Bianco, Genova)															
Giovanni Battista Castello il Bergamasco (?)	*Amore che disarma Venere* (Palazzo Belimbau, Genova)															
Lazzaro Calvi (1512–1587)	*San Martino e il povero* (Chiesa di Santa Maria della Cella e San Martino, Genova)															
Simone Dondo e Luca Cambiaso	*L'Ultima cena* (Nostra Signora degli Angeli, Voltri)															
Andrea Semino (1525–1595)	*Il Parnaso* (Museo di Palazzo Bianco, Genova)															
Luca Cambiaso (1527–1585)	*Santi Rocco, Sebastiano e Antonio Abate* (private)															
Luca Cambiaso	*Madonna col Bambino e la Maddalena* (Palazzo Bianco)															
Luca Cambiaso	*Venere con Amore sul mare* (private)															
Luca Cambiaso	*Adorazione dei Magi* (Pontremoli)															
Luca Cambiaso	*Maddalena penitente* (Coll. Doria Pamphilj, Roma)															
Luca Cambiaso	*santi Luca, Basilio, Agostino e Antonio Abate con Antonio Doria* (Palazzo Bianco, Genova)															
Luca Cambiaso	*Madonna con Bambino, Sant'Anna Meterza, Sat'Agostino e san Nicola da Tolentino* (Capitolo di S. Lorenzo, Genova)															
Luca Cambiaso	*Padre Tempo* (Palazzo Bianco, Genova)															
Luca Cambiaso	*Venere e Adone* (Museo di Palazzo Bianco, Genova)															
Luca Cambiaso	*Autoritratto con il ritratto del padre* (Palazzo Bianco, Genova)															
Luca Cambiaso	*La decollazione di San Giorgio* (Chiesa di San Giorgio, Genova)															
Luca Cambiaso	*Il martirio di San Giorgio alla ruota* (Chiesa di San Giorgio, Genova)															
Luca Cambiaso	*San Giorgio nel Calderone* (Chiesa di San Giorgio, Genova)															
Luca Cambiaso	*Orazione nell'orto* (Chiesa dei Santi Giacomoe Cristoforo di Craveggia, Verbania)															
Luca Cambiaso	*Cristo in gloria con la Vergine, san Giovanni Battista, gli Apostoli e Santi* (Palazzo Bianco, Genova)															
Allievo di Luca Cambiaso	*Venere vezzeggia Amore mentre un satiro gli sottrae le frecce* (Palazzo Belimbau, Genova)															
Allievo di Luca Cambiaso	*Angelo* (private)															
Giovanni Battista Paggi (1554–1627)	*Natività* (Santa Margherita Ligure, Genova)															
Giovanni Battista Paggi	*Natività* (Palazzo Bianco, Genova)															
Bernardo Castello (1557–1629)	*Deposizione della Croce* (Chiesa di Santa Maria e san Michele Arcangelo, Genova)															
Bernardo Castello	*Pala di San Bernardo* (Confr. San Bernardo, Santa Margherita Ligure, Genova)															
Bernardo Castello	*Sacra famiglia con san Giovannino* (private)															

ARTIST	TITLE (COLLECTION)	PREPARATION							*IMPRIMATURA* OR UNDERMODELLING							
		WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	BLACK
Bernardo Strozzi (1581–1644)	*Madonna del Rosario tra i Santi Rocca, Domenico e Sebastiano* (Chiesa di Santo Stefano Borzoli, Genova)															
Bernardo Strozzi	*San Giovanni di Capistrano* (private)															
Bernardo Strozzi	*Apparizione della Madonna Odigitria* (Chiesa di San Maurizio, Rapallo, Genova)															
Bernardo Strozzi	*S. Agostino lava i piedi a Cristo in sembiante di pellegrino* (Accademia Ligustica, Genova)															
Bernardo Strozzi	*San Francesco in meditazine* (Museum Boijmans van Beuningen, Rotterdam)															
Bernardo Strozzi	*Compianto Cristo Morto* (Accademia Ligustica, Genova)															
Bernardo Strozzi	*Santa Cecilia e i santi Valeriano e Tiburzio* (Galleria di Palazzo Bianco, Genova)															
Bernardo Strozzi	*Giuseppe spiega i sogni* (Coll. Pallavicino, Genova)															
Bernardo Strozzi	*Madonna con il Bambino e i santi Chiara, Ambrogio ed Erasmo* (Chiesa di Sant'Ambrogio, Voltri)															
Bernardo Strozzi	*Ritratto di Giacomo Raggi* (private)															
Bernardo Strozzi	*La Vergine porge il Bambino al Beato Felice da Cantalice* (Convento della Santissima Annunziata di Portoria, Genova)															
Bernardo Strozzi	*Madonna col Bambino, San Giovannino, San Lorenzo e angeli* (Chiesa dei Sordomuti, Genova)															
Bernardo Strozzi	*La Santissima Incarnazione* (Conservatorio Interiano, Genova)															
Bernardo Strozzi	*La cuoca* (Galleria di Palazzo Rosso, Genova)															
Bernardo Strozzi	*Il Pifferaio* (Galleria di Palazzo Rosso, Genova)															
Bernardo Strozzi	*Il Paradiso* (Accademia Ligustica, Genova)															
Bernardo Strozzi	*Ritrattto del vescovo Alvise Grimani* (National Gallery of Art, Washington DC)															
Bernardo Strozzi	*Ritratto di magistrato veneziano* (Coll. Pallavicino, Genova)															
Andrea Ansaldo (1584–1638)	*Ultima cena* (Accademia Ligustica, Genova)															
Andrea Ansaldo	*Annunciazione* (Chiesa di Sant'Ambrogio, Voltri)															
Andrea Ansaldo	*La Regina di Aragona osserva non vista San Vincenzo Ferrer* (Chiesa di Santa Maria di Castello, Genova)															
Andrea Ansaldo	*San Carlo Borromeo porta la croce tra gli appestati* (Chiesa dei Santi Nicolò ed Erasmo, Voltri)															
Andrea Ansaldo	*Trattenimento in un giardino d'Albaro* (Palazzo Bianco, Genova)															
Andrea Ansaldo	*Viatico di Santa Lucia* (Chiesa dei Santi Nicolò ed Erasmo, Voltri)															
Domenico Fiasella (1589–1669)	*Madonna con Bambino tra san Francesco e san Felice da Cantalice* (Chiesa delle Clarisse, Sarzana, La Spezia)															
Domenico Fiasella	*La Vergine con il Bambino e san Lazzaro* (Chiesa di san Lazzaro, Sarzana, La Spezia)															
Giovanni Andrea De Ferrari (1598-1669)	*Famiglia di Giacobbe* (Accademia Ligustica, Genova)															
Giovanni Andrea De Ferrari	*Madonna con i Santi Erasmo, Battista e Nicola da Bari* (private)															
Giovanni Andrea De Ferrari	*Madonna con Bambino, sant'Alberto e san Rocco* (Chiesa di san Colombano Loc. Costa)															
Giovanni Andrea De Ferrari	*I tre Vescovi* (private)															
Giovanni Battista Carlone (1603–1684)	*Adorazione dei pastori* (Par. di Santa Caterina, Bonassola, La Spezia)															

ARTIST	TITLE (COLLECTION)	PREPARATION							*IMPRIMATURA* OR UNDERMODELLING							
		WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	BLACK
Giovanni Battista Carlone	*Episodio della Gerusalemme liberata* (private)															
Giovanni Battista Carlone	*Profeta Ezechiele che resuscita i morti* (Oratorio di Santa Sabina, Genova)															
Giovanni Battista Carlone	*San Pietro di Alcantara in adorazione del Crocifisso* (Chiesa SS. Ann. Del Vastato, Genova)															
Giovanni Battista Carlone	*Decollazione del Battista* (Chiesa di San Giovanni Battista, Chiavari, Genova)															
Giovanni Battista Carlone	*Ritratto di uomo* (private)															
Orazio De Ferrari (1606–1657)	*San Francesco e l'Angelo* (private)															
Orazio De Ferrari	*Lactatio di San Bernardo* (Chiesa di San Bernardo, Carnoli, Genova)															
Orazio De Ferrari	*Consegna delle chiavi di san Pietro* (Chiesa di nostra Signora del Camrine, Lavagna, Genova)															
Orazio De Ferrari	*San Giovanni Battista* (private)															
Orazio De Ferrari	*Cristo che risuscita i morti* (Quimper, France)															
Giovanni Benedetto Castiglione il Grechetto (1609–1664)	*Lo zampognaro* (Museo di Palazzo Bianco, Genova)															
Giovanni Battista Castiglione il Grechetto	*Pastorale* (Museo di Palazzo Bianco, Genova)															
Antonio Travi (1609–1665)	*Matrimonio mistico di Santa Caterina* (Chiesa di S. Caterina martire, Sestri Ponente, Genova)															
Valerio Castello (1624–1659)	*San Giuseppe venduto dai fratelli* (private)															
Valerio Castello	*Putto con fiori* (private)															
Valerio Castello	*San Bernardo benedice due uomini* (A.S.P. Emanuele Brignole, Genova)															
Valerio Castello	*San Marco in trono con i santi Martino, Lorenzo, Giovanni Battista e Cecilia* (Chiesa ss. Giov. Batt. Giov. Bono, Recco)															
Valerio Castello	*Putti con cartiglio* (private)															
Valerio Castello	*Ratto di Proserpina* (Palazzo Reale, Genova)															
Domenico Piola (1627–1703)	*Putto* (private)															
Domenico Piola	*Madonna con S. Giovannino e altri Santi* (Basilica di N. S. delle Vigne, Genova)															
Seguace di Valerio Castello	*Agar e Ismaele confortati dall'angelo* (Palazzo Belimbau, Genova)															
Giovanni Battista Merano (1632–1698)	*Natività di san Giovanni* (N.S. Assunta, Sestri Ponente, Genova)															
Gian Lorenzo Bertolotto (1640–1721)	*Martirio Di San Giacomo* (private)															
Gian Lorenzo Bertolotto	*San Isidoro con Santi in adorazione della Trinità* (private)															
Nicolò Carlone (1644–1714)	*Visitazione di Santa Elisabetta* (Santuario di N. S. di Montallegro, Rapallo, Genova)															
Nicolò Carlone	*Madonna dei sette dolori* (Santuario di N. S. di Montallegro, Rapallo, Genova)															

ARTIST	TITLE (COLLECTION)	PREPARATION							*IMPRIMATURA* OR UNDERMODELLING							
		WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	WHITE	GREY	ORANGE	BROWN-RED	RED	LIGHT BROWN	DARK BROWN	BLACK
Gio Raffaele Badaracco (1648–1717)	*Il sonno di Endimione* (Palazzo Belimbau, Genova)															
Bartolomeo Guidobono (1654–1709)	*Annunciazione* (Santuario di N. S. della Misericordia, Savona)															
Anton Maria Piola (1654–1715)	*Immacolata Concezione* (Curia Arcivescovile di Genova)															
Anton Maria Piola	*Allegoria della passione di Cristo* (private)															
Anton Maria Piola	*Annuncazione* (private)															
Gregorio De Ferrari (1657–1726)	*Sant'Antonio da Padova* (private)															
Gregorio De Ferrari	*Allegoria della speranza* (private)															
Gio Enrico Vaymer (1665–1738)	*Ritratto di bambina Bianca* (private)															
Gio Enrico Vaymer	*Ritratto di Giulia Centurione* (Villa Durazzo, Santa Margherita Ligure, Genova)															
Gio Enrico Vaymer	*Ritratto di Carlo Centurione* (Villa Durazzo, Santa Margherita Ligure, Genova)															
Gio Enrico Vaymer	*Ritratto di prelato* (private)															
Gio Enrico Vaymer	*Ritratto di Francesca Spinola* (Villa Durazzo, Santa Margherita Ligure, Genova)															
Paolo Gerolamo Piola (1666–1724)	*Incoronazione della Veronica* (Dep. Museo Diocesano, Genova)															
Alessandro Magnasco (1667–1749)	*Negromante* (private)															
Alessandro Magnasco	*Trattenimento in un giardino d'Albaro* (Museo di Palazzo Bianco, Genova)															
Carlo Antonio Tavella (1668–1738)	*Paesaggio con figure e fontana* (private)															
Carlo Antonio Tavella	*Paesaggio con figure e pesci* (private)															
Carlo Antonio Tavella	*San Giovanni Battista* (private)															
Carlo Antonio Tavella	*Paesaggio* (Museo di Palazzo Bianco, Genova)															

preparations of dark brown and reddish-brown, utilising earth pigments, lead white, carbon black and in some cases, calcium sulphate. Elemental analysis has shown that calcium carbonate was present in some works by specific Genoese painters, revealing that the influence of Flemish practice continued, both in terms of style and materials. At the turn of the century, Gio Enrico Vaymer (1665–1738) alternated between beige preparations comprised of earth pigments, lead white, chalk or calcium carbonate, and almost black preparations composed of earth pigments and madder lake.

Conclusions

From the second half of the 16th century, Genoese painters used a variety of coloured preparations without a clear trend emerging: each artist independently varied the shades and stratigraphy of the preparatory layers, a practice that continued into the 17th century.

Acknowledgements

I extend special thanks to Prof. Maria Clelia Galassi for prompting me to research new areas. I would also like to thank Prof. Paolo Bensi for the material supplied; Prof. Silvia Vicini for allowing me to access the archives at the Department of Chemistry, University of Genoa; Prof. Laura Magnani and Prof. Daniele Sanguineti for helping me to date and attribute some works; and Camillo Manzitti and Anna Manzitti.

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DISCOVERING PATTERNS IN GIROLAMO TROPPA'S GROUNDS

Loa Ludvigsen, David Buti, Anna Vila and Eva de la Fuente Pedersen

ABSTRACT As so little is known of the Italian baroque painter Girolamo Troppa, especially his painting technique and materials, this paper provides a thorough investigation into his use of grounds. The Statens Museum for Kunst, Copenhagen, holds a collection of eight paintings by Troppa, lending room for comparisons. All the paintings have been subject to both in-depth material analysis and overall technical investigations. The results show a clear pattern in the artist's use of double grounds, comprising the same build-up and raw materials, as well as a recurring and continuous use of exposed ground as a middle tone. A consideration of the 17th-century Roman art market provides an understanding of Troppa's practice. He was an artist with a large output, working on commissions both from wealthy patrons and churches, as well as producing a large number of genre paintings to be sold by the art dealer Pellegrino Peri. Comparisons with two other paintings signed/attributed by/to Troppa (belonging to the Nationalmuseum of Sweden and the Church of Santa Maria Novella in Bracciano), have made it possible to increase the number of case studies, which supports the presence of patterns in his technique. These patterns might be used as a marker for Troppa's specific workshop.

Introduction

The focus of this paper are eight easel paintings by the Italian baroque painter Girolamo Troppa (born 1637, died after 1710) in the Statens Museum for Kunst (SMK) collection: a group of *Philosophers*, namely *St John the Baptist*, *St Peter Penitent*, *Homer* and *Virgil* (Fig. 1); *The Penitent St Mary Magdalene* and *The Dream of Jacob* (Fig. 2); and two pendants with representations of *Mercury Killing Argus* and *Apollo Flaying Marsyas* (Fig. 3). The eight SMK paintings play a crucial role in understanding Troppa's oeuvre, since four are signed and six are known to have been bought in Rome as early as 1669.[1] Little is known about the artist's painting technique and even less about his materials. This paper aims not only to uncover his painting technique and his use of preparatory layers, but also to present all available information on the paintings from contemporary sources, to better understand Troppa as an artist working in a highly competitive art market.

Fig. 1 1 Girolamo Troppa, (a) *St John the Baptist*, signed on the red cross, oil on canvas, 98 × 73 cm, (b) *St Peter Penitent*, oil on canvas 98 × 72.5cm, (c) *Homer*, signed on the book, oil on canvas, 98 x 72 cm, (d) *Virgil*, signed on the book, oil on canvas, 98 x 73 cm, Statens Museum for Kunst, Copenhagen, inv. nos. KMSst141, KMSst155, KMSst139 and KMSst153. (Photos: Jakob Skou-Hansen/SMK.)

Fig. 2 Girolamo Troppa, (a) *The Penitent St Mary Magdalene*, oil on canvas, 64 × 48 cm, and (b) *The Dream of Jacob*, oil on canvas, 73 × 60.5 cm, Statens Museum for Kunst, Copenhagen, inv. nos. KMSsp120 and KMSst310. (Photos: Jakob Skou-Hansen/SMK.)

Fig. 3 Girolamo Troppa, (a) *Mercury Killing Argus*, signed on the rock, oil on canvas, 96 × 132 cm, and (b) *Apollo Flaying Marsyas*, oil on canvas, 96 × 132 cm, Statens Museum for Kunst, Copenhagen, inv. nos. KMSsp122 and KMSsp123. (Photos: Jakob Skou-Hansen/SMK.)

Provenance and acquisition of Troppa's paintings for the royal Danish collections

The Norwegian-born architect and painter Lambert van Haven (1630–1695) was sent on a Grand Tour and collecting expedition to Italy by the Danish king, Frederik III (ruled 1648–1670).[2] Van Haven acquired not only paintings, but also books for the king's library, as well as rare objects and mathematical instruments for the royal collections (*Kunstkammer*). Starting out from Copenhagen on 29 September 1668, he reached Rome (via Venice, Bologna and Florence), where he resided from 6 April 1669 to 15 June 1670. While in Rome, Van Haven acquired many paintings, including six works by Troppa: four half-figure paintings larger than life now identified as *St John the Baptist*, *St Peter Penitent*, *Homer* and *Virgil*, and a bust-length depiction of *The Penitent St Mary Magdalene* and *The Dream of Jacob*.

A series depicting four men is mentioned in a single entry in Van Haven's travel accounts (Fig. 4) and has been discussed elsewhere:[3] '4 *støcser aff gamble Philosopher, giort aff Girolamo Troppi* – a: 15 *scudi* – er 60 *scudi* (4 pieces of ancient philosophers, done by Girolamo Troppi – each: 15 *scudi*– total 60 *scudi*)'. He also identified the subject of Jacob: '*1 støche S. Jacobs drøm aff Do. Troppi . 24 scudi* (1 piece S.

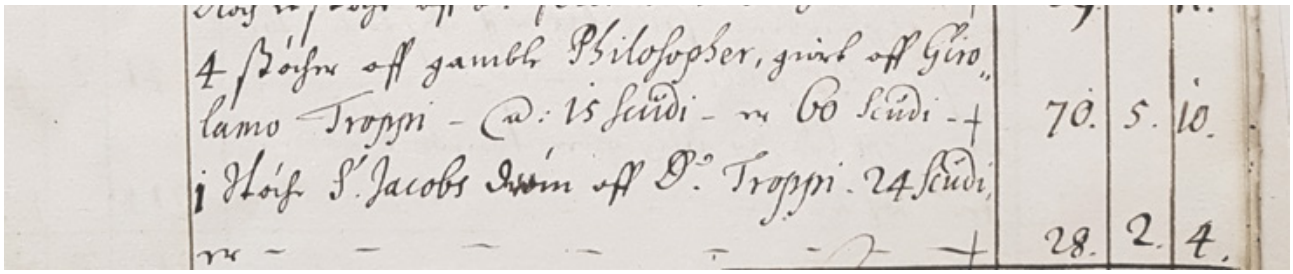

Fig. 4 Relevant entry in Van Haven's travel accounts, Danish National Archives, Copenhagen. (Photo: Eva de la Fuente Pedersen.)

Jacobs Dream, by Do. Troppi. 24 *scudi*)'. Thus far, no information on how or where he purchased these six paintings has been found. Since Troppa was active in Rome at that time, Van Haven could have bought them directly from the artist or from Roman art dealers.[4]

A hundred years later, two additional Troppa paintings were purchased for the royal Danish collections in the time of King Frederik V (ruled 1746–1766), who in 1763 sent his art expert and keeper of the royal *Kunstkammer*, Gerhard Morell, to Amsterdam. Morell returned with many paintings, among them *Mercury Killing Argus* and *Apollo Flaying Marsyas* (referred to as Apollo/Mercury pendants) bought at an auction.[5] It is known that these pendant pieces were auctioned in Amsterdam as early as 1699 and 1707.[6]

Troppa's life and work

No contemporary biography exists for Troppa: the first biographical and archival records were published by Antonino Bertolotti as late as 1885.[7] Giancarlo Sestieri published further biographical information and a list of documented and known works in 1994.[8] Recently, more biographical information has been published by scholars including Erich Schleier, Zsuzsanna Dobos and Francesco Petruzzi, while Richard Spear and Philip Sohm have made important contributions to the construction of an oeuvre.[9]

Knowledge about Troppa's life can be written in very few words. He was born in 1637 in the small village of Rocchette near Rieti in the Sabine Hills of Lazio in Italy. In 1656, the 19-year-old painter lived in Rome where he also died at an unknown date, but after 1710. A census dated 1656 reveals that Troppa lived in Campo Mazio, a Roman neighbourhood popular with many artists: it classified Troppa's household as 'poor'. At the time, all artists' households were registered as either 'poor' (65%) or 'comfortable' (28%). This was a broad classification: at this time 'poor' meant someone who did not own property but instead lived off an income.[10] In addition, in 1656 Troppa is known to have married Elisabetta de Stefani, in 1657 their daughter Giovanna was baptised, and in 1661 their son Pietro was born. In 1664 Troppa was admitted to the Accademia di San Luca and in 1666 he hired an assistant.

There is no precise information on Troppa's training, but the style of the works from the 1660s suggests that he was part of a circle around Pier Francesco Mola (1612–1666). All eight SMK paintings date to this early period.[11] Moreover, his technique borrows from Guido Reni (1575–1642) in the swiftness of execution, hatched paint strokes for the flesh tones and use of a stiff bristle brush for painting hair and beards. By 1686 at the latest, he was awarded a knighthood, indicating that he was well regarded in his time. However, like many other artists, he has vanished into obscurity today.[12]

Troppa was a very productive artist throughout his entire career, and many of his commissions took him around Lazio as well as to Umbria, Ferrara and elsewhere. He worked as a fresco painter, an easel painter and draughtsman, with churches and patrician families as his principal patrons. It is known, for instance, that Troppa was commissioned to paint a ceiling mural with an Ovidian story of Flora and Zephyr for Cardinal Chigi at his Roman residence Palazzo Odescalchi in 1668, the same year he painted two religious compositions for the Church of Saint Joseph (San Giuseppe) in Ferrara.[13]

Technique and the role of the ground in Troppa's paintings

All the examined Troppa paintings have a dark brown ground. By the start of the 17th century, commercial primers sold pre-primed canvases. The cost of primed canvas and stretchers in Rome in the 17th century was minimal, although naturally it depended on size and quality.[14] The ground was often a single layer but double layers are also seen at this time.[15] In many instances, the use of a double ground can be a pragmatic and economical solution to modify a pre-prepared canvas to the artist's wishes; this is supported by a recipe from De Mayerne, who suggested the use of a thicker layer of ochre for the lower layer to create a smooth surface upon which a thinner top layer of the desired and more expensive pigments could be applied in order to reduce the cost.[16] Studies of both contemporary sources and examination of contemporary paintings reveal that brown and red grounds were commonplace in Rome in the 17th century.[17] Although it suited the *chiaroscuro* style, it also provided a reason for art critics' contemporary debates of *colore vs designo*. It is speculated that the predominant use of this type of ground was founded on economy because the artist, having mastered the technique, could accomplish a dramatic effect with seemingly little effort.[18] The *alla prima* technique is well suited to large-scale production, and Troppa in fact boasted of his speedy painting technique on the back

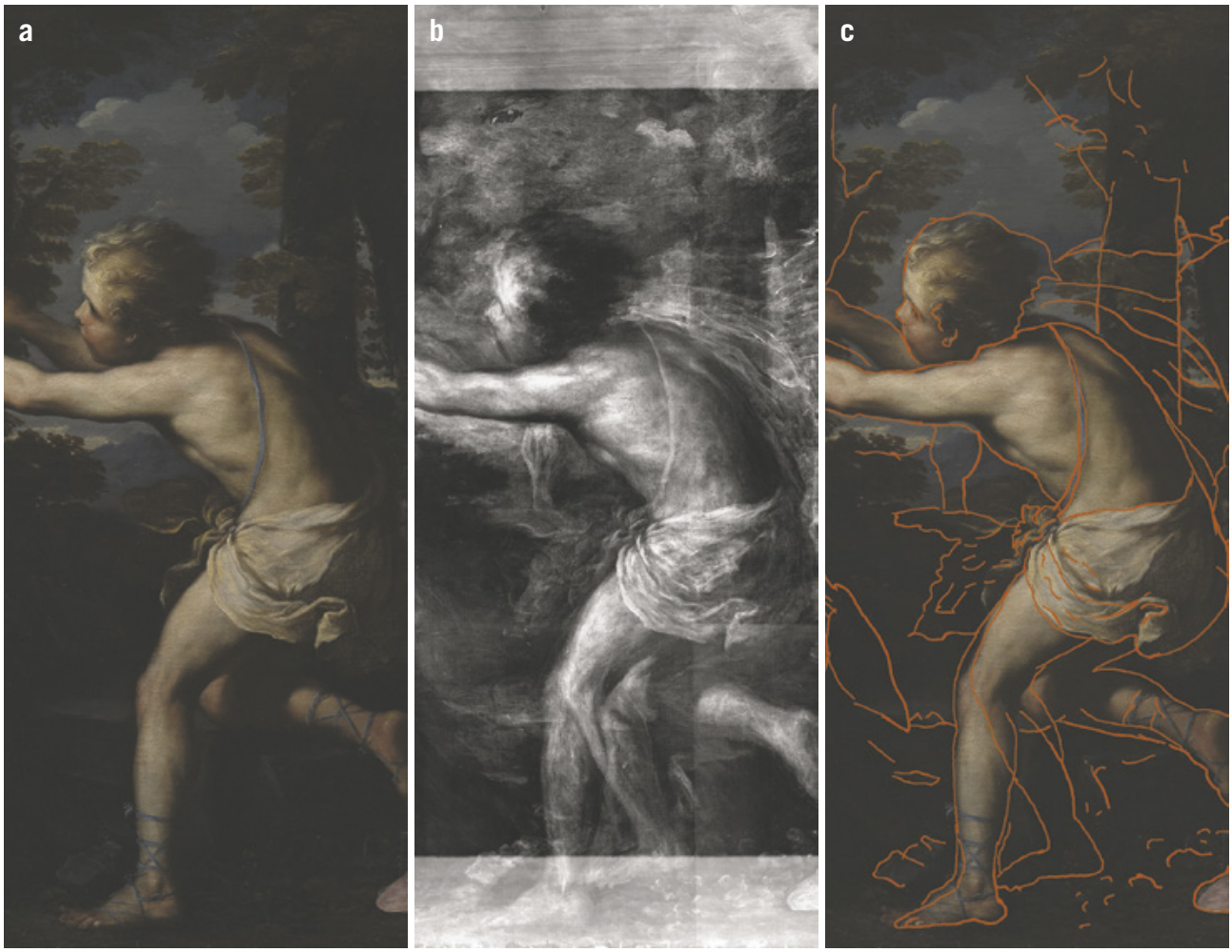

Fig. 5 Detail of Girolamo Troppa, *Apollo Flaying Marsyas* (Fig. 3b), (a) visible light, (b) X-radiograph showing the altered positions for Apollo's foot and a piece of fabric draped over his back and shoulder, and (c) tracing of the X-radiograph overlaid on (a). (Photos: Jakob Skou-Hansen; Troels Filtenborg and Jakob Skou-Hansen; Loa Ludvigsen/SMK.)

of the painting *Saint Jerome in the Wilderness*, by writing 'OPERA D.UN GIORNO DEL CAVALIER TROPPA (made in one day by the gentleman Troppa)'.[19]

Troppa's *Philosopher* series (Fig. 1) consists of four half-length paintings of emotionally agitated men, stirred by the forces of creative imagination or religious fervour. In his portrayal of the two poets, Troppa appears to have observed a commonplace iconography for the depictions of poet-philosophers, whose written basis may be Horace's statements concerning the appearance of genius. All four paintings are nocturnal scenes, the sky dramatically painted in dark blue, contrasting with the frontally illuminated figures in voluminous colourful robes. The palette is harmonious, created from a limited range of pigments used to build up corresponding saturation and tonal intensity by defining space with *chiaroscuro*. The ground plays a key optical role in Troppa's painting technique for these four paintings, slightly shining through the dark blue sky and setting their tone. The cooler tones on top of the dark ground also enhance the sensation of an optical blue in the sky.[20] The hair and beards are painted vividly with a broad stiff brush over the partly exposed ground, using it as the middle tone. Flesh tones are executed with clearly visible rapid brushstrokes with only slight impasto in the highlights. The execution of the paintings of the four 'philosophers' bear all the marks of a skilful *alla prima* technique. The paintings show no signs of *pentimenti*: X-radiographs reveal minimal application of paint to create these intense and expressive paintings. They were completed swiftly as if the artist had painted the compositions many times before.[21]

The half-length figure painting of *The Penitent St Mary Magdalene* bears a great likeness to Guido Reni's popular depictions of the same subject from the 1620–30s. On an almost monochrome background, a haloed repentant saint is looking upwards while holding her right hand to her chest, which is covered by her long blonde hair.[22] The figure stands out from the background by virtue of a light grey contour around the head, eliminating the tone of the ground otherwise shining through the thinly applied green-grey colour. In contrast to the technique used in the *Philosopher* series, Troppa blended the brushstrokes in the fair skin of the Magdalene, creating form with subtle *chiaroscuro*: only the highlights, the tears and the hair evidence Troppa's rapid working touches applied with a stiff brush. The ground also plays its part as a middle tone in the hair and cloak. Her left shoulder is placed in the shadow, covered only by light touches of hair. Unlike the *Philosophers* series, in which no changes of positions for

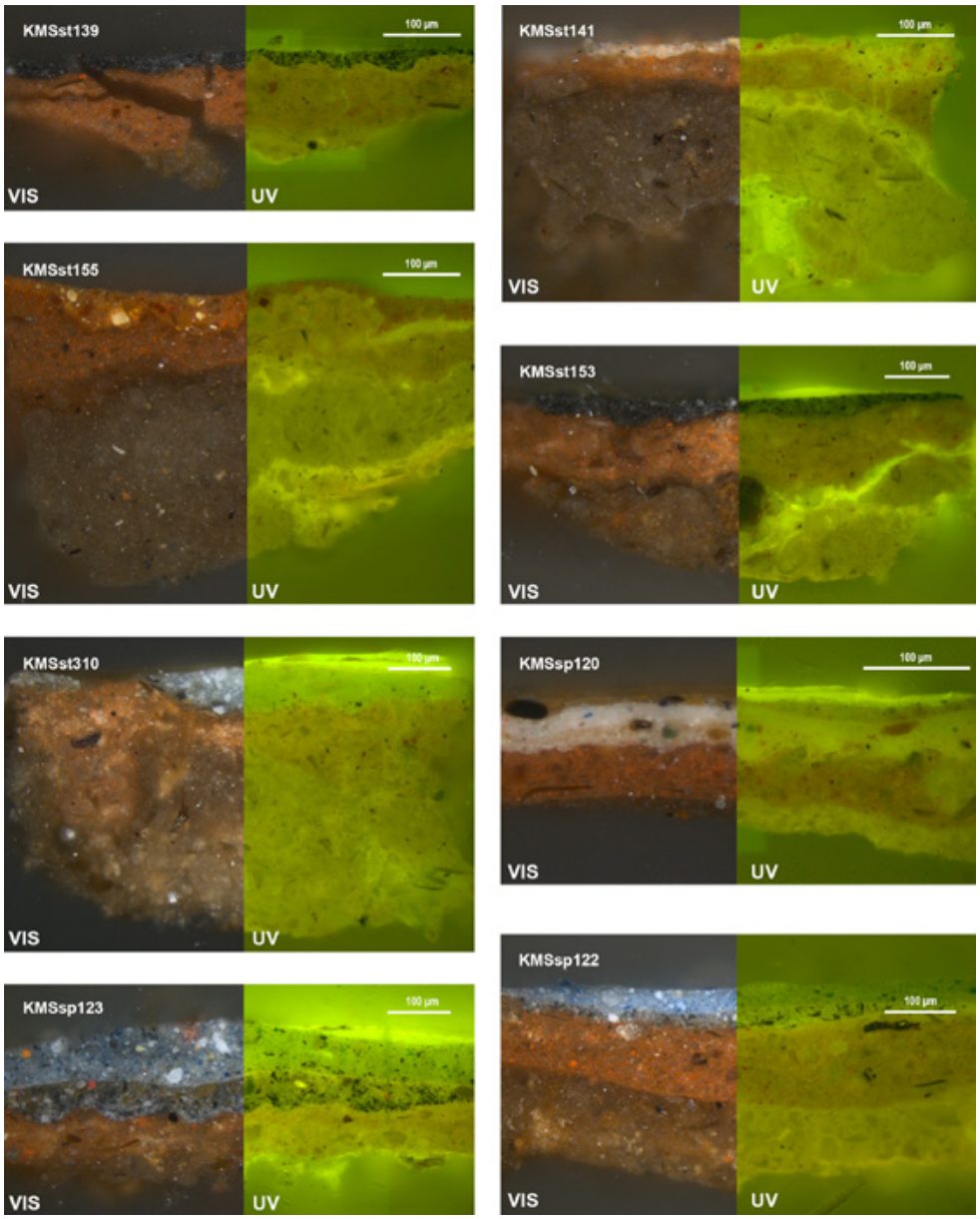

Fig. 6 Cross-sections including the ground layers for all eight paintings, labelled by the SMK inventory number as given in Figs 1–3, in visible (VIS) and ultraviolet (UV) light.

the figures can be seen, the Magdalene's gaze has shifted somewhat according to the X-radiograph. Troppa was probably less familiar with this motif than with the poses for the *Philosophers*, and had to develop it more.

The literary sources for the two mythological paintings, *Mercury Killing Argus* and *Apollo Flaying Marsyas* (Fig. 3), are Ovid's *Metamorphoses*. Both tales concern not only the jealousy of the gods and hubris, but also music as an art form and music's power to affect an audience. The *Apollo/Mercury* pendants are painted in a more elaborate manner than the *Philosopher* series, in accordance with the high style expected for history painting. The creative process included preparatory drawings.[23] Schleier drew attention to four preparatory studies now in the Kupferstichkabinett, Berlin, two of which are for the *Apollo/Mercury* pendants at SMK.[24] According to Schleier, the style of drawing is from Troppa's early years when Mola's influence was still perceptible. Both paintings exhibit *pentimenti* and reworking, especially in the figures, which can be observed in the X-radiograph (Fig. 5).

The transition of the composition from the drawings to the paintings also introduced several compositional changes. Although the overall design is similar, the *Apollo* figure shows significant changes while the composition in *Mercury Killing Argus* is partly inverted: Mercury's left leg is bent, but most importantly, he is seen from behind in the finished painting as opposed to from the side in the sketch. The X-radiograph shows that the current positioning of Mercury is unaltered, so we must assume that there were intermediate preparatory steps between the drawing and the finished painting.[25] The same applies to *Apollo Flaying Marsyas*: the most prominent discrepancy between the Berlin drawing and the finished painting is the placement of the figures. Marsyas is turned away from Apollo, his hands tied in the upper left corner of the painting, but he is turned to the right in the drawing.

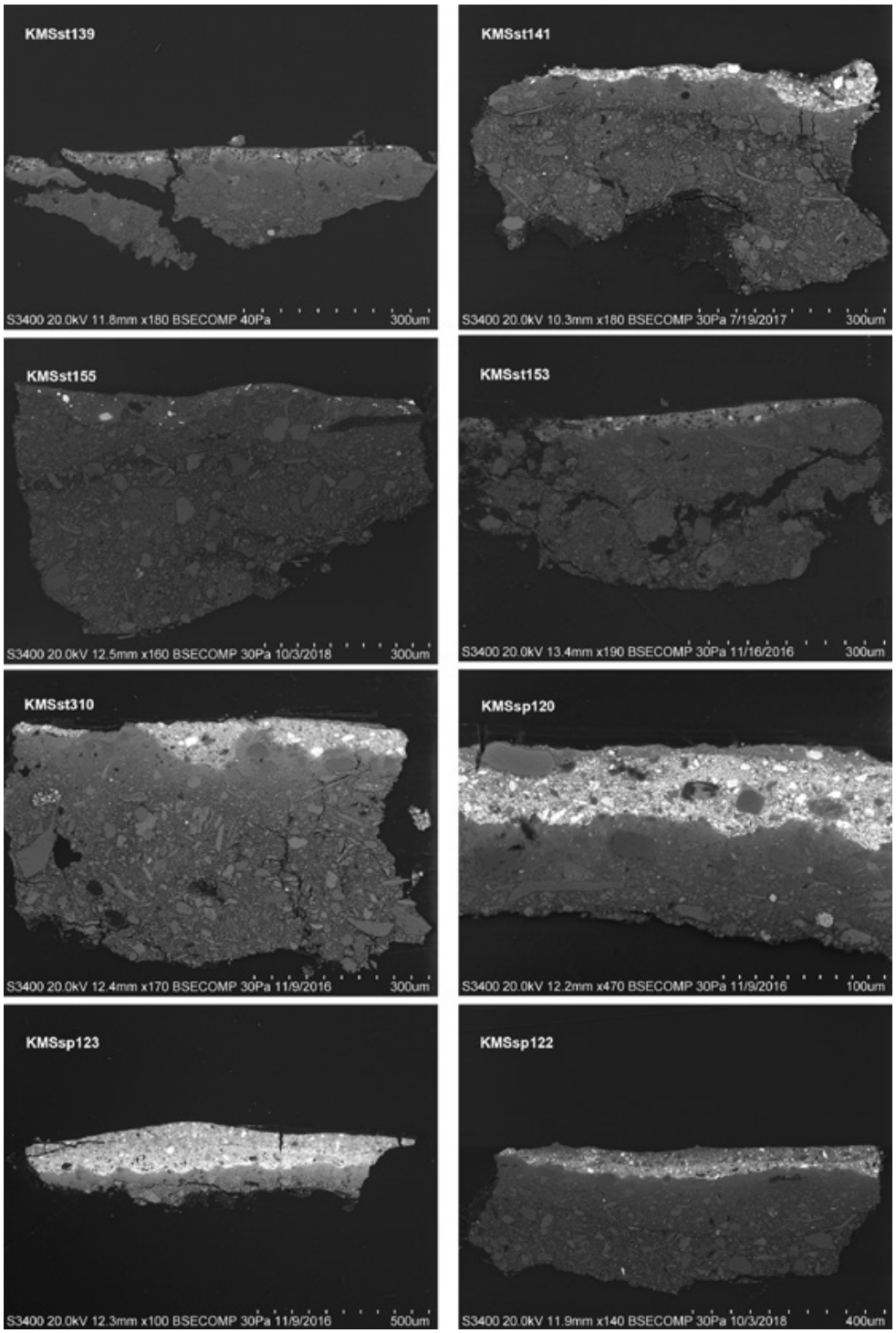

Fig. 7 SEM-BSE images of the cross-sections shown in Fig. 6.

The X-radiograph shows no changes in the Marsyas figure, whereas Apollo's left leg has altered, which occurred late in the painting process. X-radiography also reveals garments over the shoulders of both figures, replicating the drawing but eliminated in the painting. Crude brushstrokes, seen in the X-radiograph, indicate the cloth falling over the right shoulders of both figures. The clothing on Apollo's upper body is billowing in the wind. To the naked eye, traces of bright red colour are still visible around the figure of Apollo. The garments around the hips originally had more fabric, as drawn in the sketch, but this was painted out. Most notable is the use of a brown colour for the modelling of shade on the body of the sleeping Argus. Uncharacteristically, it was applied on the fully painted chest and around the right elbow, adding additional shadow from the attacking Mercury, perhaps revealing that the design was less carefully thought out and not previously replicated. Overall, the paintings evidence distinctive use of the visible ground colour for the *chiaroscuro*. The faces, hair and beard were painted as described above with a stiff bristle brush over partly exposed ground. Flesh tones reveal clearly visible brushstrokes. The foreground rocks and vegetation were painted swiftly, with a minimum blending of

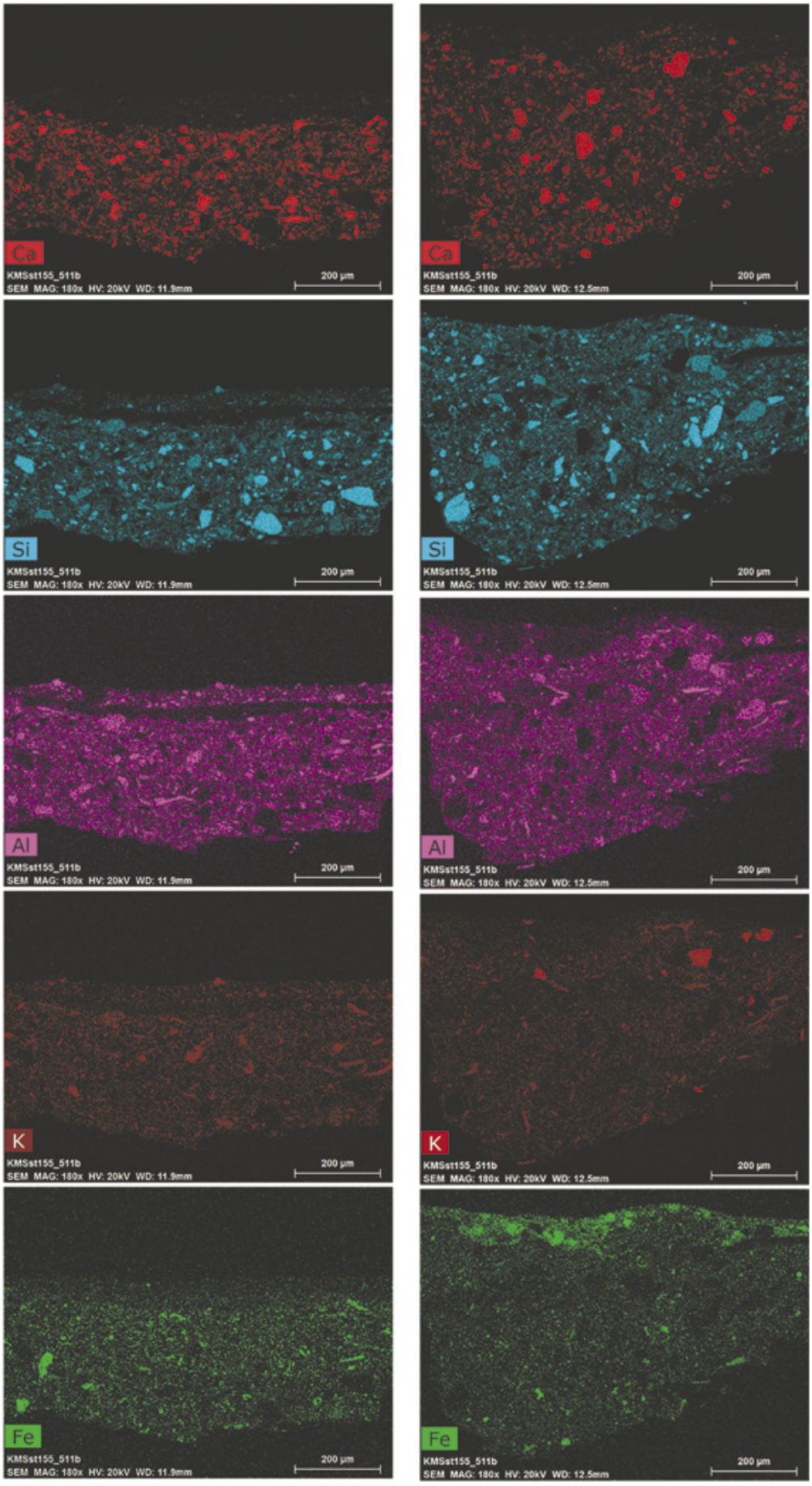

Fig. 8 EDX maps of the elemental distribution of calcium (Ca, red), silicon (Si, cyan), aluminium (Al, magenta), potassium (K, brown), and iron (Fe, green) in two cross-sections representative of the grounds for *Mercury Killing Argus* and *St Peter Penitent*. All the elements and hence the pigment particles are distributed homogeneously.

colours. The form was built up by accurate, rapidly applied colours worked from the darks to the highlights, which were added with a stiff, dry brush. The details of plants are more roughly executed compared to works by other artists such as Mola, who blended his brushstrokes and added more detail to flowers and shrubbery. The same applies to the treatment of flesh tones: Troppa used hatching and distinct brushwork as opposed to the blending seen in Mola's paintings.

The literary source for Troppa's sketchily painted *Dream of Jacob* is biblical (Genesis 28:10–22). Troppa's composition interprets the story by utilising powerful visual imagery and an arresting use of colour, light and darkness with the intention of making the story clear and easily understandable for the viewer. Jacob's vision of angels ascending and descending is painted in bright, saturated colours including white, blue and black opposed with yellow, orange-red and green. In contrast to this luminous vision, the earthly lower part of the composition depicts the sleeping Jacob almost hidden in the night's sombre darkness. *The Dream of Jacob* has a very different style compared to the other seven paintings. The colour of the ground plays a central role for the many angels in the middle ground, which are suggested only by a few light brushstrokes. The carefully planned design enabled the figures to be painted in reserves.

Analysis of Troppa's ground layers

Paint samples were taken from all the paintings and prepared as cross-sections[26] to study the stratigraphy and analyse the layers using scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis,[27] Fourier transform infrared (FTIR) spectroscopy,[28] and Raman spectroscopy.[29] The eight paintings have a similar stratigraphy with a double-layered ground structure (Fig. 6). Despite a slight variation in hue among the samples, the cross-sections show that the lower layer (labelled *ground I*) always looks more brownish in colour with a semi-transparent appearance, while the upper layer (labelled *ground II*) has a more orange-reddish and opaque appearance. A difference can be seen in the ultraviolet (UV) images: *ground I* has a yellowish fluorescence compared to *ground II*, which has a more pinkish fluorescence (Fig. 6). Furthermore, in UV light a consistent difference in morphology between the two ground layers is also visible: the bottom layer is more coarsely grained with some larger particles, while the upper layer contains finer particles.[30] Both grounds are likely oil-based (*vide infra*) and the different appearance in UV might also indicate the use of different oils, differences in oil preparation, ageing of the oil before it was used, the quantity of added driers in the two layers or a different pigment/binder ratio. The grounds are fairly thinly applied, albeit applied more thickly than the paint layers, and the most that can be said about the relative thickness of the two ground layers is that they are comparable.

Apollo Flaying Marsyas, which has a single ground layer (Fig. 6), seems to be the only exception to the double-layered ground structure. But compared to the other paintings, where

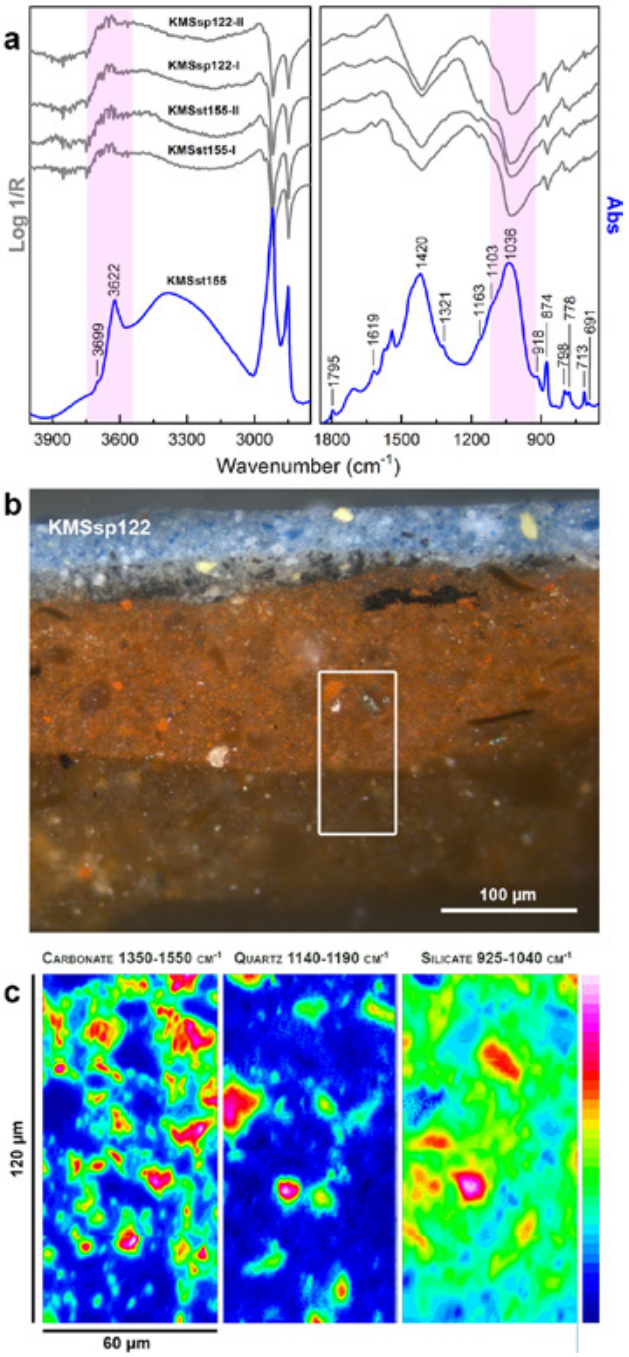

Fig. 9 (a) Reflection FTIR spectra from cross-sections representative of the ground structures in *Mercury Killing Argus* and *St Peter Penitent*, compared with the transmission spectrum of a paint fragment from the latter, showing measurements carried out on *ground I* and *II*. The pink rectangles indicate the features possibly ascribable to illite. (b) Detail of a cross-section showing the ground structure in VIS for *Mercury Killing Argus*. The white rectangle indicates the area mapped by ATR. (c) ATR maps for calcium carbonate, silicates (possibly illite) and quartz in the ground structure, indicating that the three compounds are distributed homogeneously.

the availability of several samples confirms the overall double-layer structure, only one sample was collected and it is plausible, taking into account the otherwise consistent structure of Troppa's grounds, that the sampling in this specific case did not include the bottom layer.

Compared to the visible light and UV images, the SEM backscattered electron (BSE) images (Fig. 7) do not illustrate

the presence of two ground layers so distinctly. Regarding particle size and morphology, the dissimilarity between *ground I* and *II*, as described for the UV images, is even more pronounced in almost all the BSE images of the cross-sections. In *Mercury Killing Argus* in particular, the lower layer clearly has a higher proportion of coarse grains compared with the upper layer, which seems more compact, containing finer-grained pigments. However, it should be stated that this distinction is very clear in cross-sections from *Mercury Killing Argus*, *St John the Baptist* and *The Dream of Jacob* but less so in samples from the other paintings.

Regarding the elemental composition of the ground structure (Fig. 8), silicon, aluminium and calcium are present in high amounts, together with relatively low amounts of potassium, iron, magnesium, lead, sulphur, titanium and sodium across the complete stratigraphy of the grounds in all the cross-sections. Trace amounts of titanium are often found associated with iron-based minerals in natural earth pigments.[31] The EDX results imply that the elemental composition of *ground I* and *II* is largely similar and, even more significant, it is identical in all the eight paintings apart from small differences in the relative amount of some of the minor elements. The elemental mapping gives a better idea of the homogeneity of the composition of the ground layers. Fig. 9 shows EDX maps of Ca, Si, Al, K and Fe for *Mercury Killing Argus* and *St Peter Penitent*. All the elements are equally distributed in the two ground layers without an evident separation.

Reflection FTIR identified calcium carbonate, silicates and quartz, indistinguishable between *ground I* and *II* in all the samples (Fig. 9a, upper spectra in grey). Calcium oxalates occasionally detected in *ground I* and *II* are possibly due to degradation phenomena of the organic binder. The band for Si-O stretching, indicating the presence of silicates, is not structured and therefore does not assist in the identification of a specific compound. Furthermore, quartz also absorbs in the same spectral region, making identification of a silicate even more difficult. Finally, considering that Si and Al are the major elements present in the grounds, sometimes correlated with other elements such as Na or K, it is reasonable to expect the occurrence of more than one type of aluminosilicate or the presence of other compounds such as feldspar and/or mica. The shape of the O-H stretching bands at higher wavenumbers seems more 'structured' and therefore more useful for the molecular identification. It is worth noting that in this region, the FTIR reflection profiles of the spectra collected on *ground I* and *II* are similar, indicative of the possible presence of the same compounds (Fig. 9a). This similarity occurs in all the paintings by Troppa in this study. During conservation treatment the opportunity to collect a sample of the ground that had penetrated through the canvas weave to the reverse of *St Peter Penitent* enabled identification of the main silicate compound responsible for the FTIR profile in the O-H stretching region. The FTIR spectrum[32] (Fig. 9a, blue line) is characterised by the signals for quartz (691, 778, 798, 1103 (sharp) and 1163 (sharp) cm^{-1}),[33] calcium carbonate (713, 874, 1420 and 1795 cm^{-1})[34] and calcium oxalates (1321 and 1619 cm^{-1}).[35] The silicates' spectral features at 918, 1036, 3622 and 3699 cm^{-1} (indicated by the pink highlights in Fig. 9a) can be attributed to the clay mineral illite.[36]

ATR-FTIR maps (Fig. 9b and c) confirm what was already observed using EDX. The map of the antisymmetric stretching band of $CO_3^=$ of calcium carbonate at *c.*1500 cm^{-1}, of the Si-O stretching band of illite at *c.*1000 cm^{-1} (integrated excluding the contribution of quartz) and of the Si-O stretching band of quartz at 1160 cm^{-1} can be seen in Fig. 9c. The three mapped compounds are not distinctly different in the two ground layers. With respect to the organic component, the presence in both ground layers of the carbonyl band at *c.*1730 cm^{-1} together with the CH signals at *c.*2855 and 2925 cm^{-1} could indicate the use of a lipid-containing binding medium such as oil. However, as the paintings have been subjected to conservation treatments in the past, such as lining, information on the organic components now present may not relate only to the original binding media.

Finally, Raman spectroscopy indicated the sporadic presence of a carbon-based black pigment as one of the components of Troppa's grounds (with no distinction between the upper and lower layers) together with the presence of hematite (Fe_2O_3), always occurring only in *ground II* (bands of carbon-based black pigment at *c.*1325 and 1590 cm^{-1}, hematite bands at *c.*253, 232 and 343 cm^{-1}; data not shown).[37] This finding is of paramount relevance since hematite, a component shared by *ground II* in all Troppa's paintings, is so far the only marker distinguishing the two ground layers from one another. It is worth mentioning that the presence of hematite in the top ground layer – probably used to give a deeper orange-reddish hue to *ground II*, the layer closest to the paint layers – does not affect the overall average distribution of Fe in the EDX maps. As already pointed out, there is no distinction between *ground I* and *ground II* from the elemental point of view.

The analytical results collected so far lead us to hypothesise that the same compound (a brown earth pigment containing calcium carbonate, quartz, iron oxides, illite and other silicates) was used for both ground layers, but with the further addition of red hematite to give the desired orange-reddish colour only to the top ground layer. Furthermore, the results indicate that the earth pigments could have undergone different grinding processes before their application in two different layers. This is very similar to the description by the English diarist Richard Symonds recorded in his notebook from Rome in 1650; apart from providing information on prices and dimensions of the pre-primed canvases, he also wrote about materials. He described the use of two ground layers, the lower being less finely ground.[38]

Comparative studies of paintings by or attributed to Troppa

The visual characteristics and composition of the SMK paintings are in accordance with the results reported in the only published study of the ground composition of another painting by Troppa.[39] This painting, signed on the reverse, is a large altarpiece of *St Thomas of Villanova* produced for the Church of Santa Maria Novella in Bracciano outside Rome,[40] dated

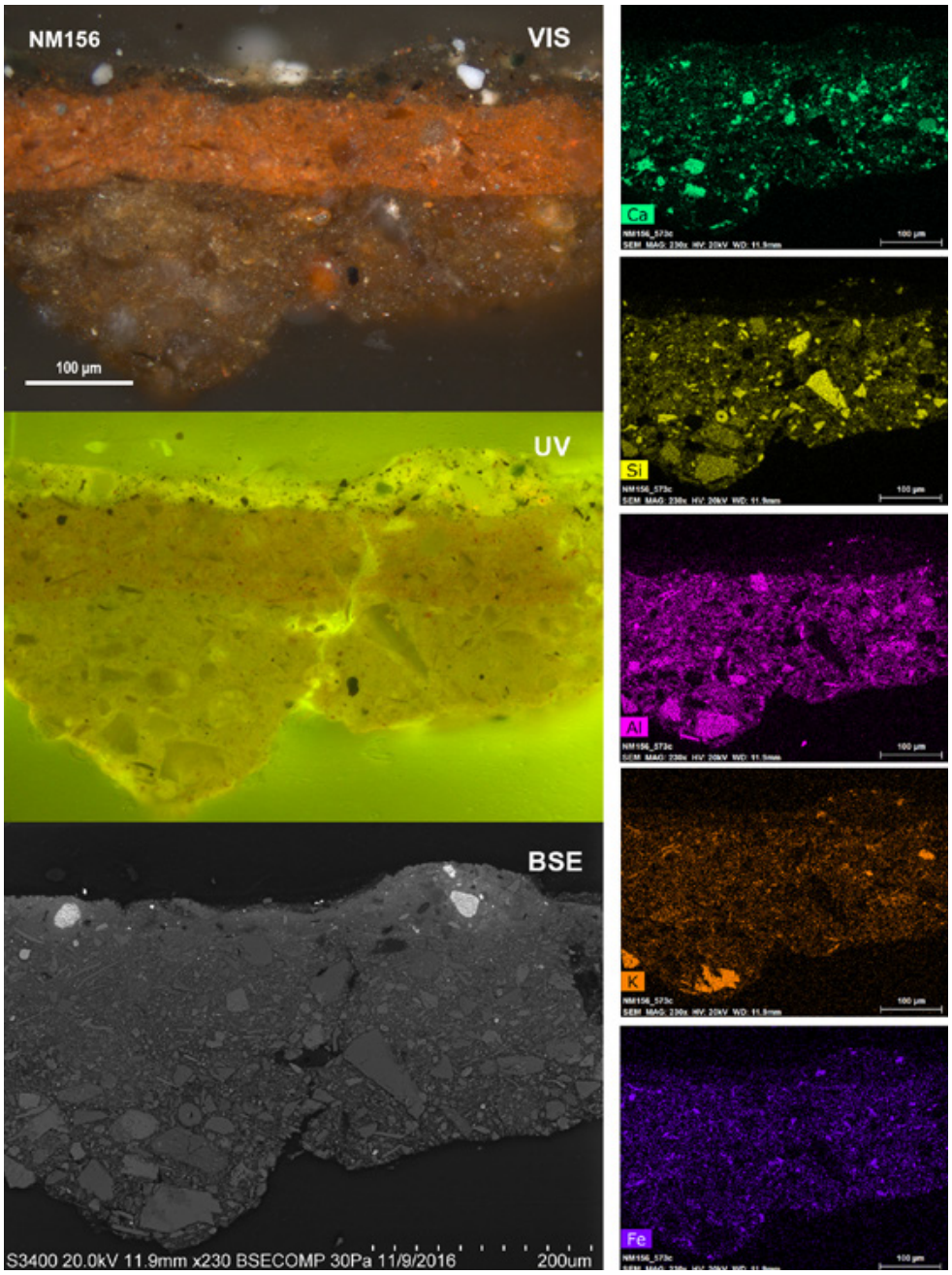

Fig. 10 Cross-section of Girolamo Troppa (attributed to), *Shepherd Playing the Pipe*, Nationalmuseum, Stockholm, inv. no. NM156. Left column: VIS, UV and SEM-BSE. Right column: elemental maps for Ca, Si, Al, K and Fe.

1658–68.[41] The image and description of the cross-section in the aforementioned publication clearly show a double ground structure as seen in the SMK paintings, while the optical microscopy and EDX results indicate that the lower brownish layer contains calcium carbonate, aluminosilicates, quartz and iron-based compounds, the latter reported in that publication as '*caput mortuum* and earth pigments'.[42] The reddish upper layer had a similar composition, with analysis indicating a higher amount of red iron-based particles, plausibly hematite, although not specifically identified as such by these authors. Therefore, the ground layer's build-up and appearance fit perfectly with those of the SMK paintings, and the chemical composition is very similar.

To reinforce the hypothesis of a pattern in the preparation and composition of Troppa's ground layers, an additional painting attributed to him, *Shepherd Playing the Pipe* in the Nationalmuseum in Stockholm, was examined at the CATS laboratories.[43] The Nationalmuseum describes the painting as 'executed in the manner of Salvator Rosa'[44] but Petrucci listed the painting among the artworks by Troppa in 2012.[45] This painting, although it is neither signed nor dated, exhibits the same ground structure of the SMK paintings by Troppa. Furthermore, the similarities in the elemental composition and distribution are significant. The sample has a ground structure similar to the SMK examples, both from the visual and materials point of view. Furthermore, in the BSE image a difference in the grain size between *ground I* and *II* can be clearly seen, similar to the SMK paintings (Fig. 10). These findings strengthen Petrucci's attribution to Troppa. Additionally, four investigated paintings by Salvator Rosa from the SMK

collection, dated from 1630 to 1661, show ground layers of different structure and different compositions, without any consistency even in the number of layers.[46] Differences in grounds have been observed in many instances for artists moving geographically and hence adapting to local practices, for example Van Dyck[47] and Velázquez.[48] Newly published research on Caravaggio's Roman paintings also reveals a lack of consistency.[49]

In addition, three paintings under investigation at the CATS laboratories – one by a follower of Mola and two by Carlo Maratti (1625–1713), dated to the second half of the 17th century – provided the opportunity to compare Troppa's ground layers with those used by two contemporary Roman artists. A study of the cross-sections revealed that all three paintings have a single ground layer (images not shown). In addition to the difference in structure, the colours are also divergent: light orange in one case and bright red in the other two. Finally, SEM-EDX analysis indicates that the composition of these single ground layers is also very different from Troppa's grounds: the two red grounds contain mainly red iron oxide, whereas the light orange ground consists largely of lead white, calcium carbonate and a little red iron oxide.

To confirm the pattern of Troppa's grounds emerging from this study, research needs to be expanded, increasing the number of paintings for comparison. But the study of three paintings by the circle of Maratti and Mola, both artists working in Rome at the same time as Troppa and influential to his career, further suggests that the consistent use of a double ground of a very well-defined composition could be a feature specific to Troppa.

Troppa and the art market in Rome

Rome was a thriving art market in the 17th century, serving high-profile collectors as well as common citizens. Paintings were sold directly from the painters and from second-hand shops, but also from barbershops and by other shop owners. As early as 1636 the Accademia di San Luca listed sellers of paintings for the purposes of regulation. Between 1650 and 1655 there was an increase from 19 to 46 registered *pittori bottegari* (painters as art dealers), but the actual number of dealers in paintings was likely to be substantially higher.[50] It is known from contracts between patrons and artists that the cost of stretchers, canvases, primers and ultramarine was often covered by the patron, in addition to the price agreed with the artist for commissioned works.[51] At least six of the eight SMK paintings were probably not commissioned hence the cost of materials was included in the price of the paintings. However, the Bracciano altarpiece was most likely a commission. Since the paintings all exhibit the same type of ground, it might be assumed that Troppa primed his canvases in his workshop, possibly using assistants, or purchased his pre-primed canvases from the same source for all the examined paintings, perhaps adding the hematite-containing layer himself. The census of 1656 of Campo Marzio lists a colour grinder (*Macinatore de colori*) living in Troppa's 'poor' household, which implies that Troppa could have used assistants for the preparation of materials for his production as early as that date.[52]

The choice of materials might well have its roots in Troppa's financial situation and status as a painter. A letter from 1672 named him among the second-rate artists,[53] although according to Dobos, he was represented in collections of renowned cultural personalities of his time.[54] The prices paid by Van Haven in 1669, noted earlier, rank among the more modest on the list of the king's acquisitions.[55] It should be noted, however, that Van Haven bought four landscapes of unknown size by Salvator Rosa, by then a well-known artist, for only 22 *scudi* apiece. We do not know how, where or from whom Van Haven purchased his paintings. However, Troppa is known to have sold paintings through art dealers. For instance, in 1656 he worked for at least two months for the painter/art dealer Mario Nuzzi de' Fiori.[56] It was quite common for young artists in Rome to work on exclusive contracts with dealers for a year or so, in order to establish themselves and become independent.[57] But it appears that after working for Nuzzi de 'Fiori, Troppa worked for the Genoese art merchant Pellegrini Peri,[58] and was obliged by contract to produce paintings for Peri on a monthly basis.[59] The inventory of Peri's possessions in 1699 lists 88 paintings of sacred and profane subjects by Troppa. *Mercury Killing Argus* and *Apollo Flaying Marsyas*[60] are also listed in the inventory and were appraised at 12 *scudi* each: these could be the paintings that ended up in Amsterdam and bought by Morell in 1763: 'He [Peri] employed artists to work for him to keep up his stock, he sold their products at the low end of the market but also supplied major collectors.'[61] Peri had painters on exclusive contracts working in his upstairs studio. In his shop downstairs, the most talented artists sold their paintings, which they could have painted in their own studios. Peri had upscale clients such as Cardinal Benadetto Pamphili, and it is plausible that Van Haven could have bought from Peri as well.[62] Troppa also painted frescos and received large commissions from churches and convents, as well as from wealthy patrons. His relative success, and membership of the Accademia, seem to indicate that he was not bound to Peri by an exclusive contract that forced him to work in the workshop upstairs, copying and painting all day long.

Conclusions

Troppa signed many of his paintings, including four of the eight in the SMK collection, indicating that his signature was of value. The question remains: why he would sell his works through an art dealer? Perhaps he was satisfied with a steady income as a supplement to fighting for commissions.[63] It is possible that he had his own workshop: if Troppa did have a large workshop production, this could explain why the composition of his grounds was so homogeneous in all the paintings studied for this paper, even though they range from secular easel paintings to altarpieces. The investigations strongly suggest that Troppa did in fact have

a preferred workshop practice: using a double ground of thicker and more coarsely ground earth pigments under a thinner layer of similar materials, but more finely ground and with the addition of hematite to achieve the desired colour. This practice might have been used to keep costs down.

Another reason for Troppa's consistent use of double grounds could be that most of the paintings examined in this study were acquired at the same time in Rome (1669) and were therefore probably produced around the same time using the same type of canvases, grounds and pigments connected to the place of production (i.e. in fashion in Rome) rather than reflecting personal choice. The *Apollo/Mercury* pendants do not have the same provenance and so far we have found no date on either. However, art historians agree in placing the execution of all eight paintings in the SMK collection to the late 1660s, a period in which Troppa was influenced by Pier Francesco Mola (d.1666).[64] The two paintings not belonging to the SMK collection might also have been produced in Rome; *St Thomas of Villanova* may have been painted in Bracciano outside Rome.

The consistency of the materials used in the grounds of the eight paintings could be coincidental, but may also indicate a very consistent working practice. The large number of paintings listed in Peri's inventory does imply a considerable workshop production alongside the many commissions Troppa is known to have executed. As further research into ground materials becomes available, we might detect more patterns in the suppliers of canvases with a ground already applied and artists' use of specific ground structures. As of now, our knowledge of Troppa and his workshop, including his supply of materials and working practice, is still incomplete. However, we can establish that the grounds of the eight early paintings from SMK were produced with an identical overall structure, technique and using the same materials. As a limited but significant reference to this group, the same materials and technique were utilised in the grounds of the Bracciano altarpiece and the painting now in the Nationalmuseum, Stockholm.

Future studies will confirm if this pattern of a double ground – a coarse lower and a smoother upper layer with slight additions of hematite – can be used as a marker for Troppa's specific workshop. In addition, further research may reveal whether it was a Roman workshop practice or if it can also be found in Troppa's paintings executed in other regions of Italy.

Acknowledgements

We would like to thank Kriste Sibul from the Nationalmuseum of Sweden for invariably fruitful collaboration and for giving permission for the analysis of the painting in Stockholm. We would especially like to thank Johanne Marie Nielsen for performing fibre analysis as well as for preparing and imaging the cross-sections alongside Astrid Grinder-Hansen, Nora Schlag and Sofie Wikkelsø Jensen. A warm thanks to Jakob Schou-Hansen and Troels Filtenborg for imaging and X-radiography.

Notes

1. The information regarding Van Haven's journey and acquisitions can be found in Danske Kancelli, Rentekammerafdelingen, arkivserie: Afregninger, løbenummer 216-220, under 'VI Hoffunktionærer', which is arranged alphabetically. See also H.C. Bering Liisberg, *Kunstkammeret, dets Stiftelse og ældste Historie*, Kbh: Det Nordiske Forlag, 1897, p. 137; H. Olsen, *Italian Paintings and Sculpture in Denmark*, Copenhagen, Munksgaard, 1961, pp. 97–98.
2. In the Danish National Archives (cited in note 1).
3. For a discussion on the identification of the four men, see E. Pedersen. 'Girolamo Troppa's "Four Portraits of Ancient Philosophers"', *Perspective*, 2017, http://perspective.smk.dk/en/girolamo-troppas-four-portraits-ancient-philosophers.
4. The Roman art market was expanding through the 17th century. In only five years from 1650 to 1655 the number of officially registered *pittori battegari* increased from 19 to 46, but it is suspected that the number of unregistered/unlicensed sellers was much larger. Artists, art dealers, second-hand dealers and various other shopkeepers such as barbers sold paintings. See L. Lorizzo, 'People and practices in the paintings trade of seventeenth-century Rome', in N. de Marchi and J. van Miegroet (eds), *Mapping Markets for Paintings in Europe 1450–1750. Studies in European Urban History 6 (1100–1800)*, Turnhout, Brepols, 2006, pp. 343–362; R.E. Spear and P. Sohm (eds), *Painting for Profit: The Economic Lives of Seventeenth-Century Italian Painters*, New Haven, Yale University Press, 2010.
5. See *Fortegnelse over Wahls & Morells Køb*, p. 126, nos. 36 and 37, handwritten acquisition inventory, Statens Museum for Kunst, Archive.
6. At Herman van Swoll's auction in Amsterdam 1699 and 1707: G. Hoet, *Catalogus of Naamlyst van Schilderyen Met Derzelver Pryzen Zedert Een Langen Reeks van Jaaren Zoo in Holland Als Op Anderen Plaatzen in Het Openbaar Verkogt, Benevens Een Verzameling van Lysten van Verscheyden Nog in Wesen Zynde Cabinetten*, 's-Gravenhage, Pieter Gerard van Baalen, 1752. On *Apollo Flaying Marsyas* see p. 50, no. 65 and p. 97, no. 10; on *Mercury and Argus* see p. 50, no. 64 and p. 97, no. 9.
7. See E. Schleier, 'Bemerkungen zu Wiederentdeckung Girolamo Troppa', in T. Ketelsen (ed.), *Girolamo Troppa: Der Zeichner. Ein Phantom*', Cologne, Wallraf Richartz Museum, 2016, pp. 8–17.
8. See G. Sestieri, 'Repertorio della pittura romana della fine del Seicento e del Settecento', *Archivi di arte antica*, Turin, Allemandi, 1, 1994, pp. 177–179.
9. See E. Schleier, 'Adiciones a Girolamo Troppa, "pintor y dibujante"', *In sapientia libertas* 26, 2007, pp. 526–534; E. Schleier, 'Nuove proposte per Girolamo Troppa pittore', *Arte Cristiana* 70, 2012, pp. 245–256; E. Schleier, 'Integrazioni e nuove proposte per Girolamo Troppa disegnatore e qualche aggiunta a Troppa pittore', *Arte Cristiana* 75, 2013, pp. 83–98; Schleier 2016 (cited in note 7); Z. Dobos, 'New additions to the art and research of Girolamo Troppa', *Bulletin du Musée Hongrois des Beaux-Arts* 106–107, 2007, pp. 115–130; F. Petrucci, 'Considerazioni su Girolamo Troppa: un *tenebrista* del tardo Seicento romano', *Prospettiva: rivista di storia dell'arte antica e moderna* 146, 2012, pp. 88–102; Spear and Sohm 2010 (cited in note 4).
10. Spear and Sohm 2010 (cited in note 4), p. 43.
11. Schleier 2016 (cited in note 7); Dobos 2007 (cited in note 9), p. 115.
12. Dobos 2007 (cited in note 9), p. 124.
13. See A. Tantillo Mignosi, 'La Galleria e l'alcova del cardinale Chigi: G. Troppa e C. Fancelli nel Palazzo ai Santi Apostoli',

in M.G. Bernardini, S. Danesi Squarzina and C. Strinati (eds), *Studi di storia dell'arte in onore di Denis Mahon*, Electa, Milan, 2000, pp. 305–312. Troppa's ceiling mural is reproduced in fig. 3, p. 308, and regarding San Giusepe, p. 309.

14. See Spear and Sohm 2010 (cited in note 4), p. 67; J. Kirby, 'The painter's trade in the seventeenth century: theory and practice', *National Gallery Technical Bulletin* 20, 1999, p. 28; M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900*, London, Archetype Publications, 2017, pp. 141–152.
15. Kirby 1999 (cited in note 14), p. 28; A. Roy, 'The National Gallery Van Dycks: technique and development', *National Gallery Technical Bulletin* 20, 1999, p. 59.
16. M. Stols-Witlox, 'Grounds 1400–1900', in J.H. Stoner and R. Rushfield (eds), *Conservation of Easel Paintings*, 2012, Oxford, Routledge, p. 175; Kirby 1999 (cited in note 14), p. 28.
17. Stols-Witlox 2017 (cited in note 14); M. Stols-Witlox, '"By no means a trivial matter": the influence of the colour of ground layers on artists' working methods and on the appearance of oil paintings, according to historical recipes from North West Europe, *c.*1550–1900', *Oud Holland* 128(4), 2015, pp. 171–186.
18. Spear and Sohm 2010 (cited in note 4), p. 65.
19. *Saint Jerome in the Wilderness* is in the Kunsthistorishes Museum, Vienna. It is large, measuring 235 × 166 cm. See Dobos 2007 (cited in note 9), pp. 115, 128 n. 6.
20. It was exceedingly difficult to identify any blue pigments in the sky of the four 'Philosophers': the optical blue confers a very convincing blue colour. This effect is described by Stols-Witlox 2015 (cited in note 17), p. 173.
21. See Pedersen 2017 (cited in note 3). Mass production of standardised works was not uncommon due to the growing demand for art: see Spear and Sohm 2010 (cited in note 4), p. 20. The Peri inventory lists numerous paintings of saints: '*Originali di Palmi 4 e 3, Santi e Sante per dritto mezze figure*' to mention a few, '*Giovanni Battista Originale di Troppa, S. Pietro Originale di Troppa*' and although not ascribed to Troppa a '*Filosofo con penna e libro Originale del…*'. See L. Lorizzo, 'Documenti inediti sul mercato dell'arte: i testamenti e l'inventario della bottega del Genovese Pellegrino Peri'rivenditore di quadri' a Roma nella seconda metà del Seicento', in F. Cappelletti (ed.), *Decorazione e collezionismo a roma nel Seicento: vicende di artisti, committenti, mercanti*, Rome, Gangemi, 2003, p. 167.
22. Guido Reni, *Saint Mary Magdalene*, 1634–35, oil on canvas, 79 × 68.5 cm, National Gallery, London, NG177.
23. In 2016–2017 an exhibition on Troppa as a draughtsman was held at the Wallraf-Richartz-Museum and the Fondation Corboud in Cologne, Germany. For Troppa's drawings see T. Ketelsen (ed.), *Girolamo Troppa: Der Zeichner. Ein Phantom*, Cologne, Wallraf Richartz Museum, 2016.
24. KdZ16124. See Schleier 2016 (cited in note 7), pp. 8–12, nos. 18–20.
25. C. Fischer and J. Svenningsen, 'Determining the composition', in *Art in the Making*, Copenhagen, National Gallery of Denmark, 2018, pp. 41–51; L. Keith, '*Giulio Romano* and *The Birth of Jupiter*: studio practice and reputation', *National Gallery Technical Bulletin* 24, 2003, pp. 38–49.
26. The cross-sections were made by embedding the samples with Technovit 2000 LC in an EasySection (http://easysections.com/). The first part of the polishing was carried out wet and the last part dry using MicroMesh with grit size up to 12,000.
27. Elemental analysis and mapping were carried out with a Hitachi S-3400N SEM equipped with a Bruker Quantax 200 detection system with two Peltier-cooled XFlash silicon drift detectors with an active area of 20 mm^2 each. Measurements were performed in variable pressure mode (30 Pa) on non-coated polished sections using 20 kV voltage, 50 µA probe current and 10 mm working distance. The acquisition times for spot analyses and maps were respectively 60 and 600 seconds.
28. The samples were analysed in reflection, transmission and attenuated total reflection (ATR) mode with a Bruker Tensor 2 spectrometer coupled to a Hyperion 3000 microscope equipped with cryogenic MCT and FPA detectors. For reflection mode, the samples were analysed using the MCT detector, ×15 objective, 64 scans and 4 cm^{-1} spectral resolution in the 4000–600 cm^{-1} spectral range. The same settings were used for the transmission analysis, where the sample was placed in a diamond anvil cell. ATR was performed with the FPA detector using a ×20 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 4000–900 cm^{-1} spectral range with 8 cm^{-1} spectral resolution and 128 scans.
29. Raman spectroscopy was carried out with a Bruker Senterra system with a thermoelectrically cooled CCD detector. Raman spectra were recorded by focusing a 785 nm laser beam using a ×50 or ×100 Olympus objective lens; c.9–18 µm lateral resolution with a 400 lines/mm grating, and 3–5 µm lateral resolution with a 1200 lines/mm grating were used. The laser power at the sample was 1–25 mW with an acquisition time between 7 and 120 seconds for each spot, and 1 or 2 accumulations.
30. We have not pursued the identification of the binding media since the result would include contamination from various conservation treatments, especially the glue paste lining. The canvases are so open weave that the ground layer is either protruding or just visible through the canvas. An emulsion ground or pure glue ground would be expected to react with/soak up glue from a lining and a possible prior glue impregnation.
31. C. Seccaroni and P. Moioli, *Fluorescenza X: prontuario per l'analisi XRF portatile applicata a superfici policrome*, Florence, Nardini Editore, 2002.
32. The sample was analysed in transmission mode thus avoiding the spectral distortions inherent to ATR and reflection FTIR. Due to the minute size of the unembedded samples obtained for transmission measurements, separation of *ground I* and *II* was not possible. However, as the aim of the analysis was the identification of the compound(s) causing the same spectral reflection FTIR profile in the two layers, this was not a drawback.
33. See L. Monico, F. Rosi, C. Miliani, A. Daveri and B.G. Brunetti, 'Non-invasive identification of metal-oxalate complexes on polychrome artwork surfaces by reflection mid-infrared spectroscopy', *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 116, 2013, pp. 270–280.
34. See V.C. Farmer, *Infrared Spectra of Minerals*, London, Mineralogical Society, 1974; M. Sitarz, M. Handke and W. Mozgawa, 'Identification of silico-oxygen rings in SiO_2 based on IR spectra', *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 56(9), 2000, pp. 1819–1823.
35. Farmer 1974 (cited in note 34).
36. Monico *et al*. 2013 (cited in note 33).
37. Farmer 1974 (cited in note 34); J.L. Post and L. Borer, 'Physical properties of selected illites, beidellites and mixed-layer illite–beidellites from southwestern Idaho, and their infrared spectra', *Applied Clay Science* 22(3), 2002, pp. 77–91; E. Srasra, F. Bergaya and J. Fripiat, 'Infrared spectroscopy study of tetrahedral and octahedral substitutions in an interstratified illite-smectite clay', *Clays and Clay Minerals* 42(3), 1994, pp. 237–241.
38. Spear and Sohm 2010 (cited in note 4), p. 67; Kirby 1999 (cited in note 14), p. 28.
39. See I.M. Bell, R.J.H. Clark and P.J. Gibbs, 'Raman spectroscopic library of natural and synthetic pigments (pre- ≈ 1850 AD)', *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 53(12), 1997, pp. 2159–2179.

40. Bracciano is roughly 42 km from Rome.
41. C. Sodano, 'L'elemosina di San Tommaso da Villanova del cavalier Gerolamo Troppa: la storia, il restauro', in C. Sodano (ed.), *Restauro dell'elemosina di San Tommaso da Villanova del cavalier Gerolamo Troppa*, quaderni del Museo Civico, vol. 1, pp. 25–32, Rome, Edizioni Effigi, 2009; M. Cardinali and M.B. De Ruggieri, 'Materiali constitutivi e tecnica di esecuzione ne *l''Elemosina di San Tommaso da Villanova:* l'approccio diagnostico alla questione delle copie', in Sodano 2009, *op. cit.*, pp. 33–40. The altarpiece measures 190 × 125 cm.
42. In the literature, *caput mortuum* is considered to be an iron oxide-based pigment even though the type of iron oxide is uncertain: see G. Mastrotheodoros, K. Beltios and N. Zacharias, 'Assessment of the production of antiquity pigments through experimental treatment of ochres and other iron based precursors', *Mediterranean Archaeology and Archaeometry* 10(1), 2012, pp. 37–59; Sodano 2009 (cited in note 41).
43. Three samples were collected, embedded in resin to produce cross-sections and analysed by optical microscopy and SEM-EDX.
44. Attribution based on Schleier (several publications cited in note 9), according to the online collection information for the Nationalmuseum, Stockholm.
45. See Petrucci 2012 (cited in note 9), pp. 90 (fig. 5) 91 and 101, and n. 171.
46. CATS internal reports, data not yet published.
47. See Kirby 1999 (cited in note 14), p. 28; Stols-Witlox 2017 (cited in note 14), p. 142.
48. M. Jover de Celis and Maria Dolores Gayo, 'Velázquez and his choice of preparatory layers: different place, different colour?', in this volume, pp. 44–54.
49. See R. Vodret, *Caravaggio. Works in Rome: Technique and Style*, Milan, Silvana Editoriale, 2016, pp. 279 and 301.
50. See Lorizzo 2006 (cited in note 4), pp. 343–345; Spear and Sohm 2010 (cited in note 4), p. 42.
51. Spear and Sohm 2010 (cited in note 4), p. 68.
52. Ibid., p. 308, n. 148.
53. A letter from Padre Resta to the Spada family, advising on painters for the decoration of the family chapel in Chiesa Nouva: see Spear and Sohm 2010 (cited in note 4), p. 90.
54. See Dobos 2007 (cited in note 9), p. 126.
55. Van Haven spent roughly 4,100 *scudi* in Rome and Venice: see Bering Liisberg 1897 (cited in note 1), pp. 136–138.
56. In 1655 Fiori was licenced by the Accademia di San Luca to keep a shop for the sale of pictures and paintings; see Lorizzo 2006 (cited in note 4), p. 355; Y. Primarosa, 'Nuove proposte per Mario dei Fiori e Karel van Vogelaer con Luigi Garzi, Giovan Battista Gaulli, Anthoni Schoonjans e Girolamo Troppa', in A. Bacchi, F. Mambelli and E. Sambo (eds), *La matura morta di Ferico Zeri*, Ferrara, Fondazione Federico Zeri, 2015, pp. 195–216.
57. Primarosa 2015 (cited in note 56); Lorizzo 2006 (cited in note 4).
58. Peri also sold artist' materials, such as pigments and canvas, see L. Lorizzo, *Pellegrino Peri. Il mercato dell'arte nella Roma barocca*, Rome, De Luca Editori d'Arte, 2010, pp. 40–43.
59. Ibid., p. 47.
60. '*N. 18 Martia, et Apollo Originale di Troppa 12[scudi] & N.19 Mercurio, et Argo Originale di Troppa 12 [scudi]*' see Lorizzo 2003 (cited in note 21), p. 165.
61. Spear and Sohm 2010 (cited in note 4), p. 290.
62. Although a preliminary comparison between the list of artists from Peri's inventory and the acquisitions by Van Haven does not show any matches to artists other than Troppa, see Lorizzo 2003 (cited in note 21), pp. 165–174; Bering Liisberg 1897 (cited in note 1), p. 137.
63. See Primarosa 2015 (cited in note 56).
64. See Schleier 2016 (cited in note 7), p. 9.

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GROUND LAYERS IN FRENCH PAINTINGS FROM THE SECOND HALF OF THE 17TH CENTURY: COLOUR, STRATIGRAPHY AND FUNCTION

Claire Betelu

ABSTRACT Painting techniques in France in the Early Modern period remain understudied. Exhaustive technical examination contextualised with coeval publications on the materials in French paintings from the second half of the 17th century remains rare and when it exists, the information is often scattered in the literature. Moreover, condition and treatment reports, as well as materials analysis and imaging techniques, provide heterogeneous information. Finally, there are few published sources on the sales of artists' supplies in Paris at that time. This paper investigates the materials in use by French Academicians in the ground layers of their paintings and the application processes they adopted. At that time, according to these artists, the preparation was as important for permanence as for its effect on the colour harmony and balance of the composition. Different contemporary sources from the last 50 years, such as condition and treatment reports, technical analyses and examinations of cross-sections of paint from French paintings of the second half of the 17th century are compared to the information found in historical technical treatises.

Introduction

Painting technique in France in the Early Modern period remains poorly studied: most of the research is based on the interpretation of historical technical literature.[1] In addition, exhaustive technical examination of French paintings is rare and any information that does exist is dispersed randomly within the literature. Regarding the subject of ground layers, Alain Duval's paper in *Studies in Conservation* in 1992 on French coloured ground layers in the 17th and 18th centuries was an early example, and Elisabeth Martin's paper in 2008 on French ground layers between 1600 and 1640 in *Preparation for Paintings* are significant; Pascal Labreuche has researched suppliers of materials in Paris, and Maartje Stols-Witlox has extensively researched technical treatises in western Europe and made historically appropriate reconstructions from the recipes therein.[2]

This paper presents the first synthesised results of work in progress, focusing on the specificities of French ground layers in the second half of the 17th century. At that time, according to written sources, the treatment of the preparation was considered as important for the permanence of the painting as for its effect on the colour harmony and balance in the composition. Contemporary sources of a diverse nature published over the last 50 years– such as condition and treatment reports, technical analyses and examinations of cross-sections – are re-evaluated. This study does not focus on one artist in particular: it takes into consideration all the information available on artists who were French Academicians active between 1650 and 1699. This period is representative of the French *grande manière* (grand manner) that appeared between 1620 and 1660 (Fig. 1). At the same time, the creation of the Académie royale de Peinture et de Sculpture in 1648 fostered a new identity for the French artist, represented by the rivalry between Pierre Mignard (1612–1695) (see Fig. 2) and Charles Le Brun (1619–1690).[3]

The aim of this research is to produce an overview on the topic and to answer some, albeit not all, of the questions that have arisen during the study. Is grey on a red coloured ground the most common composition, as is commonly believed? Also, could it be the cause of specific alteration over time? Data were found for 1297 paintings and technical reports for 468 of these by consulting the multilingual EROS database covering the results of technical studies, accessible only at the documentation centre of the Centre de Recherche et de Restauration des Musées de France (C2RMF). The

Fig. 1 Charles Poerson, *Le Repos pendant la fuite en Egypte*, 1652, oil on canvas, 53 × 63 cm, Musée Carnavalet, Histoire de Paris, Paris, inv. no. P2816. (Image: Paris Musées.)

Fig. 2 (a) Anonymous artist, *Portrait de Mignard (1610–1695)*, 1860–1890, 84 × 52 mm, albumin print on paper, Musée Carnavalet, Histoire de Paris, Paris, inv. no. PH53894 and (b) the reverse. (Images: Paris Musées.)

documentation on 250 paintings, 150 of which have one or more technical reports, was examined in detail. These data are put into context with information from technical treatises and merchants' inventories, which are indicative of the materials available on the market between 1650 and 1699. After presenting the corpus, the supply of prepared canvases in Paris in the second half of the 17th century is considered followed by a discussion of the characteristics of such canvases in terms of their materials and hue.

Review of the corpus studied

Terminology

With regard to the terminology used to designate ground layers, a change is noticeable in the meaning of the terms used between the period studied and now. The main written sources for this period were published between 1683 and 1755. André Félibien des Avaux (1619–1695) and Roger de Piles (1635–1709), architect and painter, known as *érudits* (scholars) in their time, were interested in compiling information on contemporary painting techniques. Philippe De la Hire (1640–1718), son of the artist Laurent De la Hire (1606–1656), was first educated as a painter in his father's workshop before becoming an astronomer. He gave lectures on his *Traité de la pratique de la peinture* at the Académie des Sciences in 1709. The publication served as a compilation of the techniques he observed and used as a painter.[4]

In the second half of the 17th century, the designations *toile imprimée* and *toile préparée* were used by de Piles in 1683,[5] *impression* by De la Hire in 1730,[6] and *imprimeure* by Félibien.[7] According to de Piles, *toile imprimée* was the term commonly employed by his contemporaries to describe a 'canvas stretched on a strainer and prepared for painting'.[8] At the same time, *impression* and *imprimeure*, found notably in Félibien's treatise, refer in particular to the ground layer. *Imprimeure* would be the term used by craftsmen to describe the first coloured layer applied to a canvas. This was regarded as a base for the coloured layers applied later that form the composition. According to Félibien, the term *imprimature*, which he used in the 17th century, was a mangled version of the Italian word *imprimatura* and he condemned its use as improper.[9] None of these terms appear in the first dictionary of the Académie, published in 1694, therefore they should be regarded as specialised technical vocabulary.

Studies over the last 50 years (1970–2019) have also developed a specific terminology. Indeed, it is noticeable that in articles and reports, art historians, scientists and conservators differentiate the first layer called '*preparation*', or 'ground' in English, from the second layer named '*impression*', or 'priming' in English, simply for convenience. As can be observed, the distinction is based mainly on a difference of thickness and colour and does not refer to any 17th-century usage. The word *impression* appears in 18th-century French treatises to describe the ground layer.

Paintings and artists studied

This project is based on a corpus of paintings restored in the C2RMF studios. The study included 1297 French paintings produced in the second half of the 17th century and held in French public collections.[10] Thus far, information on the ground layers of 113 paintings has been collected, taking into consideration only those French painters who were well received at the Académie royale de Peinture et de Sculpture during their careers: 37 painters and 92 paintings. For five artists – Mignard, Le Brun, Jean Cotelle (1642–1708), Jean-Baptiste Martin (1663–1742) and Hyacinthe Rigaud (1659–1743) – five or more paintings with their accompanying documentation were located. For 15 painters, between two and four paintings were found, and for 17 artists, only one painting. This includes Sébastien Bourdon (1616–1671), Henri Testelin (1616–1695) and Claude Vignon (1593–1670), three of the 12 leading painters of their time who founded the Académie in 1648.

Condition

Half of the corpus comprises supports with a glue paste lining or which have been transferred to a new support – only one painting has a wax lining. This information is important for two reasons: firstly, it raises the question of the survival and originality of the ground layer in the case of a transfer and secondly, it suggests the possibility of specific fragility of the coloured ground layer, leading to detachment of the paint from the ground. This was the justification for numerous transfers in the 19th century and the first half of the 20th century. According to treatment reports, just 3 out of 93 paintings presented attachment problems before their last treatment. In 2009, curator Gilles Bastian described the flaking of the painting *Allégorie, Le jour* by Noël Coypel (1628–1707) (inv. no. 3491, Musée du Louvre) as due to the nature of its double red ground comprised of ochre or red bole. Another clear example of attachment problems due to the nature of the ground, also identified in 2009, is *Vue de la Cité et du Château de Versailles de Montboron* (MV 749, Châteaux de Versailles et du Trianon) in which flaking had occurred over large areas.[11] The backs of the flakes showed the canvas weave imprinted in the ground layer because it had detached completely from the canvas.

Nevertheless, according to condition and conservators' reports, it seems that fragility is not specific to *coloured* preparations, but rather an example of paint attachment problems due to the processes used for canvas preparation, sometimes involving the temperature of the animal glue size.

Preparation process

The necessity of a ground layer when painting with oil on canvas was discussed by various French writers of the second half of the 17th century. For de Piles and for De la Hire, a ground layer was required for oil painting practice:[12]

according to de Piles, 'you paint on whatever support as long as it is prepared'.[13] For Félibien, however, colours were more beautiful and would be more durable if there was no ground layer, even though he mentioned the existence of craftsmen preparing canvases, as discussed later.[14] In the corpus studied, all the canvases possess a ground layer.

A market for prepared canvases in Paris between 1650 and 1699?

It is not a simple task to find information on those in Paris who specialised in prepared canvases between 1650 and 1699: the archives are not very revealing and there are no specific mentions of sales in the almanacs. Thanks to recent research, we know of the existence of two groups of tradesmen – drapers and laundry women – who sold different types of canvases, and painter-merchants who retailed canvases and pigments. Three of the latter were known in Paris at that time: Nicolas Herbert, Louis Perrin and Jérôme Cheron.[15] In Perrin's and Herbert's shops, a large canvas with a ground was valued at two *sols*: the bigger the canvas the less expensive it was per unit area. At that time, a boatswain earned 16 *sols* a day.[16]

References in the treatises by de Piles and Félibien also indicate that there was a specialised market. When de Piles explained why a canvas should be covered with a ground layer, he stated that artists could buy it ready to use,[17] and if they did not have a canvas ready to work on, they should first work on a sheet of paper covered with oil instead of preparing the canvas themselves. Félibien similarly mentioned craftsmen who were in charge of the manufacturing process.[18] The fact that, like De la Hire, he dedicated a chapter to the preparation process can be explained by the desire to reach a broad public interested in painting matters through his publication.

With this corpus, the question can be asked whether painters bought canvases with a ground layer already present and then applied a second layer themselves if necessary, adjusting the hue as required. Indeed, on Mignard's *Portrait of a Man* (inv. no. 86.2, Musée Saint Loup, Troyes) a first red-orange layer is covered with a thin layer of lead white. Judging by the colour harmony and the build-up of the composition, the artist made intentional use of this white layer. Conversely, on four of his other paintings with single red or double red then pink grounds, the red was retained as a final ground layer. The warm, dark tones are visible on the surface and influence the tonality of the general composition.

The function of the ground

Thanks to the treatises, it is possible to reassess the function of the ground and, potentially, to interpret material clues observed in the paintings. Félibien and De la Hire[19] provided descriptions of the ground-making process. Applied with a knife, after the glue sizing on a stretched canvas was dry, the ground layers had to be as thin as possible to allow artists to roll up their supports without causing the paint to crack and flake. According to these authors, a layer containing lead white that might flake readily – the second layer in particular – could be counter-balanced by applying that layer quite thinly. De la Hire suggested that what was left on the canvas by the knife should be minimal, just enough to unify the colour on the canvas. In 2009, curator Bruno Mottin noted a variation in the thickness of the ground layer on the *Battle Between the Amazons and the Greeks* by Claude Deruet (inv. no. RF 2009-10, Musée du Louvre): it appeared thinner at the top of the painting whereas the rest of the surface was homogeneous.[20] According to Mottin, the fact that the irregularity of the thickness was specifically located at the top and on a width corresponding to that of the strainer would indicate that the preparation was applied from top to bottom, with more pressure at the point of first application of the knife. For all examples where the thickness of the ground layers has been measured, the second layer is about half or one-third the thickness of the first.

Concerning references to the nature of materials, information is generally coherent from one historic text to another. If the information differs between Félibien and De la Hire, this can be explained: De la Hire reported what was usually done, whereas Félibien added information on what *should* be done, for the sake of permanence. Both stated that the first layer was generally a mixture of oil and reddish-brown earth colours to give bulk and density to the layer. Félibien specified that the oil should be linseed or walnut and both authors suggested the use of a siccative. Félibien explained that a small addition of lead white would accelerate the drying process. He warned against '*mine*' or minium, commonly used as a siccative, according to De la Hire.[21] If its first effects as a drier were significant, in time, the artist would regret it:[22] the layer would become brittle. For the second ground layer, Félibien indicated a mixture of lead white and charcoal. Pierre Le Brun offered another alternative: mixing oil and parchment glue with ochre: although an option, this *imprimure* would flake as soon as the canvas was rolled up.[23] Moreover, according to Le Brun, it would be better to wait as long as possible between the fabrication process and the time of use by the artist; the colours of paint layers would become more beautiful due to the delay.[24] In addition, as noted by Félibien, the use of glue as a ground binder was rare at that time because of its sensitivity to moisture and tendency to flake.[25] However, the paint layer was known to preserve its brightness for longer on a ground layer of which glue was the binder. To combine both permanence and colour intensity of the paint layer, as little oil as possible should be used during the painting process and some oil of spike lavender, known as *volatile*, added to the paint.[26]

Only a few binders and pigments had undergone materials analysis in the corpus under study: in the 150 technical reports consulted, binders had been analysed in only seven cases. It was also noticed that conservators' interpretations of ground layer sensitivity did not overlap with materials identification when it existed. Previous treatments to these supports may explain an increase in reactivity to aqueous treatment. Most of the information on the pigments is based on microscopical examination of cross-sections by scientists in the 1980s and 90s. Oil was detected in three ground layers: in the first ground layer in *Portrait d'un homme* (Musée Saint Loup, Troyes) by Mignard,[27] in *Apollon couronné par Minerve*

Table 1 Single ground layer (18 examples) in French easel paintings 1650–1699.

Colour of ground	C2RMF report no.	Artist	Title	Dimensions (in metres)	Collection	Inv. no.
White	63683	Monier, Pierre	*Hercule à qui les idées donnent des armes pour défendre Thèbes*	1.45 × 1.84	École Nationale Supérieure des Beaux-Arts, Paris	INV 6727/ MRA1674
Pink	71370	Corneille, Michel	*La vieille et Charité*	1.29 × 0.95	Centre des Monuments Nationaux, Paris	SUL2010003410
Pink	72457	Cotelle, Jean	*Vue de la fontaine de l'Encelade*	2.01 × 1.37	Château Versailles, Versailles	MV735
Pink	72732	Cotelle, Jean	*Vue du bassin des cinquante-deux jets ou du Plat-Fond à Trianon avec Mars et Vénus*	2.04 × 1.42	Château Versailles, Versailles	MV777
Pink	68289	Champaigne, Philippe	*Crucifixion*	2.48 × 1.61	Musée du Berry, Bourges	Sn
Red	72459	des Batailles, Martin	*Vue perspective de la ville et du château de Versailles depuis la butte Montboron*	2.34 × 1.865	Château Versailles, Versailles	MV749
Red	10489	Rigaud, Hyacinthe	*La famille Léonard*	1.26 × 1.54	Musée du Louvre, Paris	INV7519
Red	72590	Lebrun, Charles	*Portrait équestre du roi Louis XIV*	3.29 × 2.57	Musée de la Chartreuse, Douai	237
Red	64796	Mignard, Pierre	*Portrait de Jacques Bénigne Bossuet*	1.30 × 0.98	Musée Bossuet, Meaux	MB2006-2
Red	65316	Coypel, Noël	*Allégorie, Le jour ?* (*c.*1694)	96.4 × 1.40	Musée du Louvre, Paris	INV3491
Red	65568	Poerson, Charles	*L'empoisonnement de Camma et Synorix au temple de Diane*	1.28 × 1.21	Musée de la Cour d'Or, Metz	942P606
Red	67881	Mignard, Pierre	*Louis XIV à cheval couronné par la victoire vers 1694*	3.59 × 2.60	Château Versailles, Versailles	MV2032/ INV6649/1808
Red	69319	Mignard, Pierre	*Portrait de madame de Maintenon* (1694)	1.08 × 0.79	Château Versailles, Versailles	MV4268/B2149
Red	70271	Boullogne, Bon	*Vénus à sa toilette et Mercure*	2.89 × 1.76	Château Versailles, Versailles	MV 7559/ INV 2771
Red	71211	Houasse, René Antoine	*Paysage*	3.40 × 1.36	Château Versailles, Versailles	MV8357
Red	71212	Houasse, René Antoine	*Paysage*	3.40 × 1.36	Château Versailles, Versailles	MV 8358
Red	71812	Boullogne, Bon	*Jupiter et Bacchus*	0.66 × 0.51	Musée Magnin, Dijon	1938F93
Red/orange	F10067	Largillière, Nicolas	*Portrait d'un homme*	1.17 × 1.98	Musée Jacquemart-André, Paris	D1263
Yellow	10567	Coypel, Antoine	*Athalie chassée du temple*	1.56 × 2.13	Musée du Louvre, Paris	INV 3496

(inv, no. 3461, Musée du Louvre) by Coypel[28] and in *La résurrection du Lazare* (inv. no. 2768, Musée du Louvre) by Bon Boullogne (1649–1717).[29] In Coypel's painting, a larger proportion of oil was identified in the second layer compared to the first. In Le Nain's paintings, minium was found in very small proportions. It should be noted that these paintings do not present any particular conservation problems.

Stratigraphy and colours

Stratigraphy and colours observed in the corpus

The stratigraphy of 36 paintings was described in reports from the observation of cross-sections or *lacunae*. Eighteen paintings present a single ground layer (Table 1): 1 example is white in colour, 1 is coloured by yellow ochre, 1 orange, 4 pink and 11 red. A further 18 paintings (Table 2) had a double ground layer, the first of which was red; for the second layer, 1 was white, 7 grey and 10 pink. Apart from the Le Nain brothers, the same artist used different colours of ground in different paintings. At that period, De la Hire suggested a single preparation layer was preferable to limit detachment of paint and oil absorption into the ground.[30] Moreover, according to Félibien, a reddish-brown hue in the ground layer was considered as 'neutral' in comparison to the colours used in the paint. Red or pink appear as the dominant tones. The most prevalent stratigraphy, pink on red, has been observed in Troy's painting of 1691, *Portrait d'un couple en Vénus et Paris* (RF 1942-4, Musée du Louvre).[31]

Portrait équestre de Louis XIV devant Cassel (MV9124, Château Versailles) by Mignard and *Hercule à qui les idées donnent des armes pour défendre Thèbes* (inv. no. 6727, École

Table 2 Double grounds (18 examples) in French easel paintings 1650–1699.

Colour	C2RMF report no.	Artist	Title	Dimensions (in metres)	Collection	Inv. no.
White on red	10643	Mignard, Pierre	*Portrait d'un homme*	1 × 0.80	Musée Saint-Loup, Troyes	86.2
Pink on red	67365	Mignard, Pierre	*Portrait équestre de Louis XIV devant Cassel*	0.50 × 0.60	Château de Versailles, Versailles	MV9124
Pink on red	69317	des Batailles, Martin	*Château et jardins vus du bassin de Neptune*		Château de Versailles, Versailles	MV751/ INV6469
Pink on red	F10094	Coypel, Noël	*Saint Jacques le Majeur, conduit au supplice, guérit un paralytique et embrasse son accusateur*	4.02 × 3.31	Musée du Louvre, Paris	MI335
Pink on red	10144	Mignard, Pierre	*Erato, Euterpe et Uranie*		Musée national du château Fontainebleau, Fontainebleau	INV6645/ MR2166
Pink on red	10329	Belin, Jean	*Fleurs dans un vase d'or*	1.90 × 1.62	Musée du Louvre, Paris	INV4464
Pink on red	11165	Troy, François	*Portrait d'un couple en Vénus et Paris*	1.50 × 1.20	Musée du Louvre, Paris	RF1942-4
Pink on red	11284	Jouvenet, Jean-Baptiste	*Jésus Christ chez Marthe et Marie*	1.45 × 1.10	Musée du Louvre, Paris	INV5483
Pink on red	11141	Coypel, Noël	*Prudence*		Musée national du château Fontainebleau	INV 3470/ B 2570
Pink on red	11142	Coypel, Noël	*Vigilance*		Musée national du château Fontainebleau	B 2571/ INV 3471
Pink on red	11494	Desportes, Alexandre François	*Portrait de l'artiste en chasseur*	1.97 × 1.63	Musée du Louvre, Paris	INV 3899
Grey on red	13049	Champaigne, Philippe	*Saint Pélagie se retirant dans la solitude*		Mayence, Germany	
Grey on red	12137	Champaigne, Jean-Baptiste	*Double portrait de mère Angélique et Agnès Arnauld*	1.65 × 2.29	Musée de Louvre, Paris	PRP30
Grey on red	F10090	Le Brun, Charles	*La Chasse de Méléagre et d'Atalante*	3.10 × 5.11	Musée du Louvre, Paris	INV2899
Grey on red	10835	Le Brun, Charles	*Le Crucifix aux anges*	1.74 × 1.28	Musée du Louvre, Paris	INV 2886
Grey on red	11350	Le Nain, Mathieu	*Adoration des mages*	0.96 × 1.17	Musée Bossuet, Meaux	988.1.1
Grey on red	11351	Le Nain, Mathieu	*Annonciation*	104.5 × 187.3	Musée Rolin, Autun	988.5.1
Grey on red	11696	Le Nain, Mathieu	*Le Concert*	0.77 × 0.87	Musée archéologique municipal, Laon	INV 991 1

Nationale Supérieure des Beaux-Arts) by Pierre Monnier (1641–1703), are the only paintings in which white was used for the first or a second preparatory layer. Unfortunately, the nature of the binder was not identified. De la Hire explained that famous artists who were concerned about the effect of oil on the ground layer used a white ground made from traditional glue in order to preserve colour intensity.[32]

The seven paintings in which the preparation has a double grey-red colour were produced by Philippe de Champaigne (1602–1674) (Fig. 3), Le Brun and the Le Nain brothers. It is important to underline that this stratigraphy was generally taken to define contemporary French painting technique at this period.[33] However, the five artists previously mentioned are some of the rare painters for whom a monographic study is available. At the same time, the stratigraphy corresponds to Félibien's advice: his texts are still commonly used today to study French painting techniques, which could explain the generalisation made in the 20th century relating to the double grey-red colour. It appears from our sample that this stratigraphy represents 10% of canvas production and is relevant to artists from the beginning of the 50-year period studied. The correspondence between technical treatises and data from paintings suggests that a number of measures were employed by artists to preserve colour intensity and limit oil absorption of the underlying layer.

Ground colour: use of a neutral tone and level of artists' experience

Several factors might contribute to the variations in ground layer colours. Artists may have wished to anticipate the general tonality of their composition or to make use of the halftones left visible in the blank areas of the composition. De Piles offered another explanation related to the experience of the artist:[34] novice painters were advised to use an oil ground with a halftone colour. In this advice, de Piles differed from his contemporaries who suggested that 'painters

Fig. 3 Philippe de Champaigne and Nicolas de Plattemontagne, *Scène de la vie de saint Benoît: l'ange désignant à saint Benoît l'emplacement du monastère du mont Cassin*, 1656, oil on canvas, 93 × 148 cm, Musée Carnavalet, Histoire de Paris, Paris, inv. no. P1475. (Image: Paris Musées.)

who needed to practice' ought to 'paint on light grey grounds', as reported by Maartje Stols-Witlox.[35] According to de Piles, as an artist gained experience, he should progress to lighter and greyer colours and not middle tones in the ground. For a young artist, it was easier to achieve a balanced composition and a good distribution of light and shadow by starting with a mid-toned base rather than a light-toned one. The first grey value was a reference point and would also have a positive effect on brighter colours by improving colour saturation and counterbalancing a lack of control in the colour of the paint. It would also give a greater indication of the intensity of the paint colour. Finally, only experienced painters were advised to work on white ground layers, bound with oil or glue. In that case, the artist was to choose a thin canvas and a light-toned ground layer.[36]

Other supports: is the first tonal layer related to its medium?

With reference to the underlying hue given by the preparation, a short detour via monumental decorative painting took place within the study. Most of the history painters from the Académie, such as Le Brun and Coypel, received royal commands to provide decorations for Versailles. Artists often had to work on these substantial projects as a team. For the ceilings, they had two options: either to paint on plaster or on a canvas that was then fixed to the ceiling. This raises the question of whether they employed the same stratigraphy and colours in the preparation of such monumental compositions as used for smaller easel paintings on canvas. First of all, we noted that every report on the stratigraphy for the Mercury Salon and the Royal Table Antechamber at the castle of Versailles referred to canvases with coloured ground layers. In the Mercury Salon, four paintings were made by Jean-Baptiste Champaigne (1631–1681). Thirteen of these examples had been investigated,[37] all of which showed a single red ground layer. In the Royal Table Antechamber, six paintings – three by Vignon and three by Antoine Paillet (1626–1701) – were studied in 2006 but there is no homogeneity in the results. Two of Paillet's ground layers and one of Vignon's include a first red layer and a second of yellow ochre – the others have single red layers.

According to these results, or at least from observations of these easel paintings, there was a modulation of the hue in relation to the overall tonality of the subject. A single type of preparation was not associated with any individual artist. Any conclusion seems premature with so little information but it would appear that the same colour was used for the preparation of easel paintings and ceiling paintings on canvas, but differed when painters worked on plaster, even when the same artists worked on both types of supports. Contrary to Félibien, who advocated first applying a red oil colour on all kinds of surfaces, artists such as Testelin started working on white plaster surfaces at Versailles. In these works, there is no initial layer of homogenous colour covering the entire surface: each element was painted independently, the first tones adapted to the tint of the figures.[38]

Conclusions

In conclusion, it should be remembered that there were no specific terms to distinguish ground layers in French 17th-century terminology. The terms *impression*, *préparation* and *imprimeure* were used indiscriminately. In the corpus examined to date, the same number of single as double layers were used for the preparation. With few exceptions, the first layer is generally red. Grey-on-red preparations, described by Félibien, seem to have been employed by a few artists from the beginning of the period. With the exception of the Le Nain brothers, individual artists did not use the same type or colour of ground layer consistently.

The role of the ground layer in terms of its influence on the final colour, and efforts to minimise loss of colour intensity, appear to be at the centre of the whole thought processes of these artists and the treatises seem to reflect artists' concerns. However, the corpus of paintings studied revealed a larger range of colours for the preparation than is suggested by the written sources.

Finally, hue variations in the second ground layer, where present, seem to anticipate the general tonality of the final composition. Was this second layer laid on by the artist in order to modulate the first red tone applied by a painter-merchant? Information is too fragmentary for conclusions to be drawn. Since it is known that painter-merchants were present in Paris between 1650 and 1700, it is difficult to determine the proportion of canvas purchased ready to use compared to canvases prepared in artists' workshops.

This initial research has provided a few pointers for future work. It would be interesting to attempt to find a correlation between grey used as the preparatory layer and the experience of the artist. Targeted research into a larger corpus would offer a more exact and diachronic overview of painting practice in the second half of the 17th century, and more systematic binding analyses, correlated with surface examination and written sources, would allow more definitive conclusions to be drawn.

Notes

1. A. Massing, 'French painting technique in the seventeenth and early eighteenth centuries and De la Fontaine's Académie de la peinture (Paris 1679)', in E. Hermens, A. Ouwerkerk and N. Costaras, *Looking through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research*, London, Archetype Publications, 1998, pp. 319–390.
2. A. Duval, 'Les préparations colorées des tableaux de l'école française des dix-septième et dix-huitième siècles', *Studies in Conservation* 37, 1992, pp. 239–258; S. Bergeon and E. Martin, 'La technique de la peinture française de XVII[e] et XVIII[e] siècles, *Technè* 1, 1994, pp. 65–78; E. Martin, 'Grounds on canvases 1600–1640 in various European artistic centres', in J.H. Townsend, T. Doherty, G. Heydenreich and J. Ridge (eds), *Preparation for Painting: The Artist's Choice and its Consequences*, London, Archetype Publications, 2008, pp. 59–67; P. Labreuche, *Paris, capitale de la toile à peindre: XVIIIe–XIXe siècle*, Paris, Cths INHA, 2011; M. Stols-Witlox, '"By no means a trivial matter": the influence of the colour of ground layers on artists' working methods and on the appearance of oil paintings, according to historical recipes from North West Europe, c. 1550–1900', *Oud Holland* 128(4), 2015, pp. 171–186; M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900*, London, Archetype Publications, 2017.
3. A. Chastel, *L'art français. L'ancien r*égime 1620–*1775*, Paris, Flammarion, 2000.
4. P. De la Hire, 'Traité de la pratique de la peinture', in *Mémoires de l'Académie royale des Sciences. Depuis 1666 jusqu'à 1699,* Paris, Imprimerie de Jean-Baptiste Coignard fils, 1730, IX, p. 640.
5. R. de Piles, *Les premiers eléments de la peinture pratique enrichis des figures de proportion mesurées sur l'antique, définies et gravées par JB Corneille peintre de l'Académie royale*, Geneva, 1973, p. 63, section on 'Pour parler dans les termes [toile] toute imprimée'. Reprinted by Minkoff from Langlois 1684.
6. A. Félibien, *Des principes de l'architecture, de la sculpture, de la peinture et des autres arts qui en dépendent. Avec un Dictionnaire des Termes propres à chacun des arts*, Paris, Coignard, 1690, p. 413.
7. Ibid.: 'Imprimer: on imprime une toile ou autre chose pour peindre lorsqu'on couche une première couleur, qui sert de fond à celle qu'on doit mettre ensuite, pour faire un tableau. Les ouvriers disent imprimeure.'
8. R. de Piles, 'Toile imprimée: est une toile tendue sur un châssis et préparée pour peindre', in *Recueil sur divers ouvrages sur la peinture et le coloris*, Paris, Jombert, 1755, p. 406.
9. Félibien 1690 (cited in note 6): 'Les ouvriers disent imprimeure et quelques-uns mal à propos imprematura pour les italiens qui disent imprematura'.
10. The condition or treatment reports as well as technical reports on these paintings can be consulted at C2RMF.
11. C2RMF 72459, Rapport de restauration 30447, Chatellier 2013.
12. De la Hire 1730 (cited in note 4): 'On peint présentement à l'huile presque toujours sur toile ou sur des étoffes imprimées avec des couleurs à l'huile'; De Piles 1684 (cited in note 5), p. 63.
13. De Piles 1684 (cited in note 5), p. 63: 'On peint à l'huile sur toute sorte de chose pourvu qu'elle soit préparée.'
14. Félibien 1690 (cited in note 6), p. 413.
15. A. Schnapper, 'Bordures, toiles et couleurs : une révolution dans le marché de la peinture vers 1675', *Bulletin de la Société de l'Histoire de l'Art français*, 2000, p. 95.
16. R. Gascon and M. Baulant, *Histoire economique et sociale de la France*, Paris, PUF, 1993, p. 1.
17. De Piles 1684 (cited in note 5), p. 63: 'On trouve de ces sortes de choses toutes préparées'.
18. Félibien 1690 (cited in note 6), p. 413.
19. De la Hire 1730 (cited in note 4), p. 710.
20. C2RMF-68395-17871-Rapport laboratoire, Bruno Mottin, 2009.
21. De la Hire 1730 (cited in note 4), p. 710: 'On imprime ensuite la toile de brun rouge broyé à l'huile et médiocrement épais dans lequel on met quelque siccatif qui est pour l'ordinaire quelque mine rouge bien broyée et bien mêlée avec le brun rouge. On étend cette impression sur la toile avec le couteau comme on a fait la colle, en poussant la toile par derrière de distance en distance à mesure qu'on étend la couleur pour n'y en laisser que fort peu et seulement autant qu'il faut pour commencer à unir la toile. S'il était passé un peu de cette couleur par derrière quelques petits trous de la toile que la colle n'aurait pas bouchés, on la ratisse encore toute fraiche avec le tranchant du couteau et on laisse bien sécher cette première impression. Ensuite on ponce encore la toile pour la rendre plus unie et pour donner une autre couche.'

22. Félibien 1690 (cited in note 6), p. 415: 'Quand la toile est bien sèche on l'imprime d'une couleur qui ne fasse point mourir les autres couleurs, comme du brun rouge qui est une terre naturelle qui a du corps et avec lequel on mêle quelques fois un peu de blanc de plomb pour le faire plutôt sécher.'
23. P. Le Brun, *Manuscrit de Bruxelles,* 1635, in M.P. Merrifield, *Original Treatises on the Arts of Painting*, London, 1849, p. 821: 'Pour imprimer une thoille promptement en sorte qu'on y puis peindre le meme jour qu'elle aura été imprimée, il faut prendre colle de parchemin et imprimer à l'huile, pui broyer le tout ensemble et aussitôt en imprimer sa toille, et durcit incontinent, mais le dit imprimure est sujet à s'écailler sitot que l'on enroule la toile.'
24. Ibid., p. 843: 'Plus les toilles sont vieilles imprimées tant mieux vallent, les couleurs qu'on met après par-dessus en deviennent plus belles.'
25. Félibien 1690 (cited in note 6), p. 415: 'Pour ce qui est d'imprimer d'abord les toiles avec une couche de détrempe, il est vrai que cela ne se pratique pas souvent, parce qu'elles peuvent s'écailler et qu'elles se roulent avec l'humidité. C'est pourquoi on se contente de leur donner une imprimeure de couleurs à l'huile.'
26. Félibien 1690 (cited in note 6), p. 413: 'l'imprimeure à detrempe attire et boit l'huile qui est dans les couleurs et fait qu'elles reflètent plus belles, l'huile ôtant beaucoup de leur vivacité. C'est pourquoi ceux qui veulent que leurs tableaux demeurent frais emploient le moins d'huile qu'ils peuvent et tiennent leurs couleurs plus fermes y mêlant un peu d'huile d'aspic qui s'évapore aussitôt.'
27. C2RMF 10643, Rapport laboratoire 2015, 1986.
28. C2RMF 1163, Rapport laboratoire 387, 1971.
29. C2RMF 13400, Rapport laboratoire 1903, Jean-Paul Rioux, 1984.
30. De la Hire 1730 (cited in note 4), p. 710: 'Il y a des peintres qui se servent de ces toiles qui n'ont qu'une seule couche et ils préfèrent à celles qui en ont plusieurs, parce qu'elles font moins mourir les couleurs de la peinture et qu'elles se peuvent rouler plus facilement pour être transportées.'
31. C2RMF2533, Rapport laboratoire, Elisabeth Martin, 1987 (Cp4911-b).
32. De la Hire 1730 (cited in note 4), p. 711: 'Il y a eu des peintres fameux qui ont cru que toutes les impressions à huile gâtaient toujours les couleurs qu'on y mettait dessus : c'est pourquoi ils se sont seulement servis de toiles imprimées de blanc à détrempe et ils ont peint à l'huile par-dessus. Les couleurs des tableaux qu'ils ont peints sur ces sortes de toiles sont demeurées belles et très vives.'
33. Bergeon and Martin 1994 (cited in note 2), pp. 65–78.
34. De Piles 1684 (cited in note 5), p. 63: 'Ceux qui commencent feront bien de se servir de fonds imprimés à l'huile d'une demi-teinte douce, c'est-à-dire entre clair et obscur, parce que les couleurs que l'on y met en peignant font d'abord leur effet: mais quand on sera plus avancé, il sera bon de s'accoutumer aux toiles d'une couleur plus claire et tirant sur le gris, parce que les couleurs s'y conservent plus fraiches.'
35. Stols-Witlox 2017 (cited in note 32), p. 174.
36. De Piles 1684 (cited in note 5), p. 65: 'Il faut donc laisser cette pratique aux plus habiles qui non seulement se peuvent servir de fonds de bois quand ils veulent peindre sur le blanc mais aussi sur des toiles qui sont imprimées de cette couleur, ou à l'huile, ou à la détrempe : et si c'est à détrempe, il faut que la toile soit fine et l'impression très légère, à la manière de Titien ou de Paul Véronèse. Mais si le blanc parait trop incommode, il est libre de faire faire à détrempe une impression sur toile ou sur bois de quelle couleur l'on veut, et je ne trouverais pas hors de propos d'éteindre le grand éclat du blanc dans les impressions.'
37. C2RMF 70013, Rapport laboratoire 24026, Sigrid Mirabaud, 2012.
38. C2RMF 67758, Rapport laboratoire 21033, Sigrid Mirabaud, 2010.

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THE EFFECT OF GROUND COLOUR ON THE APPEARANCE OF TWO PAINTINGS BY THOMAS WILLEBOIRTS BOSSCHAERT IN THE ORANJEZAAL, HUIS TEN BOSCH

Lidwien Speleers, Margriet van Eikema Hommes, Ineke Joosten, Suzan de Groot and Annelies van Loon

ABSTRACT The 12 painters charged with the execution of paintings on canvas for the decoration of the Oranjezaal (1648–52) in the royal palace of Huis ten Bosch were provided with canvases already prepared with a light beige priming. Due to a change in the commission, however, one painting in the ensemble has a different canvas with a red-brown ground: *Frederick Henry as Lord of the Seas* by the Antwerp painter Thomas Willeboirts Bosschaert. A close comparison with Willeboirts Bosschaert's other painting in the Oranjezaal shows that the red-brown ground colour prompted him to use an alternative painting technique in specific passages. His working method, however, was very similar in both paintings, regardless of their ground colour. Today, the two paintings differ greatly in appearance. The striking differences seem to result from ageing phenomena – especially the increased transparancy of lead white paint and smalt paint – that have a stronger visual impact on a darker ground than on a light one.

Introduction

The Oranjezaal, the central reception hall of the royal palace Huis ten Bosch in The Hague is one of the most impressive creations of the Dutch Golden Age (Fig. 1). The decoration project was executed between 1648 and 1652 for Princess Amalia van Solms (1602–1675), who commissioned it to commemorate her late husband, the Dutch stadholder Frederick Henry, Prince of Orange (1584–1647). Dozens of paintings, both on canvas and on the hall's wooden interior, glorify his life and accomplishments. For this decorative scheme the princess chose the 'best painters of the country', as she called them: 12 eminent masters from both the Northern and Southern Netherlands.[1]

Over the centuries, several interventions have been made to the Oranjezaal's architecture, however, the monumental series of paintings has been preserved in its entirety. The paintings have undergone only a few conservation treatments over the years and have survived in a condition close to their original state: most, for instance, have not been lined but remain stretched on their original strainers. For this reason, the Oranjezaal presents a unique opportunity to study and compare the materials and techniques used by the painters.[2]

This paper discusses two paintings in the ensemble executed by the Antwerp-based painter Thomas Willeboirts Bosschaert (born Bergen op Zoom 1613/14, died Antwerp 1654). Remarkably, the grounds of these differ in colour. We examine the reason for this discrepancy and analyse the degree to which it influenced his painting process, as well as the effect it has had on the current appearance of the paintings.

Historical background

Stadholder Frederick Henry was the youngest son of stadholder William of Orange (1533–1584), who had led the resistance against Spain in the early years of the Dutch Revolt. William was succeeded by his son Maurice (1567–1625), who

Fig. 1 The Oranjezaal, Huis ten Bosch Palace, The Hague. *Frederick Henry as Lord of the Seas* (Fig. 2) can be seen to the upper left of the right chandelier. (Photo: Cultural Heritage Agency of the Netherlands.)

in turn appointed his younger half-brother Frederick Henry as his successor. The revolt lasted until 1648 when, a year after Frederick Henry's death, the peace treaty of Münster was signed. From this time, the seven Northern provinces would be known as the Republic of the United Provinces, while the Southern Netherlands remained under the authority of the Spanish crown. The stadholder was the highest official in the Republic, but not a sovereign: sovereignty resided with the States, the governing bodies of the provinces. However, the stadholder exerted much political influence and also had significant military power due to his position as Supreme Commander of the States' army.

Although Frederick Henry was not a sovereign prince (he only enjoyed this title in the small principality of Orange in the south of France), he and Amalia van Solms had princely and dynastic ambitions that were expressed in their lavish court culture, which included magnificent palaces and an extensive art collection. The couple enthusiastically collected and commissioned works by Rubens (1577–1640) and Anthony van Dyck (1599–1641). After the deaths of both masters, Thomas Willeboirts Bosschaert – whose style was closely related to that of Van Dyck – became their favourite painter. Willeboirts Bosschaert would eventually supply 24 paintings for the Orange court.[3] Hence, it was clear from the Oranjezaal's very conception that he would contribute works to this monumental hall.[4]

The Oranjezaal

In 1645, Amalia van Solms was given permission to create her own residence in the woods surrounding The Hague.[5] The architect Pieter Post (1608–1669) designed Huis ten

Fig. 2 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas*, 1650, oil on canvas, 320.5 × 208 cm. (Photo: Margareta Svensson for Royal Collections of the Netherlands.)

Fig. 3 Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance*, 1650, oil on canvas, 317 × 204.5 cm. (Photo: Margareta Svensson for Royal Collections of the Netherlands.)

Bosch around a large central reception hall, which would later be known as the Oranjezaal. After Frederick Henry's death in 1647, Amalia decided to glorify her husband in the decorations of the central hall in an effort to justify the hereditary nature of the office of stadholder and to protect the Orange dynasty.[6]

The Oranjezaal is built on the plan of a Greek cross with slanted re-entrant corners. The hall has a wooden vault supporting an octagonal lantern with circumferential windows, which is crowned by a dome. The 8 m high walls are covered with 31 paintings on canvas and 6 on panel that are embedded in a sand-coloured panelling of trompe l'oeil architecture including Corinthian pilasters, illusionistic rustication on the wainscot, and an entablature above the canvases. The wooden vault, dome and entrance door are also painted.

The paintings on canvas are arranged on two levels. The lower level depicts a classical triumphal procession, culminating in the colossal *Triumph of Frederick Henry* (1652) by Jacob Jordaens (1593–1678), which covers the entire eastern wall. Episodes from Frederick Henry's life and his personal attributes are represented on the second level; the two paintings by Willeboirts Bosschaert are part of this cycle. *Frederick Henry as Lord of the Seas* glorifies the successes at sea of the stadholder (Fig. 2). We see Neptune handing over his chariot to the stadholder, who is accompanied by Victory and putti. *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* depicts Frederick Henry as a young man of 16, with his elder brother the stadholder Maurice at the Battle of Nieuwpoort, accompanied by Victory who crowns them with a laurel wreath with a sparkling star (Fig. 3).[7]

Amalia hired architect-painter Jacob van Campen (1596–1657) to produce design sketches for the paintings; it was he who translated thematic ideas into concrete compositions and conceptualised the visual totality of the room decoration. Van Campen also coordinated the decorations' execution, a task in which he was aided by Post, as well as court secretary Constantijn Huygens (1596–1687). Supervising the project must have been extremely complex. The paintings on wood, such as on the vaulted ceilings and cupola, were done *in situ*, but the paintings on canvas were produced in the painters' individual studios, located in different cities. Clear instructions and vigilant art direction were required to achieve the desired unity between all the elements, therefore Van Campen provided sketches for each painting accompanied by written explanations.[8] None of these sketches have survived, but four brief written

Fig. 4 Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* (Fig. 3): reverse before treatment (the crossbar is not original). (Photo: Stichting Restauratie Atelier Limburg.)

instructions for the paintings still exist today. Two of these so-called *memories* – notes on what should be remembered – concern Willeboirts Bosschaert's paintings.[9] Among other things, these *memories* discuss the subject, the scale of the figures, the level of the horizon and the direction of light depicted.

An important source of inspiration for the decorative scheme of the Oranjezaal were the decorations for the 1635 festive entries into Antwerp and Ghent of the new governor of the Spanish Netherlands: Cardinal-Infante Ferdinand of Austria (1609–1641).[10] To commemorate these events, both cities published lavish albums containing prints of the decorations and explanatory texts. The book on the Ghent *Intocht* was published in 1636, while that for the Antwerp entry appeared in 1641.[11] The compositions of the two paintings by Willeboirts Bosschaert were drawn from both these publications. The horses and triton in *Lord of the Seas* rely on *The Voyage of the Cardinal-Infante from Barcelona to Genoa* that was designed by Rubens for Antwerp.[12] *Frederick Henry and Maurice as Generals* was inspired by *Charles V and his Great-grandson Ferdinand on Horseback,* which was designed for the Ghent *Intocht* and was executed by the Brussels painter Gaspar de Crayer (1584–1669).[13]

A uniform ground for all paintings

To guarantee that the paintings had the correct measurements and a good quality preparation, artists were sent the canvases already prepared. They were given the same light beige colour as the hall's wooden panelling in order to achieve unity in their visual appearance. The contract with the Haarlem *primuurder* François Oliviers (1617–1690) for the delivery of these primed canvases has been preserved. According to the contract, dated 4 December 1647, Oliviers had to stretch the primed canvases on strainers.[14]

The canvases were carefully composed of two or three strips with almost invisible seams thanks to the overcast stitch used.[15] Oliviers first gave the canvases a glue size layer. His subsequent oil ground, consisting of lead white and a little umber, was applied in one or two layers. In several paintings, small amounts of black, red earth or yellow ochre are also present. The grounds of three paintings also contain some chalk, with the grounds of four other paintings containing up to 50% chalk.[16] This indicates the use of several batches of ground paint, which is not surprising given that the 31 canvases collectively represent a surface area of hundreds of square metres.

During preparation, the canvases were laced to temporary strainers with string, as is evident from the elongated holes at the edges of the canvases and the remains of cord caught in the dried paint of the ground. Oliviers applied the priming thinly and/or smoothed it down so that in places the upper threads of the canvas are visible. This ensured that the large canvases remained flexible and could be rolled up without cracking the ground layer.[17] The fact that the Oranjezaal canvases were rolled for transport is known from a letter dated May 1649 from Oliviers to Huygens in which Oliviers mentions sending four canvases to The Hague that were rolled together according to instructions by Van Campen. Oliviers advised sending them directly to the painter(s), without first unrolling them because they were packed well.[18]

The ground and paint layers almost reach the outer edges of the canvases, indicating that they were not folded around the strainers during priming and painting. When the paintings were eventually placed in the Oranjezaal, they were stretched onto the strainers that are still in use today (Fig. 4).[19] In this last round of stretching, again with string, the edges of the canvases were tucked around these final strainers, which were smaller than those used in the priming and painting stage. This original method of stretching has remained intact in all the unlined paintings.[20] The sizes of the final strainers were customised to fit their exact location. In some areas, ground paint used for the adjacent wooden architecture has spilled onto the strainers, indicating that they were already in place before the arrival of the painted canvases. The strainers Oliviers had to deliver according to the contract are not mentioned in his letter of 1649 therefore it remains unclear whether the contract refers to the temporary strainers used during priming and painting or to the strainers intended for the final instalment of the paintings in the Oranjezaal. The latter seems the most likely.

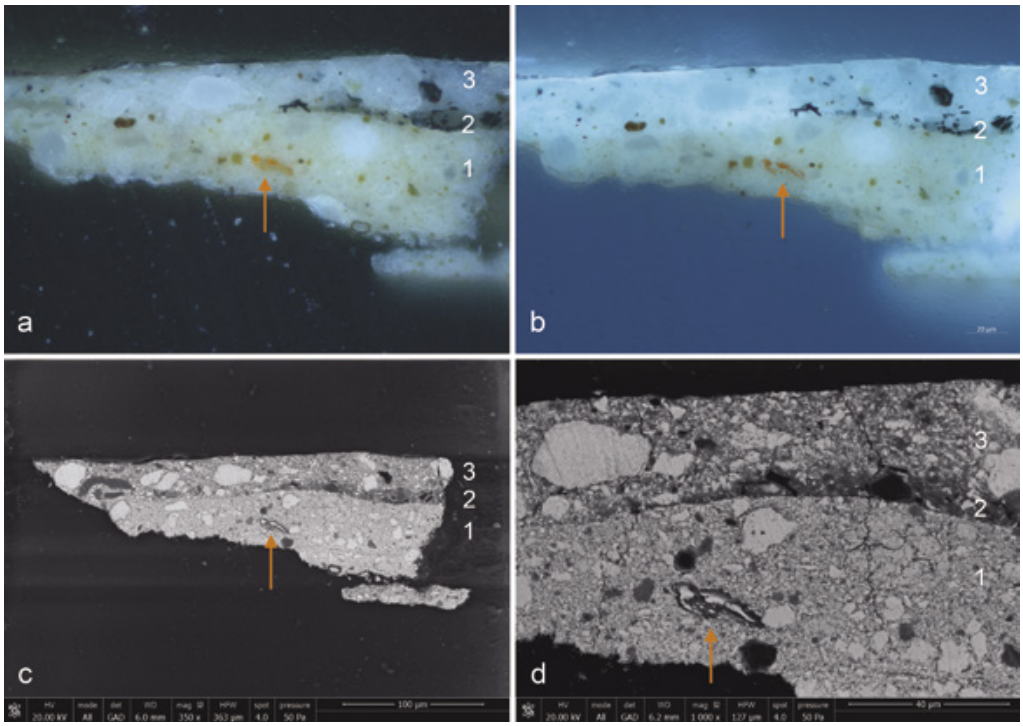

Fig. 5 Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* (Fig. 3): cross-section from the breast of the white horse including a black line of the underdrawing. (a) Visible light ×500; (b) UV light ×500; (c) and (d) SEM backscattered electron (BSE) images, ×350 (c) and ×1000 (d). From the top, the layers are: 3 = white paint of horse (20–25 µm): lead white, a little chalk, black pigment, and (organic?) brown pigment; 2 = black underdrawing (5–9 µm): charcoal black, a trace of chalk; 1 = oil ground (max. 75 µm): lead white, umber, some silicates and clay. The arrow indicates a lead soap aggregate with particles of red lead.

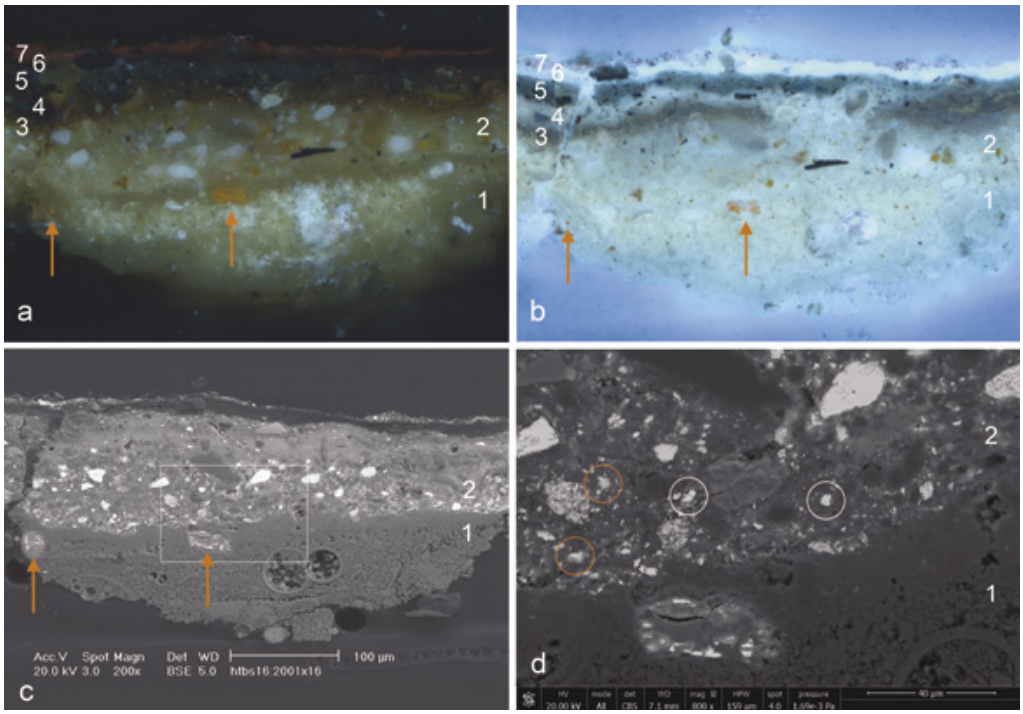

Fig. 6 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): cross-section from the sea. (a) Visible light ×200; (b) UV light ×200; (c) and (d) SEM backscattered electron (BSE) images, ×200 (c) and ×800 (d). From the top, the layers are: 7 = red paint of frame (not original); 6 = varnish layer; 5 = medium-rich layer of sea (15–20 µm): azurite, discoloured smalt, charcoal black; 4 = brown medium-rich layer with strong fluorescence in UV (0–15 µm): azurite, discoloured smalt, charcoal black, lead white, a little brown and red earth; 3 = brown medium-rich layer (15–30 µm): discoloured smalt, black pigment; 2 = second ground (30–40 µm): lead white, chalk, charcoal black, red and yellow earth. In (d) orange circles show partly saponified lead white and white circles indicate intact lead white, that has more definition in the image; 1 = first ground (max. 100 µm): chalk, some red earth, quartz and umber. The arrows show two lead soap aggregates with red lead particles. The rectangle in (c) corresponds to (d).

One divergent ground

Willeboirts Bosschaert painted *Frederick Henry and Maurice as Generals* on a canvas that was made by Oliviers, consisting of two vertical strips and primed with the usual mixture of lead white and umber (Fig. 5);[21] however, his second composition with the subject *Lord of the Seas* is the only painting in the Oranjezaal that has a different canvas and ground. This canvas, composed of only one piece 208 cm wide, averages 16 vertical (warp) and 10 weft threads per cm, deviating somewhat from Oliviers' canvases in which there is a smaller discrepancy between the number of warp and weft threads.[22] Furthermore, the painting has a double ground. The first layer, containing mainly chalk with a little red ochre, umber and black, is bound in oil.[23] Scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis identified traces of lead throughout the layer. Possibly, a lead siccative was mixed in the chalk/oil paint or an oil was used that had been processed (prepolymerised) aided by a lead siccative in order to accelerate its drying. In paint cross-sections, no lead-containing particles are visible in the layer with the exception of some red lead particles in the lead soap aggregates (Fig. 6). These particles are either the source of the lead soap aggregates or have formed over time in a remineralisation process.[24]

The second ground layer, also bound in oil and with a brown-red colour, consists of a mixture of lead white and chalk with some charcoal black and a little red and yellow ochre (Fig. 6).[25] Both grounds have been applied almost to the edges of the canvas, indicating that the canvas was fully stretched on a strainer during priming. To that end it seems to have been fixed with small pins rather than strings: the holes left in the canvas are circular, not elongated.

The extensive archival documentation surrounding the genesis of the Oranjezaal project explains this one deviation: it is related to an unforeseen change during the commission stage. The preserved *memories* reveal that Willeboirts Bosschaert's subjects were initially planned to be commissioned from two separate painters. '*Signor Willeboors*' was meant to paint only the *'Seevittorie*' (*Sea Victory*); the other canvas would be painted by '*Sign. Craeyer*', the aforementioned Brussels painter Gaspar de Crayer. This painting depicts '*de slagh van Vlaenderen*', which is the famous Battle of Nieuwpoort (July 1600). Near this coastal town in Flanders, the States' armies under the leadership of stadholder Maurice had defeated the southern troops of governor Archduke Albert of Austria (1559–1621). This was Frederick Henry's first military campaign. The decision of the court in The Hague to choose De Crayer as the painter of this subject is surprising, considering his close ties to the court in Brussels, where the Catholic governors of the Spanish Netherlands resided. De Crayer had worked for Archdukes Albert and Isabella of Austria and in 1635 he was appointed court painter to their successor Cardinal-Infante Ferdinand of Austria, a position he maintained under Archduke Leopold-Wilhelm of Austria (1614–1662), governor of the Spanish Netherlands at the time of the creation of the Oranjezaal.[26] The initial choice of De Crayer for the Oranjezaal was presumably sparked by his double portrait *Charles V and his Great-grandson Ferdinand on Horseback* for the Ghent joyous entry.

Because of his appointment in Brussels, De Crayer understandably passed on the opportunity as known by a letter from Huygens to Amalia dated 16 August 1649: 'De Crayer, the great painter of Brussels, has excused himself from making his piece by letter, under false pretexts. I believe that the true reason is, that the subject is too Huguenot and Orangistic to be executed in Brussels'.[27] De Crayer would have realised that painting the humiliating defeat of the army of the governor's predecessor Archduke Albert would be an insult to the court in Brussels.[28]

In the same letter, Huygens suggested that Amalia should ask Thomas Willeboirts Bosschaert instead, since several Antwerp painters had assured him that no one was more skilled in the painting of horses.[29] When Willeboirts Bosschaert received this second commission, he was in the midst of preparing his design for *Lord of the Seas*. This is known because Huygens wrote in the same letter that – only five or six days earlier in Antwerp – he had seen the '*eschantillons*' or models by Willeboirts Bosschaert and his fellow townsman Gonzales Coques (1614–1684), who produced one painting for the Oranjezaal. Upon completion, these designs would be submitted to Amalia for evaluation before the execution of the full-sized compositions could commence.[30]

Huygens sent another letter to Amalia on 3 September 1649 in which he relayed that Van Campen approved of the selection of Willeboirts Bosschaert as De Crayer's replacement.[31] Huygens wrote that he had immediately sent Willeboirts Bosschaert a letter by express delivery containing the second commission. He also urged him and the other Antwerp painters to send their designs to The Hague as expeditiously as possible. Of these, only the model for *Frederick Henry and Maurice as Generals* has been preserved: a small-format sketch in oil on panel with loosely indicated brushstrokes.[32]

The fact that Willeboirts Bosschaert had indeed received his second commission prior to starting work on his first canvas is also evident from the canvases themselves: the painter in fact executed his first painting depicting the *Seevittorie* on the divergent canvas, while the subsequently ordered *Frederick Henry and Maurice as Generals* was painted on the standard canvas for the Oranjezaal. Apparently he never received the second primed canvas prepared by Oliviers – perhaps because it had previously been delivered to De Crayer in Brussels – or did not do so in time. It seems that Willeboirts Bosschaert ordered a new primed canvas locally. Given the importance of the princely commission, he strove for high quality, as is apparent from his choice of a seamless canvas of over 2 m wide. Broad canvases of one width in this period were more expensive than those composed of multiple strips.[33] It is quite likely that he turned to his regular supplier Peter van Nesten (*c.*1609–?) for this new primed canvas. Van Nesten testified in 1654 'that he had frequented the house of Sieur Thomas Willeborts for at least twenty years and had primed the canvases for him'.[34] Since one of the two canvases by Oliviers was not used for the Oranjezaal, it is possible that somewhere a painting by De Crayer or Willeboirts Bosschaert still exists, executed on this Oranjezaal canvas.

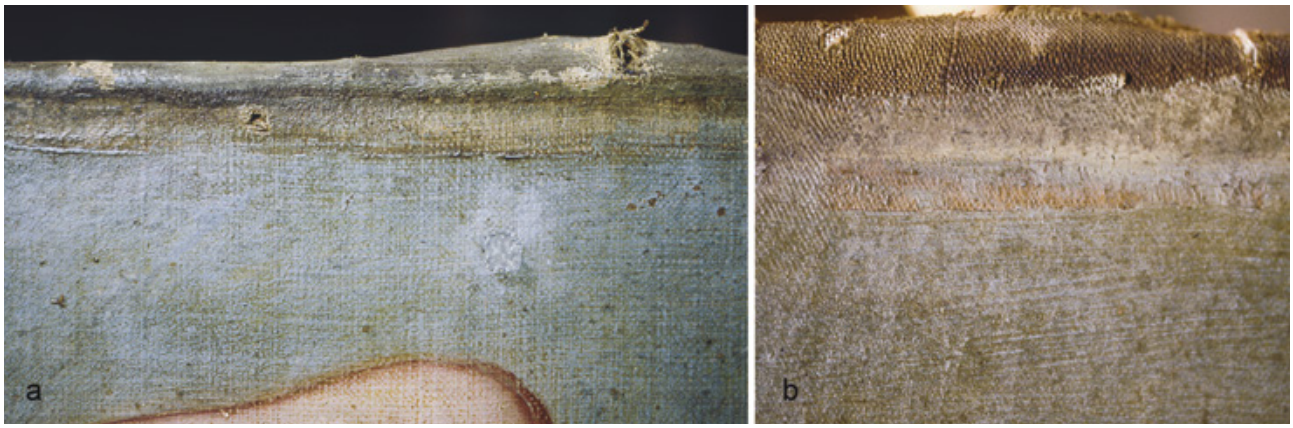

Fig. 7 (a) Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* (Fig. 3): detail. (b) Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): detail. Imprints in the wet paint suggest that both canvases were removed from their strainers while the paint was still wet and then clamped between wooden bars at the upper edge, damaging the wet paint and leaving areas of bare ground visible.

Willeboirts Bosschaert appears to have used only one strainer for the initial stretching of both his compositions which, after all, shared the same measurements. Tool and finger traces around the canvas edges demonstrate that during the painting process, while the paint was still wet, the artist unstretched the canvases. Furthermore, in both works the upper edge of the canvas shows an imprint left in the wet paint by a wooden bar, which also caused transference of wood splinters into the paint (Fig. 7). The unstretched canvas was apparently hung to dry while secured in place by wooden bars. It is possible that Willeboirts Bosschaert switched between the two canvases multiple times, as he claimed to have painted both pictures simultaneously: 'I currently have my hands on both pieces for Her Highness, although the working up will require quite some effort', he wrote to Huygens on 13 December 1649.[35]

Correspondence reveals that the court in The Hague kept pressuring the Antwerp painters about their progress, so for this reason Willeboirts Bosschaert wasted no time painting. Both of his paintings are characterised by a quick working method in which most shapes are loosely indicated, often with the help of contour lines and without much detail.[36] This swift, suggestive approach was indeed appropriate, as the artist knew from the *memories* that both his canvases would be placed at a height of over 5 m.[37] Eventually, the two paintings would be finished around May 1650.[38]

Two different ground colours

The red-brown ground of *Lord of the Seas* appears significantly darker on the painting's surface than Oliviers' beige ground. This difference in colour is surprising: it might be expected that Willeboirts Bosschaert would have preferred to use a consistent ground colour for his canvases, especially since the commission mandated the use of a uniform ground colour for all paintings.[39]

In interpreting the colours of these grounds, however, the fact that both have been subject to changes over time has to be taken into consideration. Analysis confirms that in *Frederick Henry and Maurice as Generals* some of the lead white in the ground has reacted with fatty acids from the oil binding medium, producing translucent lead soaps. One cross-section also shows a lead soap aggregate containing red lead particles. As previously mentioned, these could be the source of the aggregates or may result from a remineralisation process (Fig. 5). The formation of lead soaps from lead white leads to a loss of opaque white particles and increases the transparency of the ground. As a result, the layer will appear darker.[40] It is difficult to assess the extent of the darkening, since analytical results are ambiguous as to the degree of saponification. Fourier transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR) imaging indicates the overall presence of lead soaps in the ground of *Frederick Henry and Maurice as Generals,* suggesting that it has considerably saponified.[41] But SEM backscattered electron (BSE) images of samples demonstrate that a large number of the lead white particles remain intact, including the finer particles that typically react first.

The ground in *Lord of the Seas* has also been affected by saponification: lead soap aggregates containing red lead particles are present in the lower chalk ground (Fig. 6).[42] The second ground evidently has the most effect on the painting's appearance as it is visible on the painting's surface. Cross-sections show that this layer contains relatively few coloured pigments, not greatly exceeding those found in Oliviers' ground for *Frederick Henry and Maurice as Generals*. It is, however, significantly more translucent, and as a result appears much darker, both at the paint surface and in the cross-sections. This translucency of the ground is caused partly by the large amount of chalk which in oil medium appears light brown and semi-transparent. The saponification of the ground's lead white also plays a role. FTIR-ATR imaging demonstrates that the formation of lead soaps is restricted to specific regions of the ground. SEM-BSE images show both intact lead white (that is sharply defined) and partly saponified lead white (with halos around the particles) (Fig. 6). We can therefore assume that the ground in *Lord of the Seas* has darkened somewhat through loss of

Fig. 8 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): detail of the triton. In the hair of the triton the red-brown ground was left visible along the green leaves of the seaweed crown.

Fig. 9 Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* (Fig. 3): detail of Victory. For the light tones in Victory's knee and lower leg, opaque paints were used. In the shadows and half shadows, the underpainting in brown and beige was left visible.

white particles. At the same time, it seems extremely likely that initially this ground already had a warmer and darker tone than that of *Frederick Henry and Maurice as Generals*. This can be deduced, for instance, from the fact that in *Lord of the Seas* Willeboirts Bosschaert left the ground deliberately exposed to serve as a base colour in the bald head of Neptune and in the seaweed crown of the triton (Fig. 8): this working method only makes sense if the colour of the ground matched the red-brown flesh tones of these suntanned sea figures. Several notable differences in painting technique also support the idea that Willeboirts Bosschaert worked on grounds with two different colours.

Influence of the ground colour on the painting technique

Previous studies of 16th- and 17th-century paintings have shown that the ground colour can significantly influence the working methods of an artist.[43] A light ground can be left partly visible in the light and mid-tones, while, if covered only thinly in the dark areas, it can reflect light, so that these areas in shadow remain luminous, lively and readable. On a dark ground the artist would have to apply the light paints quite thickly in order to fully cover the ground. In the mid-tones and the shadows, however, the dark undertone can be exploited. A dark ground can also speed up the working process because it facilitates the harmony between the different elements of the composition.

Indeed, these different approaches can be found in the two pictures by Willeboirts Bosschaert in the Oranjezaal. A clear example of this are the differences in the rendering of the female figures. In *Lord of the Seas*, Victory was modelled directly onto the red-brown ground in a wet-in-wet painting technique. In *Frederick Henry and Maurice as Generals*, however, she was first elaborately underpainted with brown and sand-coloured paints. After these had dried, this female figure was loosely fashioned on top (Fig. 9). The decision whether or not to use an underpainting appears to correlate with the colour of the ground. In *Lord of the Seas* its red-brown colour already provided the desired undertone for Victory's body, which meant that an underpainting could be omitted. In both paintings, the (light) brown undertone is locally visible or is covered only thinly, allowing it to shine through in shaded sections.[44]

A difference in approach resulting from the divergent ground colour is also visible in the white horses, even though here Willeboirts Bosschaert's technique is based on similar principles. In both paintings, the horses were painted largely in one session with the different shades mixed wet-in-wet. Modelling has been achieved partly by mixing some black or brown pigment into the lead white paint, and partly by using varied thickness for the lead white paint, so that the ground colour shimmers through to varying extents. The light passages were painted with a lean lead white paint containing only a small amount of oil. For the mid-tones and shadows, fluid, more medium-rich grey

Fig. 10 Thomas Willeboirts Bosschaert, *Frederick Henry and Maurice as Generals with the Battle of Flanders in the Distance* (Fig. 3): detail of Maurice's horse modelled with white and grey paints. The ground shimmers through in the thinly painted half-shadows.

Fig. 11 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): detail of the horse showing that the paints are applied more thickly with more lead white than in Fig. 10, in order to cover the ground. Drying cracks disrupt the sky to the right.

Fig. 12 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): detail of the hands of Neptune and Frederick Henry. The skin tones in these hands entirely cover the ground even though their mid-tones match its colour.

paints were used. The light beige ground in *Frederick Henry and Maurice as Generals* provided a good base tone for this working method and the paint could be applied thinly (Fig. 10). On the other hand, in *Lord of the Seas*, Willeboirts Bosschaert had to use the lead white paint more opaquely in larger areas and needed to apply this paint as a thicker layer in order to cover the darker ground sufficiently. In this painting, he even used a very stiff 'dry' paint for the highlights to create high impasto (Fig. 11).

Willeboirts Bosschaert also exploited the light beige ground in other areas of *Frederick Henry and Maurice as Generals*. He underpainted the shapes with transparent paints and worked out their details only in thin and loose brushstrokes, particularly in the mid-tones. The face of Frederick Henry and the grey wings of Victory even lack an underpainting, since the light beige ground already offered a suitable base tone for these light-coloured sections. The artist also used the reflective qualities of the light ground to lend luminosity to dark passages. To this end, these were painted thinly, as can be seen in the brown horse and the shadows of the armour. Victory's red mantle and Frederick Henry's orange sash, by contrast, were finished in rather opaque paints. Maurice's face was also finished in densely applied paints that conceal the ground.

Despite the darker ground, a roughly similar distribution of opaque and transparently painted sections was employed in *Lord of the Seas*. Here as well, a transparent paint application was used in the armour, while opaque paint layers were again used for the orange and red draperies. The orange mantle of Frederick Henry in *Lord of the Seas* was painted in exactly the same manner as the orange sash in *Frederick Henry and Maurice as Generals*, with highlights and shadows applied in loose brushstrokes over an opaque orange base colour. The skin tones of Frederick Henry fully cover the ground, as did those of Maurice in the other painting. This also applies to most parts of the bodies of Neptune and the triton, although here, the ground was left visible in some small areas (Figs 8 and 12). In *Lord of the Seas*, such an opaque layering is surprising, since the red-brown ground could potentially have served as a base tone for these warm colours.

From this analysis, it would seem that Willeboirts Bosschaert preferred light grounds and had more experience of using them in his paintings. He made effective use of the light ground in *Frederick Henry and Maurice as Generals* while seemingly neglecting some opportunities provided by the red-brown ground in *Lord of the Seas*. Research into grounds used in other works by this artist indicates that he

Fig. 13 Thomas Willeboirts Bosschaert, *Frederick Henry as Lord of the Seas* (Fig. 2): raking light image before treatment. (Photo: Stichting Restauratie Atelier Limburg.)

nevertheless painted on both light and red-brown grounds at this point in his career.[45]

Influence of ground colour on the effect of ageing phenomena

The different grounds have had a major impact on the way the two paintings have been preserved. Before the last restoration of 1998–2001, the canvas of *Lord of the Seas* exhibited severe deformations (Fig. 13) that were alleviated during treatment. No other painting in the Oranjezaal presented these issues. It seems likely that this responsiveness to moisture and changes in relative humidity relates to the canvas or ground layers, although the mechanisms at work here are unclear. Moreover, *Lord of the Seas* is characterised by dark tonality and muted colours. This not only sets it apart from *Frederick Henry and Maurice as Generals*, but also from all other Oranjezaal paintings, which appear fresher and of a lighter tone. The sombre colour effect is primarily the result of degradation processes within the painting.[46] Firstly, as described above, the already darker and warmer ground of *Lord of the Seas* has darkened somewhat due to saponification. Furthermore, the ground has become more visible as a result of the increased transparency of oil-rich lead white paints applied on top. A comparison between today's modelling of the white horses in both paintings clearly underscores this point. At present, the animals in the two paintings exhibit a striking difference in modelling. In *Frederick Henry and Maurice as Generals*, the mid-tones and shadows of the white horse are pale with many nuances, while smoothly blending into lit passages (Fig. 11). The modelling of the white horses in *Lord of the Seas*, by contrast, is characterised by abrupt transitions and very dark and indistinct shadows. Originally, the animals must have looked quite similar. Due to its lighter ground, the increased transparency of the lead white paints has not had any adverse affect on *Frederick Henry and Maurice as Generals*, while in *Lord of the Seas* it is quite significant.[47] In the half-shadows especially, which have been modelled with diluted greys, the red-brown ground dominates, resulting in loss of nuance and abrupt transitions.

Likewise, the discrepancy in the grounds has led to a different appearance of the sky in both canvases, even though a similar ageing phenomenon has occurred. Both skies suffered from discoloration of the blue smalt pigment and simultaneous darkening of the oil medium.[48] The discoloration of smalt has made the paint more transparent, allowing the ground to shine through more clearly. As a result, the sky in *Lord of the Seas* has a dark, greyish colour, while the same ageing phenomenon has had less visual impact on *Frederick Henry and Maurice as Generals*: the discoloration of smalt is somewhat counterbalanced by the reflection of light on the beige ground layer.[49]

Other discolorations have contributed to the current sombre appearance of *Lord of the Seas*. Victory's pale green drapery would originally have been a vivid green given the presence of bright blue-green and yellow pigments: verditer, lead-tin-yellow and chalk (probably the substrate for a yellow dyestuff). This colour change is due to a combination of darkening of the oil medium and discoloration and fading of the pigments.[50] Extensive darkening of the oil medium seems to have occurred in the azurite paint of Frederick Henry's tunic and the garment of the triton – only in the highlights, where much lead white was added, has the blue colour been preserved. In the red drapery of Frederick Henry and Neptune, the modelling has been lost due to blanching and fading of the original glazes respectively. Apart from discoloration, drying cracks hamper the readability of dark passages, such as the shadows in Victory's drape and the shoulder of the triton. Moreover, they are responsible for darkening the yellow sky along the horizon, where dark underlayers are exposed (Fig. 11).

In some areas of *Lord of the Seas* the increased transparency in the upper paint layers has resulted in increased visibility of *pentimenti*, which has affected the clarity of the modelling and brightness of the colours. For instance, the left putto, added later, has a dull grey skintone because the dark paint of the sky shines through his body. In the figure of Victory, changes in the face and the fabric draped around her legs have become more apparent, negatively influencing

the luminosity of her skin colour. Finally, in some areas, abrasion of the paint during former cleaning treatments has brought the red-brown ground to the surface.

Conclusions

Willeboirts Bosschaert's two paintings in the Oranjezaal have different types of ground due to a change in the commission: one canvas was primed with the same standard beige oil ground as the other Oranjezaal paintings while the second was ordered by Willeboirts Bosschaert himself and given a red-brown ground. Although both grounds exhibit some discoloration as a result of paint deterioration (saponification), their colours differed from the start.

Despite these divergent ground colours, Willeboirts Bosschaert would have aimed to properly harmonise the tonality and colour scheme of both compositions. This is possibly why he worked on both canvases simultaneously, as he described in a letter. He took the different ground colours into account by adjusting which passages he painted in either an opaque or a more transparent manner, and in which passages he used or omitted an underpainting. However, in most instances he opted for similar techniques in both canvases, which yielded better results on the lighter ground. The fact that the colours and tonality of his two paintings appear remarkably different today results mainly from ageing phenomena in the paints, which had a different visual impact depending on the type of ground.

Acknowledgements

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Notes

1. J. Visser (ed.), *Gloria Parendi. Dagboeken van Willem Frederik, stadhouder van Friesland, Groningen en Drenthe 1643–49, 1651–54*, The Hague, Nederlands Historisch Genootschap**,** 1995, p. 540 (3 July 1648). On the choice for this large group of painters see M. van Eikema Hommes, '"As though it had been done by just one Master". Unity and diversity in the Oranjezaal (1648–1652), Huis ten Bosch', in A.W.A. Boschloo, J.N. Coutre and S. Dickey (eds), *Aemulatio: Imitation, Emulation and Invention in Netherlandish Art from 1500 to 1800. Essays in Honor of Eric Jan Sluijter*, Zwolle, Waanders, 2011, pp. 288–303; M. van Eikema Hommes and E. Kolfin, *De Oranjezaal in Huis ten Bosch. Een zaal uit loutere liefde*, Zwolle, Waanders, 2013, pp. 169–177.
2. Examination of the paintings and paint cross-sections as well as art historical research was performed by Lidwien Speleers and Margriet van Eikema Hommes. The paintings were studied before, during and after the restoration of the ensemble (1998–2001) by Stichting Restauratie Atelier Limburg (SRAL). Preliminary research on paint cross-sections was carried out by Karin Groen and Annelies van Loon, Cultural Heritage Agency of the Netherlands (RCE). Research into the painting techniques was continued by Speleers and van Eikema Hommes within the MOLART Program funded by the Netherlands Organisation for Scientific Research (NWO), and the project 'Comparative Studies of Paintings in the Oranjezaal' (project leader Prof. A. van Grevenstein) as part of the NWO-funded De Mayerne Research Program. Within these two NWO projects, analysis of painting materials and degradation processes was carried out by Annelies van Loon, Ester Ferreira, Gisela van der Doelen and others, under the supervision of Prof. Dr Jaap Boon (FOM Institute AMOLF, Amsterdam). Their work was supported by the FOM-approved research programs 28 and 49 granted to Boon. Additional analysis of the ground and paint layers was performed with scanning electron microscopy with energy dispersive X-ray (SEM-EDX) analysis by Ineke Joosten (RCE) and Fourier transform infrared spectroscopy with attenuated total reflection (FTIR-ATR) imaging by Suzan de Groot (RCE).
3. P. van der Ploeg and C. Vermeeren, '"Uijt de penningen van de zeeprinsen". De stadhouderlijke schilderijenverzameling', in P. van der Ploeg and C. Vermeeren (eds), *Vorstelijk Verzameld. De kunstcollectie van Frederik Hendrik en Amalia*, exh. cat., The Hague, Royal Cabinet of Paintings Mauritshuis, Zwolle, Waanders, 1997, pp. 34–60, esp. p. 57; J.G. van Gelder, 'De opdrachten van de Oranje's aan Thomas Willeboirts Bosschaert en Gonzales Coques', *Oud Holland* 64(1), 1949, pp. 41–56.
4. While the choice for various painters had not yet been finalised, Willeboirts Bosschaert had already been chosen. His name appears on two lists of artists' names: P. van der Heiden, Archiefonderzoek Oranjezaal, *De Oranjezaal. Catalogus en Documentatie*, 2015, http://oranjezaal.rkdmonographs.nl/archiefonderzoek. See also van Eikema Hommes and Kolfin 2013 (cited in note 1), pp. 54 (fig. 23) and 57 (fig. 26).
5. For the building history see van Eikema Hommes and Kolfin 2013 (cited in note 1), pp. 35–61.
6. B. Brenninkmeyer-de Rooij, 'Notities betreffende de decoratie van de Oranjezaal in Huis Ten Bosch', *Oud Holland* 96(3), 1982, pp. 133–190; H. Peter-Raupp, *Die Ikonographie des Oranjezaal.* Hildesheim and New York, Georg Olms Verlag, 1980; van Eikema Hommes and Kolfin 2013 (cited in note 1), pp. 63–115.
7. M. van Eikema Hommes and L. Speleers, 'Cat. no. 09. Thomas Willeboirts Bosschaert, Frederik Hendrik en Maurits als veldheren met in het verschiet de slag van Vlaanderen [1650]', in *De Oranjezaal. Catalogus en Documentatie*, 2015, http://oranjezaal.rkdmonographs.nl/cat.-nr.-09; M. van Eikema Hommes and L. Speleers, 'Cat. no. 17. Thomas Willeboirts Bosschaert, Frederik Hendrik als heerser over de zeeën [1650]', in *De Oranjezaal. Catalogus en Documentatie*, 2015, http://oranjezaal.rkdmonographs.nl/cat.-nr.-17
8. See letters by Huygens and Jordaens: Briefwisseling van Constantijn Huygens 1607–1687 http://resources.huygens.knaw.nl/briefwisselingconstantijnhuygens/brieven, nos. 4974, 4997, 5132. See also J.A. Worp, *Briefwisseling van Constantijn Huygens*, 6 vols, The Hague, Martinus Nijhoff, 1911–1917, vol. 5, 1916, nos. 4974, 4997, 5132; van Eikema Hommes and Kolfin 2013 (cited in note 1), pp. 48–58; L. Speleers and M. van Eikema Hommes, 'Jordaens and the Oranjezaal in Huis ten Bosch Palace: the paintings and the letters', in B. Münch and Z. Pataki (eds), *Jordaens: Genius of Grand Scale*, Stuttgart, ibidem-Verlag, 2012, pp. 131–163; I. Broekman, *Constantijn Huygens, de kunst en het hof*, PhD thesis, University of Amsterdam 2010, pp. 150–152.
9. For transcriptions see van der Heiden 2015 (cited in note 4); D.F. Slothouwer, *De Paleizen van Frederik Hendrik*, Leiden, A.W. Sijthoff, 1945, p. 318.

10. Van Eikema Hommes and Kolfin 2013 (cited in note 1), pp. 209–214.
11. Respectively: G. Becanus, *Serenissimi principis Ferdinandi Hispaniarum infantis S.R.E. cardinalis triumphalis introitus in Flandriae metropolim Gandavum*, Antwerp, 1636 and J.C. Gevartius and P.P. Rubens, *Pompa introitus honori serenissimi principis Ferdinandi Austriaci Hispaniarum infantis …*, Antwerp, 1641. For the Antwerp publication, Theodoor van Thulden made the prints after Rubens' designs. Van Thulden would contribute to the Oranjezaal with six paintings. See also J.R. Martin, *The Decorations for the Pompa Introitus Ferdinandi*, Corpus Rubenianum Ludwig Burchard, vol. 16, Brussels, Arcade, 1972; C. van der Velde and H. Vlieghe, *Stadsversieringen te Gent in 1635 voor de blijde intrede van de Kardinaal-infant*, Ghent, Oudheidkundig Museum van de Stad Gent, 1969.
12. Gevartius and Rubens 1641 (cited in note 11), plate 7. For an image: Amsterdam, Rijksmuseum, cat. no. RP-P-OB-70.247. Rubens' sketch is in the Harvard Art Museums, Cambridge, MA, USA, cat. no. 1942.174.
13. Becanus 1636 (cited in note 11), pl. 20. For an image: Rijksmuseum, cat. no. RP-P-OB-70.222. The painting by De Crayer is in the town hall of Ghent, Belgium. See also A. Heinrich, *Thomas Willeboirts Bosschaert (1613/14–1654): ein flämischer Nachfolger Van Dycks*, Turnhout, Brepols**,** 2003, p. 307; J. Foucart, 'Une esquisse de Willeboirts pour la Huis ten Bosch', *Oud Holland* 82(1), 1967, pp. 57–59. Portraits of a ruler on horseback being crowned with a laurel wreath by a winged female figure had previously been painted by artists from the Southern Netherlands, for instance in Rubens' Medici cycle (1621–25) for the Palais Luxembourg in Paris, a painting scheme that formed another inspiration for the Oranjezaal.
14. Royal Archives, Archive Frederick Henry A14-XIII-23: 'geplaneert en tot schilderen bereidt, soo dat monsr van Kampen sal oordeelen deselve loffelick te wesen, mits gaders de respectieve ramen daer toe behoorende met gem. doecken daer op gespannen en vast gemaekt naer behooren'; van der Heiden 2015 (cited in note 4); van Eikema Hommes and Kolfin 2013 (cited in note 1), p. 48; J.G. van Gelder, 'De schilders van de Oranjezaal', *Nederlands Kunsthistorisch Jaarboek* 2, 1948–1949, pp. 121–122. On the little that is known of Oliviers' life see M. Franken and L. Speleers, 'De schildersdoeken en hun gronderingen in de Oranjezaal, Huis ten Bosch', forthcoming. Van der Willigen has erroneously dated his death to 1667 based on a misinterpretation of the archival record. The document in question in fact does not refer to Oliviers' burial, but to that of one of his children: A. van der Willigen, *Les artistes de Harlem; notices historiques avec un précis sur la gilde de St. Luc*, Haarlem/The Hague 1870, facsimile Nieuwkoop, B. de Graaf, 1970, p. 233.
15. Franken and Speleers forthcoming (cited in note 14).
16. Respectively cat. nos 12, 32, 35 and cat. nos 4, 13, 23, 24. Pigments identified with SEM-EDX: K. Groen, *Onderzoek naar schildertechnische aspecten op de schilderijen in de Oranjezaal in Huis ten Bosch*, report Instituut Collectie Nederland (now RCE), Amsterdam 1999. Binding medium analysis using DTMS by Gisela van de Doelen in 2000 and Ester Ferreira in 2004: E. Ferreira, *Grounds from the Oranjezaal Paintings*, report FOM Institute AMOLF, Amsterdam 2004.
17. As explained by the French art theorist Dupuy du Grez: 'mais on y employe si peu de couleur qu'il se peut, de peur qu'elle ne soit cassante, lors qu'on voudra rouler la toile. … Mais quand la toile est bonne & fine, le moins qu'on y peut mettre de couleur pour l'imprimer, c'est toûjours le meilleur': B. Dupuy du Grez, *Traité sur la peinture pour en apprendre la théorie et se perfectionner dans la pratique*, Toulouse, 1699, reprinted Geneva, Minkoff Reprints, 1972, pp. 244–245.
18. *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 3260 (May 1649): 'Uijt Haarlem den (?) Meij 1649 … De doecke heb ick bijeen gerolt volgens het schrijve van Mons. van Campe. Deselve doecke moge zonder zorgh zoo voorder gesonde werde, want die heel wel besorght sijn.' Worp 1911–1917 (cited in note 8), vol. 3 (1914), no. 3260 has wrongly dated the letter 1643. We hesitate to accept his transcription of the date as 27 May.
19. Only Gonzales Coques' *Willem II receives the Survivance* has lost its original strainer: http://oranjezaal.rkdmonographs.nl/cat.-nr.-18.
20. Only 5 of the 31 canvases were lined in the past. During the Oranjezaal restoration (1998–2001), strings that were lost were replaced and more recent restorations with nails were undone.
21. Left canvas strip *c.*101.5 cm; right canvas strip *c.*112.5 cm. Some quartz and clay is present, associated with the umber pigment. Also present are round transparent particles that contain high quantities of phosphorus and magnesium, and some potassium and calcium, all analysed with SEM-EDX.
22. *Frederick Henry and Maurice as Generals* has an average thread count of 12.6 warp threads per cm (12–13 threads per cm) and 10.4 weft threads per cm (9–12 threads per cm). The weave density of Oliviers' canvases varies per painting. The thread counts were done by Michiel Franken as part of his analysis of the Oranjezaal canvases.
23. Pigments analysed with SEM-EDX. FTIR-ATR imaging has shown the presence of infrared bands typical for calcium carbonate and a carbonyl band at 1732cm^{-1}, suggesting the presence of a drying oil. However, other specific absorption bands of a drying oil are masked by the broad carbonate band of calcium carbonate. No absorption bands suggesting the presence of an aqueous medium were found. The occurrence of lead soaps in the layer is further evidence of the presence of oil. In theory this oil could have sunk in from the oil-bound ground layer above, however the presence of traces of lead throughout the first ground layer is indicative of the use of a lead drier, which would only make sense in an oil-bound layer.
24. P. Noble, 'A brief history of metal soaps in paintings from a conservation perspective', in F. Casadio, K. Keune, P. Noble, A. van Loon, E. Hendriks, S.A. Centeno and G. Osmond (eds), *Metal Soaps in Art: Conservation and Research*, Cham, Springer, 2019, pp. 1–22, esp. pp. 6–9; J.J. Boon, F. Hoogland and K. Keune, 'Chemical processes in aged oil paints affecting metal soap migration and aggregation', in H. Mar Parkin (ed.), *AIC Paintings Speciality Group Postprints* 19, 2006, pp. 16–23; C. Higgitt, M. Spring and D. Saunders, 'Pigment-medium interactions in oil paint films containing red lead or lead-tin yellow', *National Gallery Technical Bulletin* 24, 2003, pp. 75–95.
25. Pigments analysed with SEM-EDX. Binding medium analysis with FTIR-ATR imaging by the authors and with GCMS by Gisela van der Doelen, FOM Institute AMOLF.
26. H. Vlieghe, *Gaspar de Crayer; sa vie et ses oeuvres*, Brussels, Arcade, 1972.
27. *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 4969 (16 August 1649): 'Craijer, le grand peintre de Bruxelles, s'est excusé par lettre de faire sa piece, sous des pretextes controuvez. Je croij que la veritable raison est, que le subject est trop Huguenot et Orangeois, pour estre executé dans Bruxelles.'
28. Vlieghe 1972 (cited in note 26), 1, pp. 41–58.
29. *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 4969 (16 August 1649).
30. Ibid., 'A Anvers je vis il ij a 5. ou 6. jours les eschantillons ou modelles de Willeboirt et Gonçales des pieces qui leur ont esté ordonnées, et je faij estat de les trouver à la Haije, pour les

monstrer à V.A. et en sçavoir ses sentimens, san quoij je n'aij rien voulu prendre à ma charge.'

31. *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 4974.
32. 24.5 × 15.5 cm. Paris, Musée du Louvre, inv. no. R.F. 1938–28. See Foucart 1967 (cited in note 13), and van Eikema Hommes and Speleers 2015 (cited in note 7), fig. 8.
33. This follows analysis of 17th- and 18th-century newspaper advertisements by *primuurders*. This study, carried out by Ige Verslype, Rijksmuseum Amsterdam, will be published in her doctoral dissertation on the technical developments in painted wall hangings (expected 2022).
34. E. Duverger, *Antwerpse kunstinventarissen uit de zeventiende eeuw*, vol 7: 1654–1658, Brussels, Peeters Publishers, 1993, nos. 1964 and 1965, pp. 85–86: 'dat hij wel twintich jaeren te huijse van de selven Sieur Thomas Willeborts heeft gefrequenteert ende voor denselven de doecken gepremuert'.
35. Willeboirts Bosschaert to Huygens 13 December 1649: *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 5014: 'Ick hebbe de stucken voor Haere Hoocheyt alle beijde in handen hoe wel aent opmaecken sal noch al wat werck vallen.'
36. The painting technique has been thoroughly discussed in van Eikema Hommes and Speleers 2015 (cited in note 7).
37. 'staet hoogh 16 voet uijt de vloer'. The *Rijnlandse voet* was used here, which measures 31.4 cm. Willeboirts Bosschaert also composed his figures to be seen slightly from below and positioned the horizon low within the composition.
38. Willeboirts Bosschaert to Huygens 19 March 1650: *Briefwisseling van Constantijn Huygens 1607–1687* (cited in note 8) no. 5033.
39. It is possible that Willeboirts Bosschaert had already ordered a new primed canvas in advance of receiving the one from Oliviers. It does not seem plausible that Willeboirts Bosschaert had obtained a newly primed canvas from De Crayer since this painter appears to have worked mainly on light grey grounds during this period. De Crayer only used a chalk ground under a second oil ground occasionally: see E. Martin, 'Grounds on canvas 1600–1640 in various European artistic centres', in J. Townsend, T. Doherty, G. Heydenreich and J. Ridge (eds), *Preparation for Painting: The Artist's Choice and its Consequences*, London, Archetype Publications, 2008, pp. 59–67. *Christ on the Cross* in Geraardsbergen and two paintings with *Saint Paul and Antonius in the Desert* in the Royal Museums of Fine Arts of Belgium, Brussels, have light grey grounds. Of the last two paintings, one can be dated around the time of the Oranjezaal (inv. no. 61, A220 in Vlieghe 1972 [cited in note 26]). Hélène Dubois, then Royal Museums of Fine Arts of Belgium, personal communication, 2007. See also G. Messens and H. Vlieghe, 'Christus aan het kruis met vier heiligen door Gaspar de Crayer te Geraardsbergen', *Bulletin de l'Institut Royal du Patrimoine Artistique/Bulletin van het Koninklijk Instituut voor het Kunstpatrimonium* 23, 1990–1991, pp. 123–133.
40. SEM-EDX and FTIR-ATR imaging. Lead soap aggregates with red lead particles are a rare find in the cross-sections of Oliviers' grounds in the Oranjezaal. On lead soaps see Noble 2019 (cited in note 24), pp. 1–22 and references therein on transparency, esp. pp. 10–11; P. Noble, A. van Loon and J. Boon, 'Selective darkening of ground and paint layers associated with the wood structure in seventeenth-century panel paintings', in J. Townsend, T. Doherty, G. Heydenreich and J. Ridge (eds), *Preparation for Painting: The Artist's Choice and its Consequences*, London, Archetype Publications, 2008, pp. 68–78, esp. p. 75.
41. The absorption band at 1509 cm^{-1} is specific for lead carboxylates.
42. In Fig. 6 lead soaps and red lead particles are visible at the interface of the first and second ground layer. In SEM-BSE images of other cross-sections, lead soaps and red lead particles are also visible at the bottom of the first ground layer.
43. H. Miedema and B. Meijer, 'De introduktie van de gekleurde schildergrond en de invloed daarvan op de stilistische ontwikkeling van de schilderkunst in het bijzonder in de Nederlanden van de 16de eeuw', *Proef* (July 1973), pp. 123–150; H. Miedema and B. Meijer, 'The introduction of coloured ground in painting and its influence on stylistic development, with particular respect to sixteenth-century Netherlandish art', *Storia dell' arte* 35, 1979, pp. 79–98. On the use of light and coloured grounds by Rembrandt: E. van de Wetering, *Rembrandt the Painter at Work*. Amsterdam, Amsterdam University Press, 1997, chs 2 and 8; by Caravaggio: L. Keith, 'Three paintings by Caravaggio', *National Gallery Technical Bulletin* 19, 1998, pp. 37–51. That the ground colour could seriously influence the appearance of a painting is described by Gerard de Lairesse in his *Groot Schilderboek*, 2 vols, Amsterdam 1707, 1, pp. 329–330. He explained how he once wrestled with a set of ceiling paintings for which the client had supplied him with the primed canvases, one of which had a ground that was not the same colour as the others. As he was painting De Lairesse found it impossible to key the colours of the shadows of the forms painted on the anomalous canvas to those on the others. Although he did his 'utmost to remedy this in the finishing as best I possibly could, and make it the same as the others' ('en schoon ik zulks in t opmaaken, zo veel my mogelyk was, trachtte te verhelpen, en met d'anderen gelyk te maaken'), the differences could still be seen.
44. Even taking into consideration the fact that this effect has been amplified by the increased transparency of the paint layers due to ageing, see below.
45. *The Ascension of Christ* (1651) in Roermond Cathedral has a brown-red ground (Jos van Och, SRAL, personal communication, 2013). A double ground of chalk-glue and a light oil ground (lead white, black, earth pigments) was used for *The Apotheosis of the Virgin* (Rijksmuseum inv. no. SK-A-598) attributed to Willeboirts Bosschaert. *Mars Receives the Weapons from Venus and Vulcan* (*c.*1646–1654) (Rijksmuseum inv. no. SK-C-400) has a light greyish ground (Gwen Tauber and Barbara Schoonhoven, Rijksmuseum, personal communication, 2007).
46. This is more evident in the Oranjezaal itself than in the photograph, which required strong illumination.
47. FTIR-ATR imaging and analysis of the (almost pure) lead white paint used for the breast of the white horse in *Frederick Henry and Maurice as Generals* indicates it has saponified. In the SEM-BSE image (Fig. 5c and d) some particles show the halos typical for saponification, but not all have reacted away completely.
48. On smalt degradation see J.J. Boon, K. Keune, J. van der Weerd and M. Geldof, 'Imaging microspectroscopic, secondary ion mass spectrometric and electron microscopic studies on discoloured and partially discoloured smalt in cross-sections of 16th century paintings', *Chimia* 55, 2001, pp. 952–960; M. Spring, C. Higgitt and D. Saunders, 'Investigation of pigment-medium interaction processes in oil paint containing degraded smalt', *National Gallery Technical Bulletin* 26, 2005, pp. 56–69.
49. On the (dis)advantages of light versus darker grounds as mentioned in historical documents see M. Stols-Witlox, '"By no means a trivial matter": the influence of the colour of ground layers on artists' working methods and on the appearance of oil paintings, according to historical recipes from North West Europe, c. 1550–1900', *Oud Holland* 128(4), 2015, pp.

171–186, esp. pp. 177–178; M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900*, London, Archetype Publications, 2017, pp. 155–160.
50. A. van Loon and L. Speleers, 'The use of blue and green verditer in green colours in the mid-seventeenth-century paintings of the Oranjezaal, The Hague', in M. Spring (ed.), *Studying Old Master Paintings: Technology and Practice,* London, National Gallery, 2011, pp. 260–268; D. Saunders and J. Kirby, 'Light-induced colour changes in red and yellow lake pigments', *National Gallery Technical Bulletin* 15, 1994, pp. 79–97.

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ARE THE CHANGED APPEARANCES OF CAREL FABRITIUS' PAINTINGS A CONSEQUENCE OF MOBILITY?

Jørgen Wadum

ABSTRACT One of Rembrandt's most talented pupils, Carel Fabritius (1622–1654), has a limited oeuvre owing to his premature death in the Delft Gunpowder Explosion of 1654. Despite only 12 years of activity, Fabritius' ambitious, large history paintings from the 1640s differ considerably in style and execution from the smaller works he produced during his final years in Delft. All this presents a challenge to our understanding of the artist's development within such a short time span. In order to understand these differences, the influence of the colour of the grounds applied to canvases or panels prior to the actual painting process on the painting technique and on the final appearance, seemed a promising approach. Overall, the changes in the colour of the grounds were found to relate to the artist's mobility, from Middenbeemster to Amsterdam and then his final move to Delft.

Introduction

Carel Fabritius' oeuvre varies from large-scale history paintings with a strong *chiaroscuro* made in Amsterdam (1635–1650) to smaller and brighter images produced during his final years in Delft (1650–1654): traditionally, such artistic development is explained by the influence of teachers and contemporaries or more recently by artistic and economic competition. By examining the used supports and grounds, this paper investigates whether the changes in Fabritius' work could be due to his mobility and the availability of artists' materials in different towns. The results will assist us in understanding Fabritius' oeuvre and artistic development, and aid in comparing his achievements with those of his contemporaries in the local artistic milieu. These questions are not new: many were addressed by Karin Groen in her research into the use of grounds in Rembrandt's studio and beyond.[1] Interestingly, she concluded that when the results of the analysis of a large number of ground samples were arranged in the presumed chronological order, clusters of types of ground immediately became apparent.[2]

Technical research, conducted in preparation for the Fabritius exhibition that took place in The Hague and Schwerin in 2004–2005, attempted to clarify the chronology of the artist's undated and unsigned paintings and improve the chronology of works by or attributed to Fabritius. This paper presents the results of those technical investigations, partly published elsewhere.[3] For the first time, information on the ground layers used by Fabritius' teacher Rembrandt is incorporated, as well as those used by other painters active in Delft in the 1650s, including his younger Delft successor Johannes Vermeer.

The life of Carel Fabritius

Carel Fabritius was born in 1622 in Middenbeemster, a small town some 25 km north of Amsterdam. He was the son of the local schoolteacher, sacristan and cantor in the Reformed Church, Pieter Carelsz. Fabritius and his wife Barbara Barentsdr. van Maes. A few years earlier, Pieter Carelsz. had obtained permission to supplement his duties as a teacher by adding the art of painting to the curriculum.[4] This is of importance when understanding the early careers of Carel Fabritius and his two brothers Barend and Johannes, who all became painters after early training by their father. No document refers to Carel's activities between his birth in 1622 and his marriage in 1641, the year he supposedly moved to Amsterdam with his new bride Aaltje Velthuys.[5] In the past, it was generally accepted that Fabritius worked as an older assistant in Rembrandt's studio from around 1641 to 1643, but based on a new reading of his numerous and frequent connections and contacts in both Middenbeemster and Amsterdam, Gero Seelig argued

convincingly that Fabritius knew Rembrandt and worked with the master as early as 1635.[6] Presumably, his marriage in 1641 marked the end rather than the start of his apprenticeship with Rembrandt.[7] Fabritius' presence in Rembrandt's studio is not documented by any contracts or papers, but he is mentioned by Samuel van Hoogstraten (1627–1678) as a 'fellow pupil' (*medeleerling*) in his *Inleyding tot de hooge schoole der schilderkonst* (1678).[8]

Fabritius and his wife seem to have lived in Amsterdam from 1641, where they had a child baptised in March 1643. Aaltje died not much later, possibly as a consequence of childbirth. The inventory made of their possessions lists household items and a number of paintings with descriptions that may allude to some of the artist's early paintings, including several *tronies*.[9] In addition, the inventory lists '*een gepluijmuurde doec*' (a primed canvas) and '*drij gepluijmeerde doecken*' (three primed canvases), possibly acquired ready primed. It should be noted, however, that his late wife's father was an Amsterdam cloth merchant who may therefore have provided canvas to the young painter.

After his wife's funeral, Carel Fabritius is recorded in June 1643 as having returned with a baby daughter to Middenbeemster, where he stayed with his parents. In August that same year his daughter died and Fabritius, at the age of just 21, had now lost a wife and three children. Archival information from 1646, 1649 and 1650 confirms that he still lived and worked in Middenbeemster, but for Amsterdam clients. The sparsely populated Middenbeemster would not have afforded him sufficient clientele, and it is probable that Fabritius travelled back and forth to Amsterdam periodically.[10] He seems to have continued his association with Rembrandt and the Amsterdam art market in this period.

Fabritius met his second wife, a widow, Agatha van Pruyssen, in Amsterdam, and after their marriage in Middenbeemster they moved to Delft in 1650.[11] He may have hoped that his second wife with her family connections in Delft would help him find patrons. Carel Fabritius entered the Delft Guild of St Luke as a painter in 1652.[12] On 12 October 1654, Fabritius was killed in the notorious Delft Gunpowder Explosion (also known as the Delft Thunderclap) and buried two days later. His colleague and friend Egbert van der Poel (1621–1664) painted the scene of devastation in Delft in which one quarter of the city was severely damaged, more than 50 people died and thousands of people were injured.[13] In 1667, Arnold Bon wrote of Carel Fabritius in an eight-stanza poem that he was 'the greatest artist … that Delft or Holland ever had'.[14]

Approach: the technical findings

In less than 15 active years as a painter, Fabritius lived in three different towns: Middenbeemster, Amsterdam and Delft. His limited yet highly diverse oeuvre consists of 13 paintings: 11 canvases and 2 panels. This paper focuses on the signed paintings and the works attributed to Fabritius;[15] art historical literature is followed for assessing the execution period of the undated paintings.[16]

Technical analyses of Fabritius' paintings reveal that the combined effect of the materials, especially the nature of preparatory paint layers below the surface, determines our perception of the final image and may also contribute to understanding the chronology of an artist's works. Visual examination of the colour of the ground layers and their impact on our perception of the painted image must take into account whether or not a painting was wax-resin lined in the past. In her dissertation, Emilie Froment demonstrated that the experimental ground reconstructions became darker and cooler in hue when impregnated with wax-resin. The influence of the hiding power of the grounds was found to be a key factor: all the grounds that underwent colour change had poor hiding characteristics. This confirmed that the colour of the underlying canvas, which had darkened significantly after wax-resin treatment, has a strong darkening influence on the colour change measured at the surface of the grounds.[17]

Fabritius' canvases and grounds

Fabritius' paintings were executed mainly on canvas. This type of support can provide clues as to the eventual series of paintings, that is, paintings produced on canvas from the same bolt and therefore close in time. The colour of the ground is important as it determines the choice of paint materials and the artist's technique, as both painted and unpainted areas are influenced by the ground's tonal values. Working rapidly and leaving some of the ground exposed, as Rembrandt often did, meant that the ground would need to have a mid-tone to allow him to create a convincing *chiaroscuro*.[18]

The materials used for grounds were generally cost-efficient and typically composed of chalk and earth pigments bound in glue and/or oil. In the 17th century, commercially prepared supports were widely available.[19] The local *plamuurder* would have used mostly local materials for the ground layers, indicating that the composition and colour of the ground layers could reflect the different towns in which the artist worked.[20] If indeed the colour of the ground, or specific pigment combinations or layering are unique to a certain artist, time or artistic centre, large datasets of ground layers and their colour are of paramount importance for mapping their development and differences.

Amsterdam: Rembrandt's studio *c.*1640–1645

The weave of the large canvas depicting the *Raising of Lazarus* (1641–43) is comparable to that of the slightly smaller painting, *Hagar and the Angel* (1643–45) (Figs 1 and 2a).[21] Both monumental works are made from two strips of canvas sewn horizontally together. Since the bottom edge of the *Raising of Lazarus* shows a selvedge, we can deduce that the width of the roll of linen was 1¾ *el* (*c.*117 cm) from the edge to the seam. This is identical to the top strip of canvas used for *Hagar and the Angel*. Unsurprisingly, a study of the weave of the linen showed that both fabrics are densely woven with 15

Fig. 1 Carel Fabritius, *Raising of Lazarus*, 1641–43, signed 'CAR. FABR', oil on canvas, 210.5 × 140 cm, National Museum, Warsaw, inv. no. M.Ob.563. (Image: Piotr Ligier/NMW.)

Fig. 2 (a) Carel Fabritius, *Hagar and the Angel*, 1643–45, signed 'C.P. Fabritius', oil on canvas, 157.5 × 136 cm, The Leiden Collection, New York City, inv. no. CF-100. (b) Cross-section showing sample 4: the ground was found to contain lead white, ochre, vermilion and carbon-based black pigments. (Courtesy M. Gallagher and S.A. Centeno.)

threads per cm in the warp direction and 14 threads in the weft. Although speculative, it is possible that both paintings could have been made of linen from the same bolt and might therefore have been created fairly close in time. The two canvases would have been stretched on large strainers and the ground applied with a large priming knife.

The large canvas of the *Raising of Lazarus* was prepared with a double ground layer. The first ground layer consists of a mixture of red-brown earth, whereas the second layer contains large grains of lead white, unidentified blue (smalt?) and a little black.[22] Informed by a Wallonian *primeur*, Théodore Turquet de Mayerne recommended exactly this type of ground when he wrote:

> when the size is dry, prime rather lightly with brown-red, or red-brown from England. Let it dry, and make it smooth with pumice stone. Then prime with a second and last layer of lead white, [and] well-chosen charcoal. Small [coals] and a little umber earth to make it dry faster. One can give it a third layer, but two is all right, and [such a ground] will never crack, nor cleave.[23]

Comparable priming layers can be found on paintings produced in Rembrandt's workshop and by his Amsterdam contemporaries in the early 1630s until the early 1640s. In this period, the material composition of the ground layers changed into less finely pulverised pigment particles that were warmer and somewhat darker in tone, compared to the early light-medium grey on red double grounds.[24]

As already mentioned, the large *Hagar and the Angel* painting was executed on a canvas constructed from two pieces of medium-weight, plain-weave fabric joined with a horizontal seam. Most of the left tacking margin remains intact and contains fragments of paint, which match that of the painting. It is unclear whether this edge was originally part of the finished composition or if the artist turned it over during the painting process.[25] This support was prepared differently with a buff-coloured ground in a single layer (Fig. 2b) and with sweeping marks that are visible in the X-radiograph, indicating that the ground was applied with a palette knife.[26]

Fig. 3 Carel Fabritius, *Mercury, Argus and Io*, 1645–47, signed 'Carolus Fabritius', oil on canvas, 72.4 × 102.5 cm, Los Angeles County Museum of Art.

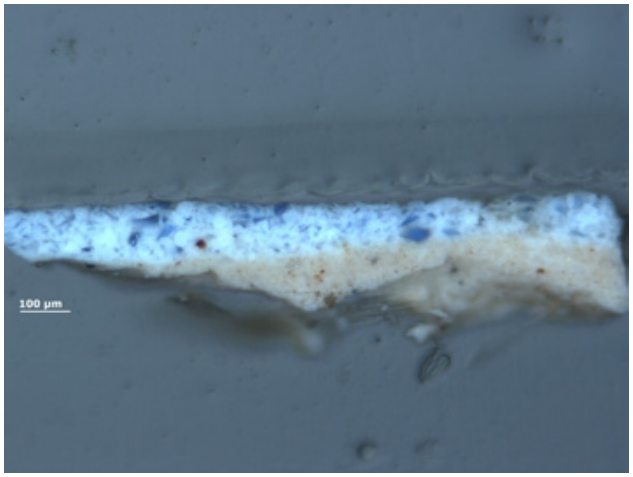

Fig. 4 Cross-section from Gerard van Honthorst, *Louise Henriette Leads Friedrich Wilhelm, Elector of Brandenburg, to her Parents*, 1649, oil on canvas, 319 × 202 cm, Huis ten Bosch (Oranjezaal), The Hague. The ground was found to contain lead white (coarse), brown umber and a tiny amount of black. (Courtesy L. Speleers.)

Amsterdam and Middenbeemster, 1645–1650

The two smaller canvases, *Mercury and Aglauros*[27] and *Mercury, Argus and Io* (Fig. 3),[28] are thought to be from the period 1645–47 after Fabritius left Rembrandt's studio. They both appear to be cut from larger prepared strips of cloth.[29] When preparing a canvas for painting it is first stretched on an oversize strainer, then sized and successively primed. Moisture from the size will make the canvas taut and create the characteristic cusping of the weave between each fixing point on the strainer. These deformations are rendered permanent by the size and subsequent ground layer application. Large prepared canvases could be cut into smaller formats and mounted on smaller strainers for use in new individual compositions. Evidence of this practice becomes visible in an X-radiograph: along one or two edges the canvas will display primary cusping, while on the other edges only minor, so-called 'secondary', cusping will be visible. This appears to be the case for both *Mercury* canvases. *Mercury, Argus and Io*, measuring 72.4 × 102.5 cm, shows cusping along the left and right sides, however the original format of the composition was probably not any larger. The *Mercury and Aglauros* painting displays cusping along the bottom and the left edges. If the two paintings were intended as companion pieces, we would expect them to be approximately identical in size. Currently, *Mercury and Aglauros* measures 72.4 × 91 cm and could theoretically have been trimmed by approximately 10 cm on the right after it was separated from its possible companion piece. Both paintings have comparable thread counts, namely 14.5 vertical and 13 horizontal threads per cm.[30]

The beige-ochre coloured priming on both canvases appear similar, comprising large lead white particles. A source for an application of a ground layer composed of lead

white and a little umber can be found in the manuscripts by De Mayerne and Willem Beurs.[31] Another possibility is that the recipe relates to the Haarlem *plamuurder* François Oliviers, whose lightly umber-coloured ground layers appear from 1636, the year he established his business. This type of ground has been found several times on canvases by Johannes Cornelisz Verspronck (*c.*1600–1662) and Frans Hals (1582–1666),[32] as well as on the large majority of canvases ordered for the Oranjezaal in The Hague, created in 1648–52 (Fig. 4).[33] The possibility that the canvases on which Fabritius painted these Mercury scenes were supplied by Oliviers needs further investigation, but is nonetheless an interesting thought. In any case, the beige-ochre colour of the ground layer in these two paintings is, in contrast to Fabritius' canvases from his early Amsterdam period, lighter and more luminous.

The beige-ochre coloured grounds in *Mercury and Aglauros* and *Mercury, Argus and Io* are visible in several parts of the compositions, in the same way that the warm-grey ground layer in Fabritius' *Raising of Lazarus* plays an important mid-tone role for the composition. Fabritius seems to have developed or changed his technique when approaching these much smaller formats. He employed an even more economical and open painting technique in the landscape of *Mercury, Argus and Io*: the ground shows through the open brushwork and affects the colour of the thinly applied paint. This is all the more striking because these smaller canvases were made to be viewed up close, and his brushwork could be easily observed. Perhaps future analysis of a painting from the Pushkin State Museum in Moscow, depicting an enigmatic composition interpreted as *Hera* (?),[34] currently attributed to Fabritius (1643–45), will make it possible to group Hera with the Mercury canvases; visual inspection suggests a similar beige-ochre priming.[35]

The canvas used for the early *Self-Portrait* (Munich) shows a different and more open fabric compared to the above, counting 12 horizontal and 13 vertical threads per cm.[36] This canvas measures 62.5 × 51 cm and displays clear primary cusping at the top and only a faint scalloping of the canvas on the left. This suggests that the canvas, like the two *Mercury* scenes, would have been cut from a large piece of prepared canvas. Only the 'C' can be seen in the signature at the lower right edge, possibly indicating that several centimetres were trimmed along the right-hand side (with the presumed rest of the signature); in this 'original format', however, the composition is unbalanced, with the portrait placed to the left side of the canvas and the large empty space to the right. Trimmed or untrimmed, this canvas is an anomaly in Fabritius' oeuvre as it was prepared with a striking white ground layer.[37] Owing to the thin paint application and with the paint covering only defined areas, the whitish ground has remained visible along the contours of various elements, such as between the collar and the background – light grounds are only encountered in later paintings from the artist's Delft period and never of this brightness. Is it possible that he prepared the ground for the self-portrait himself or should it be dated later? We do know of one other white ground from the Delft period.

In 1649, Fabritius painted the *Portrait of Abraham de Potter* (Fig. 5). The sitter, a wealthy silk merchant in Amsterdam, is dressed in sober black with a stiff, pleated ruff that was no longer particularly fashionable in 1649. The background is unusual: De Potter is depicted standing in front of a weathered plastered wall on which Fabritius painted a small, trompe l'oeil nail above his signature that appears to protrude from the canvas.[38] On both vertical sides the canvas exhibits (remnants of) selvedges, indicating that its width of 68.5 cm is identical to that of the original roll of linen, close to an Amsterdam *el* measuring 68.8 cm. The warp thus ran vertically and the weft horizontally. The canvas has an open weave of only 7 × 7 threads per cm in both directions. The portrait of De Potter is believed to be Fabritius' last painting executed in Amsterdam or Middenbeemster before leaving for Delft. The canvas has a double ground: a layer of red earth, similar to that observed in the *Raising of Lazarus*, and then a thin ochre-

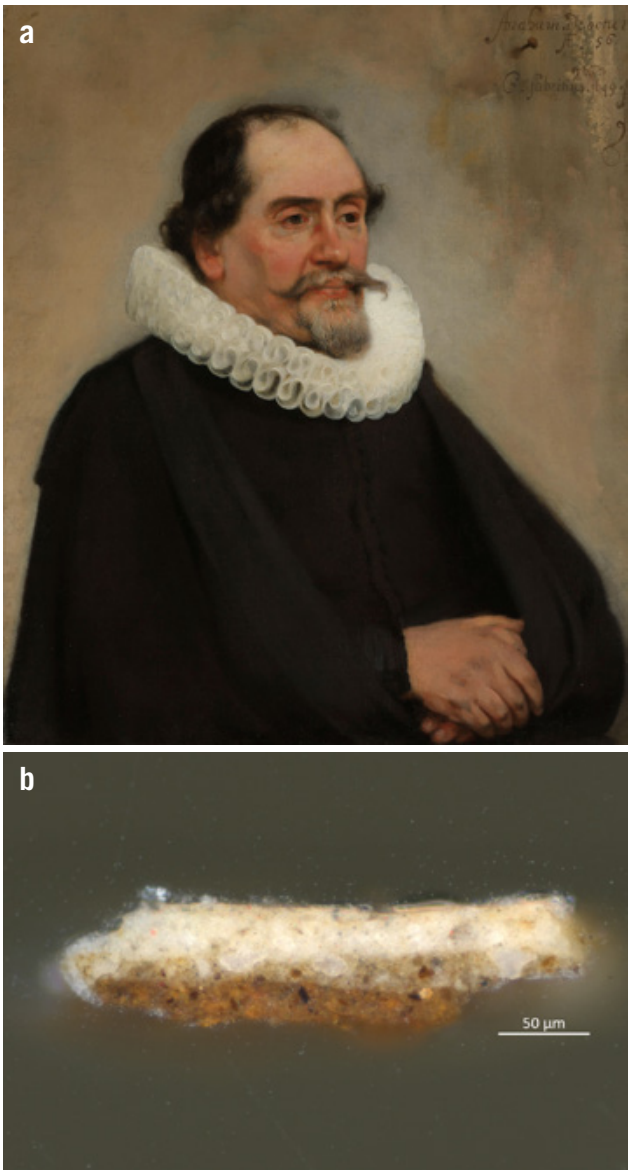

Fig. 5 (a) Carel Fabritius, *Portrait of Abraham de Potter*, 1649, signed and dated upper right 'Abraham. de potter / AE. 56 C. / C. fabritius 1649 f.', oil on canvas, 68.5 × 57 cm. Amsterdam, Rijksmuseum, inv. no. SK-A-1591 with (b) cross-section. (Courtesy G. Tauber and A. Wallert, Rijksmuseum.)

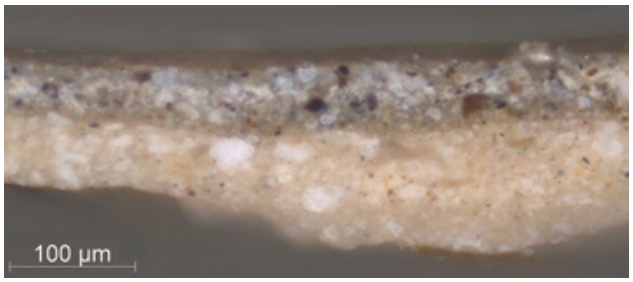

Fig. 6 Cross section from Carel Fabritius, *A Young Man in a Fur Cap and a Cuirass (probably a Self Portrait)*, 1654, signed 'c. fabritiús. / .1654', oil on canvas, 70.5 × 61.5 cm, The National Gallery, London, inv. no. NG4042. (© The National Gallery, London.)

coloured layer containing large lead white particles, providing the lighter tonality introduced in the abovementioned *Mercury and Aglauros* and *Mercury, Argus and Io*.

Delft 1650–1654

Carel Fabritius and his second wife moved to Delft in 1650. The four canvases known to be by Fabritius' hand from his Delft years are small-to-medium scale: *View in Delft with a Music Seller's Stall*, *Lady with a Pearl Earring in Profile* (attributed),[39] *Young Man in a Fur Cap and a Cuirass (Self-Portrait)*[40] and *The Sentry*.[41]

The *View in Delft* is dated 1652 and in many ways is difficult to compare with the other large or much larger paintings:[42] the canvas measures only 15.4 × 31.6 cm. It is believed that originally it had to serve a specific function and was attached to a curved copper plate placed in a viewing box.[43] This may possibly be the reason why Fabritius chose a very tightly woven strip of linen displaying no less than 19 × 22 threads per cm. The X-radiograph shows primary cusping only at the left and top sides, an indication that this small canvas was cut from a larger prepared piece. If the ground colour on the Munich *Self-Portrait* was remarkable in its whiteness, the same also applies to the small *View in Delft* painting, in which it consists exclusively of lead white. The choice of a white oil primer may accord well with the intention of giving the canvas a firm ground before fitting it to the curved copper plate.

It is notable that the next three works by Fabritius were painted on similar strips of linen. The canvases of *Lady with a Pearl Earring in Profile*, *A Young Man in a Fur Cap and a Cuirass (Self-Portrait)* and *The Sentry* all have the following comparable weave densities: 12.5 × 13, 12 × 13 and 14.5 × 13.5 threads per cm respectively (measured manually). X-radiographs of the three paintings reveal a comparable uneven structure in the canvas weave. Allowing for the uncertainties of manual measurements, it is possible that all three canvases could have originated from the same roll of linen. This is further suggested by the fact that, under the stereomicroscope, they all seem to be primed with a light beige or cream-coloured ground (Fig. 6). Analysis of the ground in *A Young Man in a Fur Cap* indicated a composition of large aggregates of lead white mixed with chalk, the so-called

Fig. 7 Carel Fabritius, *Self-Portrait*, 1645–47, signed 'fabritius / f', oil on panel, 64.8 × 49 cm, Museum Boijmans Van Beuningen, Rotterdam, inv. no. 1205.

'Ceruse commune', and minute brown particles with the appearance of brown ochre or umber, as well as a little yellow earth and black.[44]

Two panels by Fabritius

As previously mentioned, only two works by Fabritius were painted on oak panels: his early *Self-Portrait*, dating between 1645 and 1647 (Fig. 7), and the well-known *Goldfinch*, dated 1654. The first panel is constructed traditionally with two boards glued together and bevelling along all sides that appears to have remained intact. Dendrochronological research has shown that the boards may already have been available in 1629.[45] *The Goldfinch* was painted on a small panel measuring only 33.9 × 22.8 cm; a panel that at one point was considerably larger but was trimmed prior to the current composition.[46]

The two panels by Fabritius display a somewhat homogeneous preparation, linked to a more traditional method of priming rigid supports. The *Self-Portrait* and *The Goldfinch* both have a thin off-white ground layer, containing mostly chalk and possibly small quantities of fine white lead. This seems to align with the findings of other researchers that, with a few exceptions, no significant difference has been detected between the grounds of the various panels in Rembrandt's production.[47] Generally only a single type of ground appears to have been used, matching the description in the De

Table 1 Carel Fabritius: painting supports and the colour of the ground.

Collection	Title	Size V	Size H	Thread V	Thread H	Date*	Location during painting	Ground colour	
								Double ground/Single ground	
NG, Warsaw	*Raising of Lazarus*	210.5	140	14	15	1643	Amsterdam	red earth	warm grey
The Leiden Collection	*Hagar and the Angel*	157.5	136	14	15	1643–45	Amsterdam	/	warm buff
Pushkin, Moscow	*Hera (?)*	77	67	?	?	1643	Middenbeemster/ Amsterdam	/	?
L.A. County Museum	*Mercury, Argus and Io*	73.5	104	14.5	13	1645–47	Middenbeemster/ Amsterdam	/	beige-ochre
MFA, Boston	*Mercury and Aglauros*	72.4	91	14.5	13	1645–47	Middenbeemster/ Amsterdam	/	beige-ochre
Pinakothek, Munich	*Self-Portrait*	62.5	51	13	12	1645	Middenbeemster/ Amsterdam	/	white
Rijksmuseum	*Abraham de Potter*	68.5	57	7	7	1649	Middenbeemster/ Amsterdam	red earth	beige-ochre
NG, London	*View in Delft*	15.5	37.4	22	19	1652	Delft	/	white
LSSM, Hannover	*Profile of a Woman*	66.5	57.5	13	13	1654	Delft	/	light cream
NG, London	*Self-Portrait*	70.5	61.5	13	12.5	1654	Delft	whitish	light cream
SM, Schwerin	*The Sentry*	68	58	13.5	14.5	1654	Delft	/	light cream
Boijmans van Beuningen	*Self-Portrait*	65	49	oak panel		1647–48	Middenbeemster	/	white
Mauritshuis	*The Goldfinch*	33.5	22.8	oak panel		1654	Delft	/	white

* The unmarked cells are dates included in the signature by the artist, whereas the cells marked in grey follow dating based on art historical and stylistic analysis

Mayerne manuscript: 'For [a ground on] wood. First, coat it with the above-mentioned glue and chalk: and when it has dried scrape and make it even with a knife, then apply a thin layer of lead white and umber.'[48] In places, dark streaky discolorations have occurred in a vertical direction following the grain of the wood, caused by an increased transparency of the ground layers over time.[49]

In summary, this paper has studied the supports and grounds used by Fabritius in different periods and locations, allowing us to make the following observations. Based on a comparison of the canvases that the artist used for his paintings, we may conclude that his two early, large figural compositions of the *Raising of Lazarus* and *Hagar and the Angel* were painted on similar canvases. The structure of the ground layers differs, however: the first has a double ground and the other a single layered ground. Furthermore, small standard sizes and horizontal formats measuring approximately 75 × 105 cm were used for the two mythological narratives of the adventures of *Mercury*. Both were painted on seemingly similar ochre-coloured ground layers, visually identical to the ground observed on the smaller *Hera* canvas from the same years. The canvases for the Munich *Self-Portrait* and the small *View in Delft* were cut from larger pieces of primed linens of different weave densities. Both, however, have a striking bright white priming, although seemingly apart in time of execution.

Another standard-size canvas was employed by Fabritius for the following four paintings: *Portrait of Abraham de Potter*, his so-called *Late Self-Portrait*, the *Portrait of a Woman in Profile* and *The Sentry*. It appears that these four canvases were all close to one *el* in height and two feet in width (70 × 60 cm).[50] Apart from the *Portrait of Abraham de Potter*, with the double red/beige-ochre ground from 1649 when Fabritius was still in Amsterdam, the three from his Delft period all exhibit similar light beige grounds (Table 1).

Fabritius and his contemporaries: a discussion

Based on the above mapping of the ground layers in Fabritius' paintings we may ask ourselves whether on arrival in Delft, he chose to use canvases prepared by the local *primuurder* in the light colour available for ready-made canvases, or if he deliberately opted for a lighter ground. To answer this question, the *Portrait of Abraham de Potter* becomes a crucial witness. Painted in 1649, before his departure to Delft, and on a canvas with an upper layer in a lighter beige than his earlier canvases, may suggest that Fabritius had already embarked on a new and brighter path.

Perhaps Fabritius had become aligned with the taste for lighter more Italianate paintings at the court in The

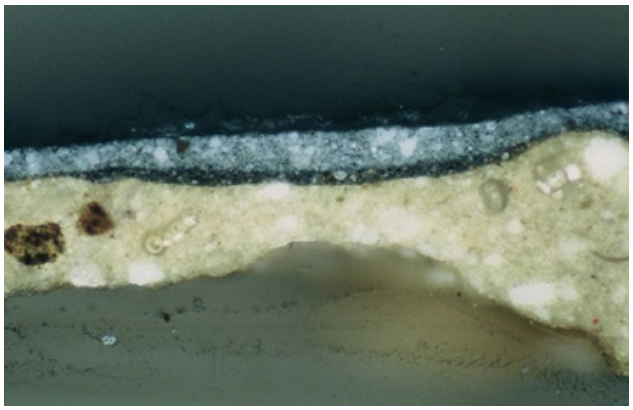

Fig. 8 Cross-section from Jacobus Leveck, *Portrait of Adriaen Braets*, 1664, signed 'J. Leveck.A.1664', oil on canvas, 93 × 72 cm. Dordrecht Museum, inv. no. DM/985/627. (Image: K. Groen, Amsterdam.)

Hague, only 10 km from Delft. It might also be expected that the newcomer to the Delft painting scene was influenced by the success of local painters of church interiors, as both Hendrick Cornelisz. van Vliet (1611–1675) and Gerard Houckgeest (1600–1661) used light ground layers for their depictions of space and light. A comparable light ground was employed for the decoration of the Oranjezaal, carried out between 1648 and 1652, something that would not have gone unnoticed in artistic circles. Another interpretation is based on the possibility that in Delft, Fabritius could only obtain these light grounds at his colourman's shop. Research on other Delft and Dordrecht painters of the second half of the 1650s, such as Rembrandt's pupils Nicolaes Maes (1634–1693) and Jacob Levecq (1634–1675), reveals similar light grounds.[51] Nicolaes Maes seems to have abandoned the darker Amsterdam ground and used a light priming for *Eavesdropper* (1657)[52] and his *Portrait of Margaretha de Geer* (1669).[53] Jacobus Leveck also painted his *Portrait of Adriaen Braets* (1664)[54] on a comparable light ground (Fig. 8). This trend was already noted in 2004 in the grounds of portrait paintings of artists working in Delft and The Hague.[55]

The recently studied canvas paintings by Jan Steen executed in The Hague and later in Delft from 1649 to 1656 show comparable compositions of the grounds: they are light in colour and consist mainly of chalk and lead white mixed with some umber and/or fine carbon black mixed.[56] Technical investigation of the ground layers of Pieter de Hooch's canvas paintings from his Delft period also confirmed light grey and beige grounds consisting of mixtures of slightly varying amounts of lead white, earth pigments and fine black as well as mixtures of chalk with small amounts of earth pigments.[57] A recent study of Vermeer's grounds indicates that they are more uniform over time than previously thought, and that the majority are composed of one or two layers of light or dark beige paint containing lead white, with an admixture of chalk, earth pigments and fine black, as well as a little umber.[58] If we compare the light Delft ground employed by Fabritius in the first half of the 1650s with those used by Vermeer, we find a comparable pigment composition in the ground of the latter's early painting of *Diana and her Nymphs* from *c.*1653–56.[59] However, these bright ground layers cannot be visualised through his dense paint application on top either in this painting or in Vermeer's following large-scale history painting. So despite Vermeer's ground layers having similar compositions and tonality to those employed by Fabritius, the effect is different from the brighter path upon which Fabritius had already embarked, a tonality that is first encountered in Vermeer's painting in the late 1650s. This underscores the importance of a more opaque and overall application of paint on the canvas as opposed to actively employing the ground tonality as a mid-tone or as a means of creating a brighter overall tone by painting more transparently or by leaving patches in the composition open to the lighter ground.

Fig. 9 Carel Fabritius, *The Sentry*, 1654, signed 'C. fabritivs: 1654', oil on canvas, 67 × 58 cm, Staatliches Museum Schwerin, inv. no. G2477.

Conclusions

This study has shown that the ground used by Fabritius in his early production of ambitious and large history paintings reflects his ties to Rembrandt. Whether he returned to Middenbeemster or continued working in Amsterdam, either with Rembrandt or independently, he appears to have changed both format and subject matter towards smaller, more loosely executed mythological paintings combined with (self-) portraits. Regarding his change of style after his move to Delft, Fabritius refined the technique he had already started in the late 1640s: he moved away from the strong Caravaggisti *chiaroscuro* by employing a brighter tonality. The *Portrait of Abraham de Potter* dates from just before his move from North Holland to Delft, and here we observe a more patchy paint application that permits the bright tonality of the ground to play a greater role in the overall perception

of the painting. This style is carried forward into his Delft period: *Lady with a Pearl Earring in Profile*, the late *Self-Portrait* and *The Sentry* (Fig. 9) point towards a new sense of abstraction in the paint application and a lighter colour scheme dominated by grey and ochre tones, closer to what would become 'Dutch Classicism', a trend that was already in vogue in The Hague through the painter-architect Jacob van Campen (1596–1657) and Caesar van Everdingen (1616/17–1678). Both Van Campen and Van Everdingen were part of the team of painters decorating the Oranjezaal (1648–1650) in Huis ten Bosch. Their paintings, executed on prefabricated canvases with a light ground layer, are here seen in juxtaposition with paintings by the Flemish baroque painters Jacob Jordaens (1593–1678) and Thomas Willeboirts Bosschaert (1613–1654) which, despite being executed on a similar light ground, are darker and more dramatic.[60]

Fabritius' short-lived career of less than two decades was influenced by his mobility, both in terms of quality and his choice of materials. How far and to what heights his talent would have taken him had he lived longer we can never know, but he quickly recognised the advantages of embracing a more luminous paint support and open paint application. By doing so, Fabritius came closer to the new classical trend, stepping away from the darker tonalities he first employed in his large-scale painting in Rembrandt's workshop. The brushwork of his late paintings reveals a true master with the potential to equal not only his principal teacher, but also the artists who would rise to prominence in Delft during the second half of the 17th century.

Acknowledgements

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Notes

1. K. Groen, 'Grounds in Rembrandt's workshop and in paintings by his contemporaries', in E. Van de Wetering, *A Corpus of Rembrandt Paintings IV: The Self-portraits*, Dordrecht, Springer, 2005, pp. 318–334.
2. Ibid., p. 323.
3. F.J. Duparc, with contributions by G. Seelig and A. Van Suchtelen, *Carel Fabritius 1622–1654*, The Hague, Mauritshuis/Schwerin, Staatliches Museum Schwerin, 2004–2005; *Oud Holland* 119(2–3), 2006 (Special Issue: Carel Fabritius). See especially Duparc's contribution based on my investigations: F.J. Duparc, 'Results of the recent art-historical and technical research on Carel Fabritius's early work', *Oud Holland* 119(2–3), 2006, pp. 76–89.
4. Duparc *et al*. 2004–2005 (cited in note 3), p. 15.
5. Ibid., p. 17.
6. G. Seelig, 'The dating of Fabritius's stay in Amsterdam', *Oud Holland* 119(2–3), 2006, pp. 93–98.
7. Ibid., p. 97. I am grateful to Gero Seelig, curator at the Staatliches Museum Schwerin, for sharing his thoughts on the artistic development of the young Fabritius in his formative years.
8. S. van Hoogstraten, *Inleyding tot de hooge schoole der schilderkonst: anders de zichtbaere werelt*, Rotterdam, by Francois van Hoogstraeten, 1678, vol. I, p. 11.
9. Duparc *et al*. 2004–2005 (cited in note 3), p. 19.
10. P. Bakker, 'Carel Fabritius', in A.K. Wheelock Jr. (ed), *The Leiden Collection Catalogue*, https://www.theleidencollection.com/artists/carel-fabritius (accessed October 2019).
11. Duparc *et al*. 2004–2005 (cited in note 3), p. 50.
12. Fabritius did not join the Delft Guild of St Luke until 1652, two years after his arrival in the city. His hesitation could be explained by the financial crisis that was affecting the art market and had already begun to impact Delft in the 1640s. See P. Bakker, 'Crisis? Welke crisis? Kanttekeningen bij het economisch verval van de schilderkunst in Leiden na 1660', *De Zeventiende Eeuw* 27, 2011, pp. 232–270, esp. pp. 237–240.
13. M. Meijer Drees, '"Providential discourse" reconsidered: the case of the Delft Thunderclap (1654)', *Dutch Crossing* 40(2), 2016, pp. 108–121.
14. D. van Bleyswijck, *Beschryvinge der Stadt Delft*, Delft, printed by Arnold Bon, 1667, pp. 853–854.
15. The *Portrait of a Seated Woman with a Handkerchief*, formerly attributed to Fabritius, oil on canvas, 124.5 × 100.3 cm, Toronto, Art Gallery of Ontario, inv. no. 64I, in which the so-called quartz ground was identified, has not been examined therefore is not included in this paper. For a view on the attribution, see C. Brown, 'The Carel Fabritius Exhibition in The Hague: a personal view', *Oud Holland* 119(2–3), 2006, pp. 139–145.
16. Duparc *et al*. 2004–2005 (cited in note 3); *Oud Holland* 119(2–3), 2006.
17. E. Froment, *The Consequences of Wax-Resin Linings for the Present Appearance and Conservation of Seventeenth Century Netherlandish Paintings on Canvas*, PhD dissertation, Amsterdam, University of Amsterdam, 2019.
18. Groen 2005 (cited in note 1), pp. 318–334.
19. E. van de Wetering, *Rembrandt: The Painter at Work*, Amsterdam, Amsterdam University Press, 1997, p. 22.
20. M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900*, London, Archetype Publications, 2017, pp. 141–242.
21. Infrared imaging performed by the author in 2004 revealed the signature 'C P Fabritius' on *Hagar and the Angel*; Duparc 2006 (cited in note 3), pp. 84–85.
22. I am grateful to Aleksandra Janiszewska, curator of the Collection of Medieval and Early Modern Art, National Museum in Warsaw (Muzeum Narodowe w Warszawie), for providing a report on the stratigraphy of three cross-sections from the painting.
23. De Mayerne offers several almost identical recipes for the preparation of a canvas including sizing and priming. For the latter, a double ground is recommended: 'Vostre colle estant seiche imprimés auec Braun rot, ou rouge brun d'angleterre assez legerement. Laisséz seicher, & applanissés auec la pierre ponce: Puis imprimés auec vne seconde & derniere couche de Blanc de plomb, de charbon de braise bien choisy. Smale coales, & un peu de terre dombre pour faire plus vistement seicher. On

peult donner vne troisiesme couche, mais deux font bien, & ne s'escaillent jamais, ny ne se fendent'; Ms Sloane 2052, f.5r. http://artechne.hum.uu.nl/node/95221 (accessed 17 September 2019).

24. Groen 2005 (cited in note 1), p. 320.
25. D. Surh, '*Hagar and the Angel*', in A.K. Wheelock Jr. (ed), *The Leiden Collection Catalogue*, https://www.theleidencollection.com/archive/ (accessed 8 September 2019).
26. I am most grateful to Silvia A. Centeno for sharing (September 2019) information on her analysis by cross-sections in conjunction with polarised light microscopy and Raman spectroscopy. The ground was found to contain lead white, ochre, vermilion, and carbon-based black pigments. Silvia A. Centeno, examination and analysis report, 5 February 2013.
27. Carel Fabritius, *Mercury and Aglauros*, *c.*1645–47, oil on canvas, 72.4 × 91.1 cm, Boston, Museum of Fine Arts Boston, Martha Ann Edwards Fund, inv. no. 03.1143. Infrared imaging performed by the author in 2004 revealed the signature '[C or c]arolús / [fa] britiús'; see also Duparc 2006 (cited in note 3), p. 82.
28. I am grateful to Joe Fronek at Los Angeles County Museum of Art (LACMA) for his extensive examination (September 2019) of the painting in preparation for this article.
29. Duparc *et al*. 2004–2005 (cited in note 3), pp. 100–110.
30. Examined under magnification by the author in 2004.
31. De Mayerne offers a recipe obtained from the Amsterdam painter Latombé (living in London): 'Apres imprimés auec blanc de plomb, & vn peu d'ombre. Vne imprimeure suffit. si on y en met deux la toile sera plus vnie. Pour faire païsages que vostre imprimeure soit de couleur fort claire', Ms Sloane 2052, f.11r. (accessed September 2019); W. Beurs, *De groote waereld in 't kleen geschildert, of Schilderagtig tafereel van 's Weerelds schilderyen*, Amsterdam, by Johannes en Gillis Janssonius van Waesberge, 1692, p. 19.
32. E. Hendriks, 'Johannes Cornelisz. Verspronck: the technique of a seventeenth century Haarlem portraitist', in E. Hermens (ed.), *Looking Through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research* (*Leids Kunsthistorisch Jaarboek* 11), London, Archetype Publications, 1998, pp. 227–267.
33. R. Ekkart, M. Franken, A. van Grevenstein and M. Lankester (eds), *De Oranjezaal: catalogus en documentatie*, RKD Studies 2015, http://oranjezaal.rkdmonographs.nl (accessed 17 September 2019). For the ground in the Oranjezaal, see Lidwien Speleers, Margriet van Eikema Hommes, Ineke Joosten, Suzan de Groot and Annelies van Loon, 'The effect of ground colour on the appearance of two paintings by Thomas Willeboirts Bosschaert in the Oranjezaal, Huis Ten Bosch', in this volume, pp. 93–106; B. Berlowicz, M.C. Christensen and J. Wadum, 'Made in Brazil? Eckhout and Post, Dutch painters in Brazil, 1637–1644', *ICOM-CC Preprints*, 2002(1), pp. 394–400, describes canvases prepared for Albert Eckhout (1610–1665) and Frans Post (1612–1680) that, given their material composition and colour, have comparable qualities to those in the Oranjezaal.
34. Carel Fabritius, *Hera*, 1642–44, oil on canvas, 77 × 67 cm, Moscow, Pushkin Museum.
35. This observation was made in the exhibition gallery and should be treated with caution. Under these conditions, it was unfortunately not possible to assess the weave pattern of the canvas.
36. Carel Fabritius, *Self-Portrait*, 1644–45, signed 'C.', oil on canvas, 62.4 × 51.1 cm, Munich, Alte Pinakothek, inv. no. 2080.
37. According to Groen, the use of chalk and chalk-lead white grounds in Rembrandt's studio seems restricted to the period after *c.*1650; see Groen 2005 (cited in note 1), p. 325, table VI, p. 674. A few red dots, the meaning of which is unclear, can be found along the left and bottom sides and at the very top on the corner of the canvas on the right side.
38. During a restoration in 2003 undertaken by Gwen Tauber at the Rijksmuseum, the trompe l'oeil of the flaking plaster and the nail close to the signature were rediscovered. I am grateful to Susan Smelt for information on the cross-section, processed for this article by Arie Wallert (9 February 2004).
39. Carel Fabritius, *Lady with a Pearl Earring in Profile*, signed and dated lower left 'fabritius 1654', oil on canvas, 66.5 × 57. 5 cm, Hanover, Niedersächsisches Landesmuseum. The preceding initial of Fabritius' signature, if it existed, was lost when the canvas was trimmed at the left side: see W. Liedtke, 'Women with pearl earrings: on paintings apparently by Carel Fabritius in Hannover, Vaduz, and Amsterdam', *Oud Holland* 119(2–3), 2006, pp. 120–129.
40. Carel Fabritius, *A Young Man in a Fur Cap and a Cuirass* (probably a *Self-Portrait*), 1654, signed and dated lower right '*c. fabritiús. / .1654.*', oil on canvas, 70.5 × 61.5 cm, London, National Gallery, inv. no. NG4042.
41. Carel Fabritius, *The Sentry*, 1654, signed '*C. fabritivs: 1654*', oil on canvas, 67 × 58 cm, Schwerin, Staatliches Museum Schwerin, inv. no. G2477.
42. Carel Fabritius, *View of Delft*, 1652, signed lower left 'C. Fabritivs. / 1652', oil on canvas, 15.5 × 31.7 cm, London, National Gallery, inv. no. NG3714. See also L. Keith, 'Carel Fabritius' *A View in Delft*: some observations on its treatment and display', *National Gallery Technical Bulletin* 15, 1994, pp. 54–63.
43. W. Liedtke, *Vermeer and the Delft School*, London, National Gallery/New York City, The Metropolitan Museum, 2001, pp. 252–254.
44. Unpublished report by J. Plesters, dated 1969 with 1985 addendum, in Scientific Department file, National Gallery, London. For the Ceruse commune, Plesters refers to J.A. van de Graaf, *Het de Mayerne Manuscript als bron voor de schildertechniek van de barok*, dissertation, University of Utrecht, 1958, p. 145. Profound thanks to M. Spring, R. Billinge and N. von Aderkas for safely digging out the report and making a new photograph of the historical sample (Fig. 6) during the Covid-19 closure of the National Gallery.
45. Report by P. Klein, University of Hamburg, 1995, https://rkd.nl/nl/explore/technical/5004976.
46. Carel Fabritius, *The Goldfinch*, 1654, signed and dated lower right 'C FABRITIUS 1654', oil on panel, 33.5 × 22.8 cm, Den Haag, Mauritshuis, inv. no. 605. A CT scan of the painting has revealed that the small board was originally part of a larger panel; however, at the time (2004), dendroprovenancing of the board by this technique was not possible.
47. K. Groen, 'Schildertechnische aspecten van Rembrandts vroegste schilderijen', *Oud Holland* 91(1/2), 1977, pp. 66–74.
48. De Mayerne had obtained the following recipe from the Amsterdam painter and seller of painters' materials Abraham Latombé (who, like De Mayerne, was working in London): 'Pour le bois. Imprimés premierement auec la colle susditte: & croye, estant sec, grattés & equalés auec le couteau, puis faites vne couche legere auec blanc de plomb & ombre', Ms Sloane 2052, f.11r, https://artechne.hum.uu.nl/node/95464 [translation by the author].
49. P. Noble, A. van Loon and J.J. Boon, 'Selective darkening of ground layers associated with the wood grain in 17th-century panel paintings', in J.H. Townsend, T. Doherty, G. Heydenreich and J. Ridge (eds), *Preparation for Painting: The Artist's Choice and its Consequences*, London, Archetype Publications, 2008, pp. 68–78.
50. In Amsterdam and Delft, cloth was often traded in the Bruges *el* (0.70 m). However, both the Amsterdam *el* (0.6878 m) and the Delft *el* (0.6832 m) are very close in size. See *De oude Nederlandse maten en gewichten*, Meertens Instituut, http://www.meertens.knaw.nl/mgw/.

51. Groen 2005 (cited in note 1), pp. 318–334, 660–677.
52. Nicolaes Maes, *The Eavesdropper*, Dordrecht, Dordrechts Museum, inv. no. DM/953/92.
53. Nicolaes Maes, *Portrait of Margaretha de Geer at the Age of 86*, 1669, Dordrecht, Dordrechts Museum, inv. no. DM/997/758.
54. Jacobus Leveck, *Portrait of Adriaen Braets*, 1664, Dordrechts Museum, inv. no. DM/985/627.
55. B. Broos, A. van Suchtelen, Q. Buvelot and R. Ekkart, *Portraits in the Mauritshuis, 1430–1790*, The Hague, Mauritshuis, 2004, p. 331.
56. M. Albrecht, O. de Noord, S. Meloni, A. van Loon and R. Haswell, 'Jan Steen's ground layers analysed with principal component analysis', *Heritage Science* 7(52), 2019 doi: https://doi.org/10.1186/s40494-019-0295-5.
57. A. Krekeler, 'Een studie naar de schildertechniek van Pieter de Hooch', in A. Jansen (ed.), *Pieter de Hooch in Delft: Uit de schaduw van Vermeer*, Delft, Museum Prinsenhof, 2019, pp. 60–62.
58. P. Noble and I. Verslype, 'The use of X-radiographs in the study of paintings/grounds', in C.R. Johnson Jr. (ed.), *Counting Vermeer: Using Weave Maps to Study Vermeer's Canvases*, RKD Studies, The Hague, RKD, 2017, §2.5.2, http://countingvermeer.rkdmonographs.nl/chapter-2-the-use-of-x-radiographs-in-the-study-of-paintings/2.4.2-x-rays-and-vermeer2019s-painting-technique/grounds
59. Ibid.
60. See Ekkart *et al*. 2015 (cited in note 33) and the forthcoming dissertation by Lidwien Speleers, University of Amsterdam.

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DISCOVERING TRENDS IN JAN STEEN'S GROUNDS USING PRINCIPAL COMPONENT ANALYSIS

Marya Albrecht, Sabrina Meloni, Annelies van Loon, Ralph Haswell and Onno de Noord

ABSTRACT In-depth research into the oeuvre of Jan Steen (*c.*1626–1679) has been a focus at the Mauritshuis since 2012, as part of the 'Partners in Science' collaboration with Shell. The aim of this project is to better understand the chronology of Steen's oeuvre based on the materials he used, since only 10% of his *c.*450 works are dated. Steen worked in different cities within the Netherlands (Haarlem, The Hague, Delft, Leiden and Warmond), each with a distinct artistic community. A group of 40 paintings from the Mauritshuis and other collections both within and outside the Netherlands has been analysed, with a special focus on the ground layers. Commercially prepared grounds seem to have been widely available in the 17th century. Did Jan Steen buy his supports pre-primed? Did he purchase them at a local artist's supplier every time he moved? To answer these questions, the composition of Steen's grounds was investigated. The group of 40 analysed paintings represents Steen's entire career, with 18 dated paintings used as a reference for the undated paintings. Both canvas paintings (24) and panels (16) are included. Cross-sections of each painting were analysed using light microscopy and SEM-EDX. Quantitative data on the elemental composition of the grounds were analysed using principal component analysis (PCA). This proved to be a useful tool to group paintings, linking them to the different cities in which Steen worked and to identify outliers in terms of the ground layer composition. The present survey also revealed that Steen not only used commercially prepared grounds, but also grounds prepared in his own studio.

Introduction

The Dutch artist Jan Steen (*c.*1626–1679) is well known for his genre paintings. He was a prolific artist – it is estimated that he painted *c.*450 works from around 1648 until his death in 1679. Since the earliest catalogue of his work, compiled by John Smith in 1833, the number of paintings attributed to him has shifted from 203 (in 1833[1]) to 889 (in 1907[2]) to 376 (in 1980[3]). Of the 450 works presently attributed to Steen, only 45 are dated by the artist. So far, dating Steen's work has been based mostly on stylistic grounds; however, this has proved to be difficult with so few dated paintings to compare with undated ones. Furthermore, Steen's painting technique varies from highly refined and detailed to bold and sketchy. This variation is not only visible in different paintings, but can also be seen within one single painting, which makes establishing a chronology in Steen's oeuvre problematic. The Mauritshuis has been carrying out in-depth technical and art historical research into Jan Steen's work since 2012, as part of the 'Partners in Science' collaboration with Shell. The aim of this project is to shed light on the chronology of Steen's oeuvre based on the materials he used.

During his life, Jan Steen lived and worked in several artistic centres in the Netherlands (Haarlem, The Hague, Delft, Leiden and Warmond). Although the distances between these artistic centres were short, there were local customs for grounds, both in colour and pigment composition. In Amsterdam and Utrecht, for instance, a double ground consisting of a red underlayer and grey top layer was often used, while this was less common in Haarlem and Leiden.[4] These local customs might have been strengthened further by local primers and/or suppliers of painting materials. Independent primers seem to have been common in the 17th century, as there are many references to commercially primed canvases in artists' recipe books.[5] Names of primers are known through contemporary contracts. By analysing Steen's ground layers in detail we aim to determine whether he conformed to local customs (and bought locally primed canvases and panels) every time he moved, or used his own mixtures no matter where he lived.

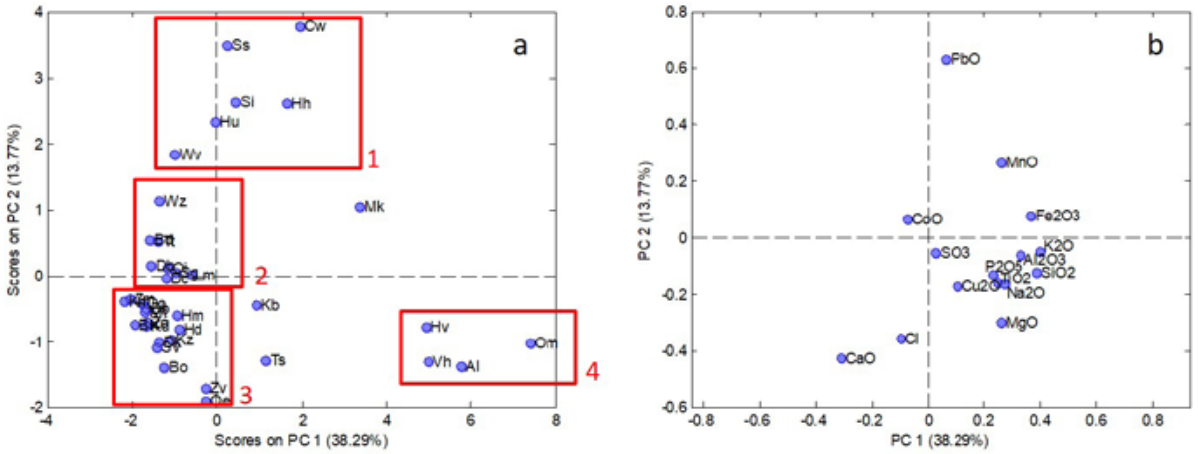

Fig. 1 Score plot (a) and loading plot (b) of PCA done on the bottom ground layers for all analysed paintings.

In order to achieve an overview of Steen's grounds, 40 paintings were analysed with at least two cross-sections taken from each painting. These were analysed using light microscopy and scanning electron microscopy coupled with energy dispersive X-ray (SEM-EDX) analysis. Principal component analysis (PCA) was used on the resulting dataset to identify trends in the composition of the grounds. These trends were put into context by comparing them with artists active in the different cities in which Steen worked.

Sample analysis

Thanks to a number of institutions, museums and private collectors, a large number of paintings by Steen was made accessible for research. In addition to the 15 paintings by Steen owned by the Mauritshuis, samples were taken of 25 other paintings. With the earliest painting dating to 1646–48 and the latest to 1674–78, the group of analysed paintings covers Steen's entire career. Both paintings on panel (16) and canvas (24) are represented. Within this group 18 paintings can be dated with certainty, serving as a reference for undated paintings (Table 1).[6]

Between two and nine paint samples were available per painting to determine the layer build-up of the grounds. The samples were prepared as cross-sections.[7] Visual examination and photography was done with a microscope in both normal reflected light (brightfield and darkfield) and ultraviolet (UV) light.[8] After initial investigation with optical microscopy, SEM-EDX analysis of the cross-sections was performed using a combination of point-and-shoot and X-ray elemental mapping.[9] Pigments were identified based on their morphology as seen in backscattered electron (BSE) images, appearance under normal illumination and UV light, and elemental composition as analysed with SEM-EDX. Quantification of the elemental composition (as oxides in weight%) of the ground layers was done with SEM-EDX box measurements. Areas to be measured were drawn onto BSE images of the cross-section manually, taking care to select a representative area of the ground layer. Several measurements of 15 selected elements (namely Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Mn, Fe, Co, Cu and Pb) were taken per layer, per painting. All data were recorded in an Excel spreadsheet.

Principal component analysis

The quantification of all ground layers resulted in a large and heterogeneous dataset. Some paintings contain just one ground layer, while others contain three. The same applies to the number of pigments mixed into the ground layers: in several paintings, layers were found to contain just one pigment, whereas in other paintings, 14 pigments were found combined into one ground layer. The dataset was analysed using PCA, a multivariate data analysis technique that compresses data into a lower dimensional space by calculating new orthogonal variables called principal components (PCs) as linear combinations of the original correlated variables. PCA can help to find correlations and outliers in large datasets, as in this study. The PCs are obtained in the order of explained variation in the data, i.e. the first PC is the most important in terms of explained variation, followed by the second PC, etc.[10]

A PCA model is determined by two sets of orthogonal vectors: the scores, which contain the values of the objects (samples, paintings) on the PCs, and the loadings, which contain the relation between the original variables and the PCs. New objects can be projected onto the space spanned by the PCA model by multiplying a data vector with values for the original variables with the relevant loading vectors.

In the present research, the original dataset contained data for 39 paintings. Several PCA models were constructed on the basis of this set.[11] Prior to PCA all variables were mean-centred and scaled to a variance of one. Many combinations of the relevant PCs were evaluated, but the most interesting information for the present study was captured in the first two PCs. Some trends could be observed in these models: analysis of the quantitative elemental data of the bottom ground layers

Table 1 Overview of analysed paintings, arranged by support and the town in which they were painted. * Paintings dated by Steen are in bold. ** Numbers from the catalogue by K. Braun, Alle tot nu toe bekende schilderijen van Jan Steen, 1980, are used to in order to distinguish between paintings with the same or similar titles.

Title	Abbreviated title	Date*	Dimensions (h × w cm)	Inv. no.	Braun no.**	Collection	Composition of the ground layer
CANVAS PAINTINGS							
The Hague/Delft		1649–1656					Chalk, lead white, umber, sometimes fine black
The Tooth-Puller	Tt	**1651**	32.5 × 26.7	0165	32	Mauritshuis	1. Chalk, lead white, umber, fine black
							2. Chalk, lead white, umber, fine black
							3. Chalk, lead white, umber, fine black
The Village Wedding	Db	**1653**	64 × 81	2314	56	Boijmans van Beuningen	1. Chalk, lead white, umber
The Fortune Teller	Wz	*c.*1650–54	73 × 59.3	1111	B52	Mauritshuis	1. Chalk, lead white, umber, fine black
Adolf en Catharina Croeser, known as *'The Burgomaster of Delft and his Daughter'*	Bd	**1655**	106 × 96	sk-a-4981	78	Rijkmuseum Amsterdam	1. Chalk, lead white, umber
Warmond		1656–1660					Lead white. yellow earth, red earth, clay particles
Portrait of Jacoba Maria van Wassenaer (1654–1683), also known as '*The Poultry Yard*'	Hh	**1660**	106.6 × 80.8	0166	113	Mauritshuis	1. Lead white, yellow earth, red earth, orange earth, fine black, clay particles, dolomite particles
							2. Lead white, orange earth, red earth, umber, fine black, coarse black, clay particles, dolomite particles
							3. Lead white, yellow, orange and red earth, charcoal black, dolomite particles
Haarlem		1660–1670					Grey over red double ground
The Life of Man	Lm	*c.*1665	68.2 × 82	0170	261	Mauritshuis	1. Chalk, red earth, umber, coarse black, clay particles
							2. Chalk, read earth, umber, coarse black
							3. Lead white, yellow earth, umber, fine black, chalk
Haarlem		1660–1670					Red or brown coloured grounds
Interior of a Tavern, with Cardplayers and a Violin Player	Hv	*c.*1665	81.9 × 70.6	RCIN 405825	278	Royal Collection Trust	1. Clay: red iron particles, umber, silicates and titanium particles in matrix of aluminium, silicon, potassium, iron mixed with chalk and yellow earth
The Oyster Meal	Om	**1660**	102.8 × 133.9	n/a	114	Private collection	1. Clay: red iron particles, umber, silicates and titanium particles in matrix of aluminium, silicon potassium, iron
The Marriage of Tobias and Sarah	Hu	*c.*1667–68	131 × 172	313	281	Herzog Anton Ullrich Museum Braunschweig	1. Lead white, chalk, red earth, charcoal black, black shale, clay particles, gypsum, barium sulphate particles
Moses and the Pharaoh's Crown	Mk	*c.*1670	86 × 72	1167	328	Mauritshuis	1. Chalk, lead white, red earth, yellow earth, umber, bone black, clay particles
							2. Lead white, smalt, red earth
							3. Lead white, red earth, yellow earth, umber, bone black, yellow lake, clay particles
Haarlem		1660–1670					Light, chalk-based grounds
'As the Old Sing, So Pipe the Young'	Zo	*c.* 1663–65	84 × 92.5	0169	200	Mauritshuis	1. Chalk
							2. Lead white, chalk, umber, fine black
Merrymaking in a Tavern with a Couple Dancing	Hd	*c.*1670	61.7 × 75.1	RCIN 404813	277	Royal Collection Trust	1. Chalk, yellow earth, organic brown
The Sick Woman	Zv	*c.*1663–66	73 × 63.5	sk-c-230	259	Rijksmuseum Amsterdam	1. Chalk, yellow earth, brown earth, umber, fine black
'Easy Come, Easy Go'	Sg	**1661**	79 × 104	2527(OK)	143	Boijmans van Beuningen	1. Chalk, lead white, umber, bone black, quartz
							2. Lead white, fine black, orange earth, chalk
The Dancing Couple	Dc	**1663**	102.5 × 142.5	1942.9.81	180	National Gallery of Art Washington	1. Chalk, red earth, yellow earth, umber, charcoal black, bone black, lead white
							2. Lead white, charcoal black, chalk, red earth
The Marriage of Tobias and Sarah	Ts	*c.*1667–68	80 v 103.2	n/a	309	Private collection	1. Chalk, quartz, fine black, yellow earth, red earth, dolomite particles, clay particles
							2. Lead white, chalk, red lead, fine black, yellow earth, red earth, quartz
							3. Lead white, fine black, yellow earth, red earth, quartz
Leiden		1670–1679					Tinted grounds based on lead white
Sacrifice of Iphigenia	Oi	**1671**	135 × 173	JS112	342	Leiden collection	1. Lead white, chalk, red earth, umber, clay particles
Christ Expelling the Traders from the Temple	Cw	**1675**	79.5 × 109	B667	363	Museum de Lakenhal, Leiden	1. Lead white, umber, red earth, yellow earth, bone black, chalk, quartz, clay particles, smalt, vermilion

Title	Abbreviated title	Date*	Dimensions (h × w cm)	Inv. no.	Braun no.**	Collection	Composition of the ground layer
CANVAS PAINTINGS							
The Mocking of Samson	Si	*c.*1675–76	65 × 82	338	365	Koninklijk Museum voor Schone Kunsten Antwerpen	1. Lead white, yellow, orange, red and brown earth, dolomite particles, clay particles 2. Lead white, fine black, brown earth, umber, red lead, chalk
'A Pig Belongs in the Sty'	Wv	*c.*1673–75	86 × 72	0736	362	Mauritshuis	1. Chalk, lead white, red earth, yellow earth, umber, fine black, bone black
Leiden		1670–1679					Dark red grounds
A Village Revel	Hm	**1673**	110.4 × 147	RCIN 405611	354	Royal Collection Trust	1. Chalk, red earth, gypsum 2. Red earth, lead white, chalk, umber, clay particles
Studio grounds							
The Alchemist	Al	**1668**	106 × 82	n/a	249A	Private collection	1. Charcoal black, bone black, umber, red and brown earth, lead white, chalk, smalt, green earth, clay particles 2. Lead white, yellow earth, red earth, bone black, charcoal black, chalk, smalt, yellow and red lake 3. Lead white, bone black, yellow earth, green earth
'As the Old Sing, so Pipe the Young'	Ss	*c.*1668–70	86 × 72	0742	201	Mauritshuis	1. Lead white, lead-tin yellow, umber, red earth, chalk, bone black, red and yellow lake, vermilion, smalt, clay particles, quartz
The Merry Family	Vh	**1668**	110.5 × 141	sk-c-229	295	Rijksmuseum Amsterdam	1. Yellow, orange and red earth, fine black, chalk, copper particles, smalt, quartz, clay particles, organic brown, umber, vivianite, vermilion, lead-tin yellow
PANEL PAINTINGS							
Peasants Dancing at an Inn	Bh	*c.*1646–48	38.5 × 56.5	0553	5	Mauritshuis	1. Chalk 2. Lead white, chalk, black pigment
The Death of Ananias	An	**1651**	45.7 × 37.8	n/a	33	Private collection	1. Chalk 2. Chalk, lead white, umber, red earth, black pigment
Village Fair	Dk	*c.*1650–51	47.2 × 66	0664	81	Mauritshuis	1. Chalk 2. Lead white, orange earth, charcoal black, umber
The Freshwater Fish Market in The Hague	Rv	*c.*1650–54	59.5 × 71.5	1926-0013-SCH	47	Haags Historisch Museum	1. Chalk 2. Lead white, chalk, umber, quartz
The Quack	Kz	*c.*1650–60	37.5 × 52.0	sk-a-387	89	Rijksmuseum Amsterdam	1. Chalk 2. Lead white, umber, some chalk
The Baker Arent Oostwaard and his Wife, Catharina Keizerswaard	Bo	**1658**	37.7 × 31.0	sk-a-390	102	Rijksmuseum Amsterdam	1. Chalk 2. Lead white, umber, some quartz
Girl Eating Oysters	Oe	*c.*1658–60	20.5 × 15.1 (rounded top)	0818	92	Mauritshuis	1. Chalk 2. Lead white, umber, some chalk
The Sick Girl	Zm	*c.*1660	58.0 × 46.5	0167	203	Mauritshuis	1. Chalk 2. Lead white, red earth, umber
A Twelfth Night Feast: 'The King Drinks'	Kd	*c.*1661	40.4 × 54.5	RCIN 407489	149	Royal Collection Trust	1. Chalk 2. Lead white, red earth, umber, chalk
Woman Playing the Cittern	Sv	*c.*1662	31.1 × 27.5	0779	132	Mauritshuis	1. Chalk 2. Lead white, chalk, yellow earth, brown earth, umber, lamp black, red lead
A Woman at her Toilet	Mt	**1663**	65.8 × 53.0	RCIN 404804	178	Royal Collection Trust	1. Chalk 2. Lead white, yellow earth, brown earth, umber, chalk
Cardplayers in a Brothel	Kb	*c.*1663–65	38.0 × 51.0	n/a	A562	Private collection	1. Chalk, some gypsum 2. Lead white, red earth, brown earth, umber, chalk
The Doctor's Visit	Do	*c.*1665–68	60.5 × 48.5	0168	318	Mauritshuis	1. Chalk 2. Brown earth, lead white, chalk, charcoal black, smalt, copper-particles
'The Caudle Makers'	Km	*c.*1665–70	41.0 × 31.5	0920	95	Mauritshuis	1. Chalk 2. Lead white, some chalk, yellow earth, umber, fine black
Fighting Cardplayers ('Het Geweldig Krakeel')	Gk	**1671**	51.7 × 71.0	NK2167	345	Rijksdienst voor Cultureel Erfgoed	1. Chalk 2. Yellow earth, umber, lead white
Peasant Wedding	Bb	**1672**	38.5 × 50.0	sk-a-388	349	Rijksmuseum Amsterdam	1. Chalk 2. Lead white, yellow earth, umber, chalk

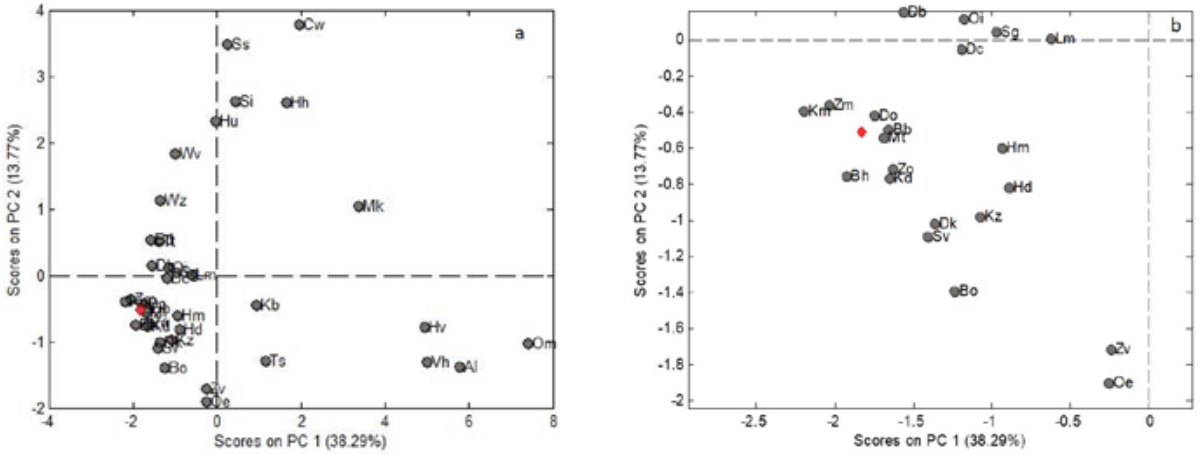

Fig. 2 PCA scores for elemental data on the first ground layers with Rv projection indicated by a red diamond: (a) full plot and (b) enlargement of relevant area.

roughly shows four clusters (Fig. 1a and b). Panel paintings are separated from canvas paintings by this clustering. Since all 16 panel paintings contain a bottom ground layer consisting only of chalk, a calcium carbonate, they are all placed close together in the score plot. Some paintings on canvas contain a similar bottom ground layer; these are found in the same cluster (cluster 3). Apart from this, three other clusters can be discerned: bottom ground layers (cluster 4, contains 4 paintings) consisting mainly of earth pigments, as indicated by the loadings of the oxides of silicon (SiO_2), aluminium (Al_2O_3), iron (Fe_2O_3) and magnesium (MgO); bottom ground layers consisting mainly of lead white, a (basic) lead carbonate (cluster 1, with 6 paintings), as indicated by the large loading of lead (PbO) in this direction; and bottom ground layers consisting of a mixture of lead white and chalk (cluster 2 with 8 paintings).[12]

Later a 40th painting, *The Freshwater Fish Market in The Hague* (Rv) was sampled and measured by SEM-EDX. This painting was chosen as it can be placed securely in The Hague and could therefore act as a reference for the PCA models. In the first instance, the samples were projected onto the PCA models previously developed to 'validate' these models. Fig. 2 shows the projection on PC1 and PC2 for the first ground layer, and indeed Rv is positioned where it should be, namely among the other panel paintings with a first ground layer consisting of chalk. Next, Rv was added to the dataset and new PCA models were constructed on the basis of data for 40 paintings. Fig. 3 shows the scores and loadings for the first two PCs from the model constructed on SEM-EDX data of the first ground layer. As expected, in comparison to Fig. 1 very little change was observed. This painting fits very well in the previous dataset and thus does not add new information that would influence the PCA model.

Panel paintings

Since there is a clear distinction in ground build-up between panels and canvases, the two supports will be considered separately in this article. Sixteen panel paintings were analysed, of which six are either dated by Steen or can be dated with certainty based on other evidence. All panel paintings contain two ground layers. *Cardplayers in a Brothel* (Kb, *c.*1663–65) is placed outside the cluster of bottom ground layers on panel paintings because in this painting the bottom ground layer contains some gypsum, while all the other bottom ground layers contain chalk only. This example shows the ability of PCA to find outliers. So far, no explanation can be given for the presence of gypsum.

Separate analyses were performed on all the second ground layers and top ground layers (either the first, second or third depending on how many layers are present on the painting). The top ground layers in the panel paintings are all light coloured, varying in tone from cream to light yellow to light grey and light brown. Some variation in their composition was noted, but no clear trends emerged for the second ground layers on panel. With PCA, a group of paintings containing a second ground layer based on lead white mixed with red and yellow earth, umber and chalk was clustered. Only one painting dated by Steen, *A Woman at her Toilet* (Mt), falls in this cluster, dated in 1663 when Steen was working in Haarlem. *A Twelfth Night Feast:'The King Drinks'* (Kd, *c.*1661), *Woman Playing the Cittern* (Sv, *c.*1662) and *The Caudle Makers* (Km, *c.*1665–70) are all stylistically dated in the Haarlem period and seem to fit well within this clustering. Two paintings that can be dated in The Hague with certainty – the early painting *Village Fair* (Dk, 1650–51), which has an underdrawing closely related to Jan van Goyen, and *The Freshwater Fish Market in The Hague* (Rv, 1650–54) – are also clustered with the aforementioned group of Haarlem paintings. The composition of the second ground layer is similar to the Haarlem paintings. All of these paintings are painted on (different) standard-sized panels,[13] making it likely that the panels were sold to artists ready prepared, with both ground layers already applied. The fact that the grounds are similar seems to indicate that comparable grounds for panels were used in all the artistic centres in which Steen worked.

The Doctor's Visit (Do, *c.*1665–68) is the only panel painting with an exceptional ground. The second ground layer

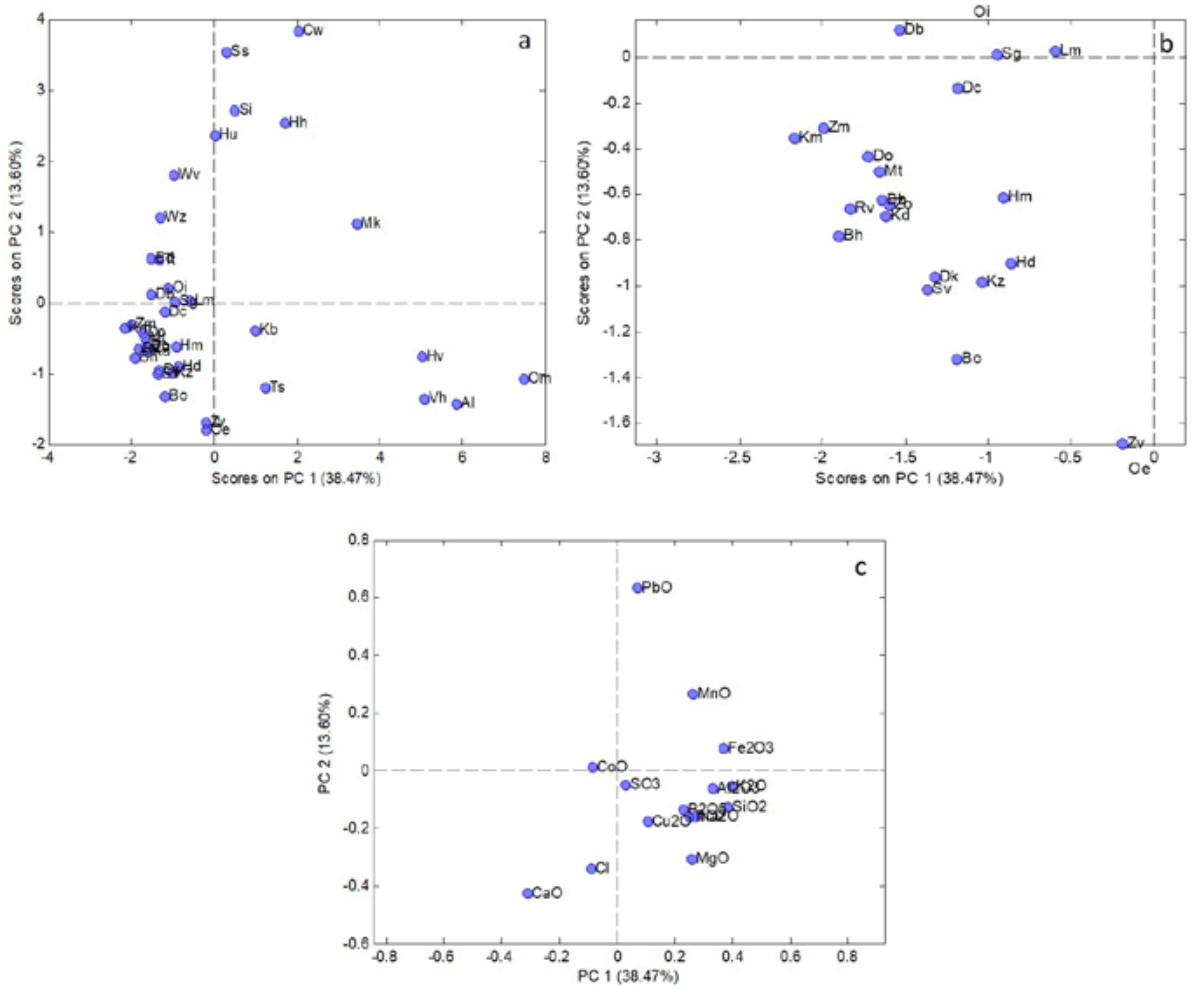

Fig. 3 PCA scores and loadings for elemental data on the first ground layers for a new dataset: (a) full score plot; (b) enlargement of relevant score area; (c) loadings.

on this painting, applied on the first chalk layer, is brown in colour and contains a mixture of yellow and brown earth, lead white, chalk, charcoal black, smalt and copper particles. The presence of smalt and copper particles may indicate the use of palette scrapings, making it possible that this layer was applied in the artist's studio. The painting is dated *c*.1665–68 based on stylistic reasons; however, underneath the current composition, a different underlying composition is present that has been painted over by Steen.[14] It is unclear when this was done, making it difficult to date the ground. No other examples of a similar ground were found in this study.

The Hague and Delft 1649–1657

Steen registered as a painter with the Leiden Guild of St Luke in 1648. One year later he married Grietje van Goyen, daughter of Jan van Goyen, in The Hague, where the couple remained until at least 1654, when Steen rented a brewery in Delft.[15] In 1655 he painted the portrait of the notable Delft grain merchant Adolf Croeser, the only painting that can be dated securely to his years in Delft. All analysed canvas paintings dated in Steen's Hague or Delft period contain a similar light ground layer consisting of chalk, lead white and umber (Figs 4 and 5) with small quantities of black pigment sometimes added. In the score plot of PCA of the bottom ground layer these four paintings are clustered together in the first four dimensions, indicating little difference between the elemental composition of the bottom ground layers.

The Tooth-Puller (Tt, 1651) is the earliest dated painting on canvas analysed in this project. It contains three ground layers of the same composition: chalk, lead white, umber and fine black (Fig. 4). Interestingly, X-radiographs of the painting show cusping that is not related to the painting's present size, indicating that it was cut from a larger piece of ready-primed canvas. No other X-radiographs of paintings from The Hague or Delft were available, so it remains unclear whether Steen used ready-primed canvas more often in this period. Ready-primed canvases were available in Delft, since Vermeer seems to have used them on multiple occasions. In both *View of Houses in Delft, known as 'The Little Street'* (*c*.1658, Rijksmuseum Amsterdam SK-A-2860) and *A Young Woman Seated at a Virginal* (*c*.1670–72, National Gallery London, NG2568), the ground covers the tacking margins and no primary cusping is found relating to the paintings' current sizes.[16]

Fig 4 Overview of *The Tooth-Puller* (a) with a cross-section taken from the boy's blue jacket in brightfield (b) and UV (c).

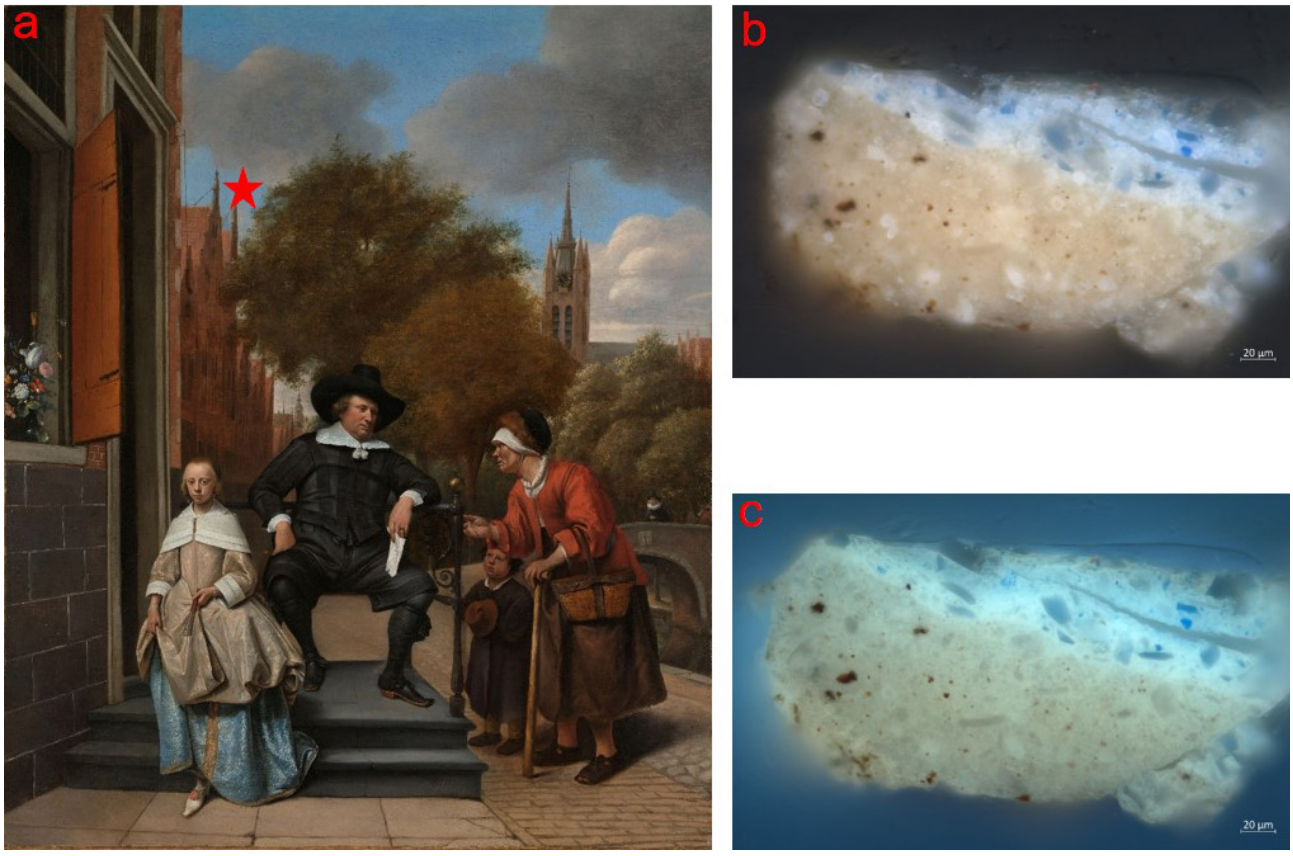

Fig. 5 Overview of *Adolf en Catharina Croeser*, known as *'The Burgomaster of Delft and his Daughter'* (a) with a cross-section taken from the sky in brightfield (b) and UV (c).

Technical studies of artists contemporary to Steen in Delft and The Hague confirm that a light coloured, single ground layer was frequently used. In Vermeer's oeuvre the majority of the grounds consisted of a mixture of lead white, chalk, earth pigments, umber and some fine black. The ground has a light or darker beige or grey colour.[17] Similar light coloured grounds were also found in paintings from Pieter de Hooch's Delft period. In *A Man Smoking and a Woman Drinking in*

Fig. 6 Overview of *Portrait of Jacoba Maria van Wassenaer (1654–1683)*, known as *'The Poultry Yard'* (a) with a cross-section taken from the foreground in brightfield (b) and UV (c).

a Courtyard (MH835), the ground is applied in two layers containing chalk, earth pigments, clay particles and black particles.[18] A smooth, off-white ground is also reported in *A Dutch Courtyard* (*c.*1658–60, National Gallery of Art, Washington, DC, inv. no. 1937.1.56).[19] It would appear that a light ground was also used in The Hague more often. Adriaen Hanneman's *Portrait of Constantijn Huygens (1596–1687) and his Five Children* (dated 1640, MH inv. no. 241) contains a light ground layer made with lead white. For Paulus Potters' works on canvas similar findings have been reported.[20]

It is possible that there was a shared supplier for artists working in The Hague or Delft. The cities are not far apart and were well connected in the 17th century. Unfortunately no colourmen from The Hague are known, but artists were prepared to travel to obtain their materials. The inventory of colourman Crijn Hendricksz. Volmarijn, located in Rotterdam, lists several artists from both The Hague and Delft as his clients.[21] Unfortunately, Steen is not mentioned so the question as to where he obtained his materials remains open, but it is plausible that there was a colourman catering to artists in both Delft and The Hague.

Leiden (1657), Warmond (1658–1660) and Leiden again (1670–1679)

In Leiden, where Steen moved after his unsuccessful attempt at running a brewery in Delft, he often used a tinted ground consisting of lead white, umber, earth pigments and bone black. A ground of this type was found in the *Portrait of Jacoba Maria van Wassenaer (1654–1683)* (also known as *'The Poultry Yard'* (Hh)), which was painted while Steen lived in Warmond (a town close to Leiden). The painting contains three ground layers of a similar composition: lead white tinted with yellow and red earth pigments (Fig. 6). X-radiographs show that it was individually prepared as cusping can be seen on all four edges of the painting. Steen's sojourn in Warmond was brief (he moved there from Leiden in 1658 and left for Haarlem in 1660) and no other paintings from this period were analysed. Several paintings executed after 1670, when Steen returned from Haarlem to Leiden, are clustered in PCA with *Portrait of Jacoba Maria van Wassenaer* (Hh) based on the composition of the bottom ground layers. It seems that this type of ground layer was common for Steen both in Warmond and Leiden. Of these paintings, *Christ Expelling the Traders from the Temple* (Cw), dated by Steen in 1675, contains a ground layer consisting of lead white tinted with umber, earth pigments and bone black (Fig. 7). Like *Portrait of Jacoba Maria van Wassenaer* (Hh), both the other paintings in this cluster (*The Mocking of Samson* (Si) and *'A Pig Belongs in the Sty'* (Wv)) are individually prepared. *The Mocking of Samson* (Si) has never been lined and is still on its original strainer. The canvas is attached to the strainer with iron nails, but was laced into a larger strainer while it was being painted. Both ground and paint layers continue up to the edge of the canvas onto what are now the tacking margins. Remnants of the string used to lace in the canvas are still present. The similarity of the ground layers indicates that although the canvases are individually prepared, they may not have been prepared by the artist but were probably purchased commercially.

Fig. 7 Overview of *Christ Expelling the Traders from the Temple* (a) with a cross-section taken from the blue clothing in brightfield (b) and UV (c).

Fig. 8 Overview of *A Village Revel* (a) with a cross-section taken from the foliage in brightfield (b) and UV (c), and a detail of the dark red top ground layer showing through the paint (d).

Apart from these lighter, tinted grounds, one exceptionally dark red ground layer was used by Steen in Leiden. On *A Village Revel* (Hm, dated 1673 by the artist), a first ground layer consisting of mainly chalk with a little red earth was applied. The second, top ground layer is dark red in colour and consists of red earth mixed with some lead white, chalk and umber. The dark red ground layer, not totally covered by paint, shimmers through thin applications of paint in many areas (Fig. 8), adding to the overall warm tonality of the work. This is quite exceptional for Jan Steen: in other paintings in

Fig. 9 Overview of *The Life of Man* (a) with a cross-section taken from the grey curtain in brightfield (b) and UV (c).

this study where such a dark ground layer was applied, it was covered by subsequent lighter ground layers. A similar ground is mentioned in the technical description of *Peasants Merrymaking Outside an Inn* (previously *Fair at Warmond*, dated *c.*1676). In this painting the dark red ground layer can also be seen in many areas where the overlying paint layers do not overlap.[22]

Leiden was the centre of the so-called *fijnschilders*: painters who were known and appreciated for their smooth and highly refined works of art. Several biographers mention Steen's links to these artists. Houbraken described Frans van Mieris and Steen going out for drinks together, while Jacob Campo Weyerman commented that Steen opened an inn that was frequented by some of Leiden's artists.[23] Although both writers used considerable poetic licence in describing Steen's life, it is conceivable that the artists actually did meet but this is not always reflected in the paintings Steen produced in Leiden and the techniques used to paint them. The later panel paintings made by Steen in Leiden analysed in this study, *Fighting Cardplayers* ('*Het Geweldig Krakeel*', Gk, dated 1671) and *Peasant Wedding* (Bb, dated 1672), are the opposite of works produced by the fine painters, both in terms of subject matter and technique. Steen used few layers to paint these works, which are not finished in a refined manner at all. Works that come closer to the Leiden fine painters in terms of subject matter, such as *A Woman at her Toilet* (Mt, dated 1663) and *A Sick Girl* (Zm, dated *c.*1660), were painted while Steen was living in Haarlem. Although these paintings are more refined than his later panels, in terms of painting technique they still differ from the fine painters. Steen used few layers, while the fine painters generally achieved their smooth surfaces by using multiple thin applications of paint.[24]

Haarlem (1660–1670)

In 1660, Steen and his family moved to Haarlem, and in 1661 he became a member of the Haarlem Guild of St Luke. The 10 years Steen lived in Haarlem were the most productive years of his career and are well represented in this study. Twelve canvas paintings from Haarlem have been analysed showing the use of three different types of ground layers.

In this study, only one painting was found with a grey over red ground layer: on *The Life of Man* (Lm, *c.*1665) a red ground consisting of chalk and red earth, mixed with umber and coarse black, was applied in two layers followed by a second warm grey ground layer containing lead white, yellow earth, umber and fine black (Fig. 9). This ground layer build-up, although it seems unusual for Jan Steen, was commonly used in Amsterdam and Utrecht and has been found on many early canvas paintings by Rembrandt.[25] Although less common for Haarlem, it was occasionally used there too – it is found on a still life painting by Vincent van der Vinne dated around 1660, two canvas paintings by Frans Hals and one by Judith Leyster.[26]

Lighter grey grounds consisting of mainly chalk were used by Steen in Haarlem more frequently than the grey over red grounds. A bottom ground layer of this lighter grey type was found on six canvas paintings, all clustered with the panel paintings in PCA of the bottom ground layers since they have a similar composition (mainly chalk). Two of these paintings were dated by Steen and can be placed in Haarlem with certainty: '*Easy Come, Easy Go*' (Sg) is dated 1661 (Fig. 10) and *The Dancing Couple* (Dc) is dated 1663. The other undated paintings were probably painted in Haarlem as well. *The Oyster Meal* (Om, also dated 1660) can be seen as another

Fig. 10 Overview of *Easy Come, Easy Go* (a) with a cross-section taken from the grey curtain in brightfield (b) and UV (c).

Fig. 11 Overview of *The Oyster Meal* (a) with a cross-section taken from the yellow frame in the background in brightfield (b) and UV (c).

version of '*Easy Come, Easy Go*' (Sg). Although the paintings are similar in terms of date, subject matter and composition, they contain very different ground layers: *The Oyster Meal* (Om) has a dark ground layer composed of clay and earth pigments only (Fig. 11). A similar difference can be seen in both versions of *The Marriage of Tobias and Sarah* (Hu and Ts). Both paintings are undated, but were probably painted around 1667–68. The larger version, currently in the collection of the Herzog-Anton-Ulrich Museum in Braunschweig, features a single red ground containing lead white, chalk, red earth, charcoal black, black shale,[27] clay particles, gypsum and barium sulphate particles. The smaller version contains a more complex ground build-up. The bottom ground layer consists mainly of chalk, mixed with quartz, fine black, yellow earth, red earth, dolomite particles and clay particles. This is followed by two subsequent layers of predominantly lead white, mixed with chalk, red lead, fine black, yellow earth, red earth and quartz. The ground has a warm tonality, but is not as brightly coloured as the other version. These examples show that Steen did not seem to choose a specific ground depending on the painting he was going to execute, but worked with several ground layers at the same time.

Although chalk (in glue) grounds were commonly used on panel paintings, they also appear to have been applied to canvas by other artists working in Haarlem. Frans Hals applied chalk (in oil) grounds to several of his canvas paintings: in some cases, the chalk layer was covered with a second, thinner and tinted ground layer, while in others the chalk layer was the only ground layer applied.[28] One example of a chalk ground applied to canvas has been found in a study of Johannes Verspronck's painting technique. On the portrait of Cornelis Akersloot (from the collection of the Frans Hals museum), a single chalk layer was found covered by an unpigmented oil layer.[29]

The last type of ground encountered in Steen's Haarlem period is a darker brown or red ground, found on four paintings, of which *The Oyster Meal* (Om) and *The Marriage of Tobias and Sarah* (Hu and Ts) have already been described above. Since a red or brown colour can be achieved by mixing various pigments, not all paintings with red or brown grounds were clustered with PCA. *Interior of a Tavern with Cardplayers and a Violin Player* (Hv, dated *c.*1665) contains a red ground that is similar to *The Oyster Meal* (Om), consisting of clay and earth pigments. Both paintings are clustered together in the bottom right corner of the PCA score plot. *The Marriage of Tobias and Sarah* (Hu and Ts) is not placed here since the red colour in this layer was achieved with red earth and lead white. The same applies to *Moses and the Pharoah's Crown* (Mk) in which the brown colour is achieved by mixing

Fig. 12 Overview of *The Alchemist* (a) with a cross-section taken from green clothing in brightfield (b) and UV (c).

chalk, lead white and earth pigments. Darker brown to red grounds were found in Haarlem more frequently towards the end of the 17th century.[30]

Studio grounds

In several paintings, grounds were found with atypical pigments, one of which is *The Alchemist* (Al, dated 1668), which has a triple ground (Fig. 12). The bottom layer of this painting has a deep dark grey colour and consists of charcoal black, bone black, umber, red and brown earth, lead white, chalk, smalt, green earth and clay particles. Two lighter grey layers were applied over this layer: the second layer contains lead white, yellow earth, red earth, bone black, charcoal black, chalk, smalt, yellow lake and red lake while the top layer consists of lead white, bone black, yellow earth and green earth. The use of such a dark bottom ground layer is not encountered in other paintings by Steen analysed in this study. It is possible that palette scrapings were mixed with charcoal black as a cheap material.

Palette scrapings were also used by Steen on two large canvas paintings. On both *The Merry Family* (Vh, dated 1668) and *'As the Old Sing, So Pipe the Young'* (Ss, dated *c.*1668–70), the ground is applied in one layer and contains pigments more often used for paint layers than ground layers, such as smalt, green earth, vivianite, lead-tin yellow and vermilion. In X-radiographs thicker ridges of ground can be seen resulting from the application of the ground with a priming knife.[31]

Conclusions

This project has shown that Jan Steen utilised a great variety of grounds that differ in colour (ranging from almost white to dark grey), number (ranging from one to three) and pigment composition (ranging from 1 to 14 pigments in one layer). Principal component analysis proved to be a useful tool for discovering trends in such a large and varied dataset. The trends that were found with the clusters seen in the score plots need interpretation. Ground layers are clustered based on their elemental composition; no other aspects of the ground (such as colour) were taken into account in the PCA. However, trends could still be observed related to the city in which Steen lived and worked.

Grounds on canvas display more variation in composition and colour than grounds on panel paintings. All panel paintings contain two ground layers of which the bottom one is only chalk. The top ground layer varies slightly in composition but mostly contains lead white, chalk and earth pigments. This could indicate that similar types of panels were available in the different artistic centres where Steen worked. One exceptional ground was found on *The Doctor's Visit*: a brown second ground layer containing, among other pigments, smalt and copper particles.

Strong similarities between paintings made in Delft and The Hague imply the use of commercially prepared grounds. This hypothesis seems to be substantiated by the fact that the canvas of *The Tooth-Puller* (Tt) was cut from a larger piece of pre-primed canvas. In Leiden, several individually primed

canvas paintings were found to contain similar ground layers. One of these paintings, *The Mocking of Samson* (Si), is still on its original strainer and remnants of the string used to lace in the canvas while applying the ground and paint are still visible. This might indicate that although canvases were given individually applied grounds, they might still have been obtained commercially.

In Leiden, Steen typically used a tinted ground layer of which the main constituent is lead white with the exception of two paintings with a very dark red top ground layer, while in Haarlem he employed several types of grounds; these seem to fit with what is known about his contemporaries from other studies. Apart from grounds that appear to be commercially prepared, studio-applied grounds were also found containing a large number of pigments, including palette scrapings consisting of pigments typically found in paint layers: organic lakes, vermilion, green earth, vivianite and smalt.

The present research suggests that Steen used several different types of grounds at the same time in his career, and that he did not seem to choose specific grounds for specific compositions or purposes. Indeed, several similar paintings (two versions of the same composition) that are dated close to each other are painted on very different ground layers, making it very difficult to classify the chronology of Steen's oeuvre purely on the makeup of the ground layers. Nonetheless, using PCA enabled identification of some trends that otherwise would have been missed.

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6. Sixteen paintings were dated by Steen. The *The Freshwater Fish Market in The Hague* can be dated with certainty based on its subject matter and *The Baker Arent Oostwaard and his Wife, Catharina Keizerswaard* can be dated based on an inscription on the back of the panel.
7. All paint samples were embedded in either polyester (Polypol PS230 with M.E.K.-peroxide hardener, Poly-Service Amsterdam, Netherlands) or methacrylate resin (Technovit 2000 LC, Heraeus Kulzer GmbH, Germany) and prepared as cross-sections by sanding down the transverse plane.
8. A Leica DM2500 M microscope coupled with a Zeiss Axiocam 512 camera was used.
9. SEM-EDX analysis of the cross-sections was performed at Shell Technology Centre Amsterdam, using a high-vacuum JEOL 7000F SEM with Noran System Six energy dispersive X-ray system from Thermo Fisher Scientific. The samples were typically examined with an accelerating voltage of 20 kV and a beam current of between 1 nA and 5.5 nA in backscatter mode.
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11. Multivariate analysis of the different datasets was performed using PCA in the Matlab 7.13 environment (The MathWorks Natick, MA, USA), partly using the PLS Toolbox 7.3.1 (Eigenvector Research, Manson, WA, USA).
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31. A ground layer based on smalt and calcium carbonate toned with lead white, earth colours and black was reported on the canvas painting *Moses Striking the Rock* (*c.*1670–71, Philadelphia Museum of Art) by M. Palmer and E.M. Gifford, 'Jan Steen's painting practice: *The Dancing Couple* in the context of the artist's career', *Studies in the History of Art* 57, 1997, pp. 127–155.

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THE GROUNDS OF CARAVAGGISM? CASE STUDY OF THEODOOR VAN LOON

Claire Toussat

ABSTRACT Theodoor van Loon is generally regarded as one of the *Caravaggisti*. This article questions this style-based categorisation from a technical and materials point of view by focusing on the ground layers which play a crucial role in Caravaggio's painting technique. The ground layers of eight paintings by Theodoor van Loon, analysed at the Royal Institute for Cultural Heritage (KIK-IRPA) in Brussels, are compared to those used by Caravaggio in order to assess his influence on Van Loon's technique. This comparison provides new insight into the notion of Caravaggism in general and the artistic intentions of Van Loon in particular.

Introduction

Theodoor van Loon (*c.*1582–1649), mainly active in Brussels, was one of the most important and renowned painters of the Low Countries in the early 17th century. Most of his preserved or documented artworks have a religious subject and were intended for religious buildings.[1] His production is inseparable from the restoration of Catholicism that followed the religious troubles of the 16th century, linked to the emergence of Protestantism.[2] The counter-reformation promoted by Archdukes Albert and Isabella resulted in the renovation or construction of a number of religious buildings, many of which were decorated by Van Loon in collaboration with court architect Wenceslas Coebergher (1557/1561–1634). Among all the prestigious commissions Van Loon received from the court, the seven monumental paintings commissioned for the decoration of the chapels and the main altar of the Basilica of Our Lady of Scherpenheuvel (painted between 1616 and 1627), are the most representative. The basilica was an international place of pilgrimage and literally a fortified bastion of the true faith in the Brabant countryside.[3]

Van Loon was deeply influenced by Italian painting, which he had admired during several stays in Rome in 1602–1608/1612, *c.*1617, 1628 and probably again in 1631.[4] At the beginning of the 17th century, Rome was a major artistic centre in Europe where artists went to immerse themselves in ancient, Renaissance and modern art. During Van Loon's first stay in the city, several innovative paintings by Michelangelo Merisi da Caravaggio (1571–1610) were installed in public buildings. In particular, Caravaggio's *Conversion of St Paul* and the *Crucifixion of St Peter*, in the Cerasi Chapel of the Church of Santa Maria del Popolo in 1605, caused a great sensation. Caravaggio's *Entombment of Christ* (1603–1604) for the Chiesa Nuova was similarly admired. Like many of his contemporaries, both Italian and foreign, Van Loon did not remain insensitive to Caravaggio's innovative style. His works demonstrate his discovery and appreciation of Caravaggio through the use of strong contrasts of light and shade and the placing of massive and non-idealised figures in the foreground on a dark and neutral background.

For all these reasons, Van Loon has traditionally been categorised as one of the first representatives of Caravaggism in the southern Low Countries. However, this stylistic categorisation is problematic as it encompasses several chronological, geographical, iconographical and formal variables, erasing the individual specificity of the so-called *Caravaggisti*.[5] On the one hand, the stylistic and thematic references to Caravaggio do not exclude the combined influences of other artists in the painter's oeuvre. This, in fact, is exactly the case of Van Loon, who also drew inspiration from various sources such as the Mannerist painters and certain Bolognese artists.[6] On the other hand, technical research carried out by Ashok Roy on the Utrecht *Caravaggisti* has revealed the variety of techniques employed by these artists, who clearly did not slavishly imitate Caravaggio.[7]

This contribution expands upon Roy's research by investigating Van Loon's painting techniques and his use of materials, and comparing it to Caravaggio's. The focus of this article is on the ground layers, as scholarly literature has demonstrated how they played a crucial role in Caravaggio's painting process.[8] The study corpus is formed from the eight paintings, belonging to different periods of the artist's life, that were examined and analysed at the Royal Institute for Cultural Heritage (KIK-IRPA) in Brussels in the course of

Fig. 1 Theodoor van Loon, *Pietà with Mary Magdalene and John the Evangelist*, 1604–1608/1612, oil on canvas, 205 × 126 cm, Church of Saint John the Baptist at the Beguinage, Brussels. (Photo © KIK-IRPA.)

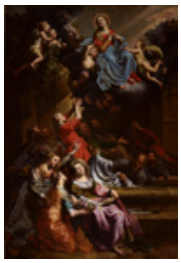
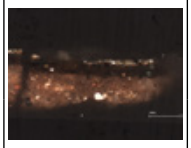
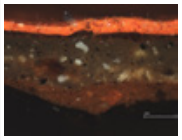
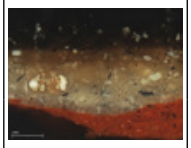
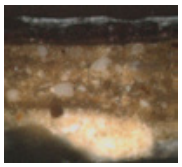
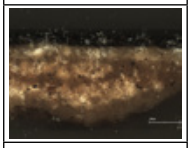
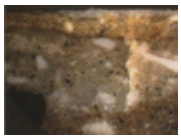
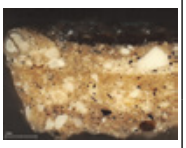
Fig. 2 Theodoor van Loon, *Pietà with Mary Magdalene and John the Evangelist* (Fig. 1): detail showing the dark ground visible between the elements of the composition. (Photo © KIK-IRPA.)

Fig. 3 Theodoor van Loon, *Holy Trinity, Worshipped by St Teresa*, *c.*1615, oil on canvas, 99 × 136 cm, Convent of the Carmelites, Brussels. (Photo © KIK-IRPA.)

Fig. 4 Theodoor van Loon, *Christ Gives the Keys of Heaven to Peter*, *c.*1615, oil on canvas, 98 × 136 cm, private collection, Brussels. (Photo © KIK-IRPA.)

Fig. 5 Theodoor van Loon, *The Liberation of St Peter*, *c.*1617, oil on canvas, 180 × 227 cm, Church of Saint John the Baptist at the Beguinage, Brussels. (Photo © KIK-IRPA.)

Table 1 Cross-sections from the paintings by Van Loon. (Cross-sections: Jana Sanyova and Steven Saverwyns, KIK-IRPA.)

1604–1608/1612	***c.*1615**	***c.*1617**	**1620**	***c.*1620**	***c.*1622**	**1623**
Pietà with Mary Magdalene and John the Evangelist	*Holy Trinity, Worshipped by St Teresa*	*The Liberation of St Peter*	*Adoration of the Shepherds*	*Annunciation of the Virgin Mary*	*Assumption of the Virgin Mary*	*Holy Trinity with Mary, St John the Baptist and Angels*
						
				(a) Left side canvas  (b) Right side canvas 		
Dark brown ground: earth pigments, quartz, dolomite, lead white, bone black.	*Red ground:* red ochre, chalk. *Grey ground:* chalk, lead white, carbon black, ochre.	*Red ground:* red ochre, lead white, traces of azurite. *Grey ground:* chalk, lead white, carbon black.	*White ground:* chalk, earth pigments. *Grey ground applied in several layers:* Lead white, chalk, earth pigments, carbon black.	(a) *Grey ground applied in several layers:* chalk, lead white, earth pigment, bone black, few grains of vermilion, traces of lead yellow. (b) *White ground:* lead white, chalk. *Grey ground:* chalk, lead white, carbon black, earth pigments.	*Grey ground applied in several layers:* chalk, lead white, earth pigments, carbon black.	*Grey ground applied in several layers:* chalk, lead white, earth pigment, carbon black.

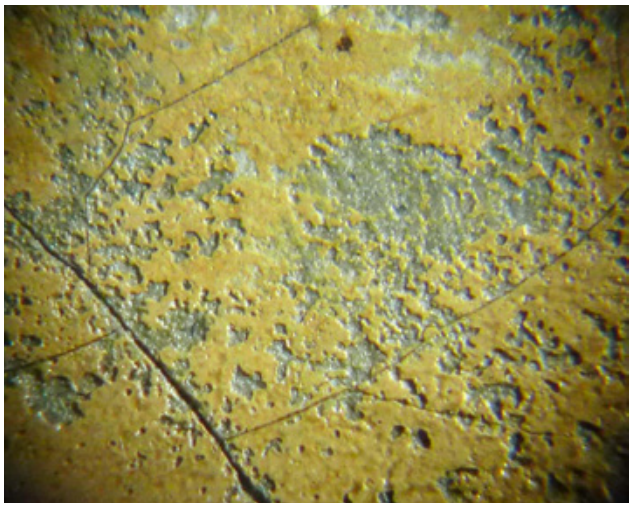


Fig. 6 Photomicrograph of Theodoor van Loon, *The Liberation of St Peter* (Fig. 5): the grey ground layer is visible in the abraded areas. (Photo © KIK-IRPA.)

two conservation campaigns[9] prior to the first exhibition dedicated to Van Loon in 2018 (BOZAR, Brussels).[10] This paper begins by presenting the type of grounds used by Van Loon, then assesses the potential influence of Caravaggio on Van Loon's choices of materials, and finally analyses the link between ground colour and the artist's aesthetic intention.

Types of grounds used by Van Loon

The earliest known painting by Van Loon is a *Pietà with Mary Magdalene and John the Evangelist* (Fig. 1), a copy after a work by the Italian Mannerist Marco Pino (1521–1583) in the Church of Santa Maria in Aracoeli, Rome, probably painted during Van Loon's first stay in the city between 1602 and 1608/1612.[11] The artist used a dark brown ground, visible in the mid-tones and between the elements of the composition,

Fig. 7 Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels*, 1623, oil on canvas, 320 × 240 cm, Church of Saint John the Baptist at the Beguinage. (Photo © KIK-IRPA.)

Fig. 8 Theodoor van Loon, *Annunciation of the Virgin Mary*, *c.*1620, oil on canvas, 341 × 200 cm, Church of Saint John the Baptist at the Beguinage, Brussels. (Photo © KIK-IRPA.)

containing earth pigments, quartz, dolomite, lead white and bone black (Fig. 2 and Table 1).[12] It greatly contributes to the *chiaroscuro* effect and the overall dark tonality of the work.

It is not known whether the colour of the ground of the *Pietà* was a personal choice or if Van Loon copied that of Pino's version.[13] In any event, it is striking to note that the grounds of the paintings Van Loon executed after he returned to Brussels have a different composition. *Holy Trinity, Worshipped by St Teresa* (Fig. 3) and its pendant *Christ gives the Keys of Heaven to Peter* (Fig. 4), painted around 1615 for the convent of the Carmelites in Brussels, both have a double coloured ground consisting of a red underlayer followed by a grey-beige layer (Table 1).[14] This is also the case with *The Liberation of St Peter* (Fig. 5, Table 1), which is not dated but its composition and smooth brushwork suggest a date around 1617.[15]

The use of coloured double grounds is common at the beginning of the 17th century and is recommended several times in northwestern European technical treatises.[16] However, although the process is well documented, the reasons for the application of two colours are debated in the literature. Ernst van de Wetering, followed by Jo Kirby and Ashok Roy, believe that economic considerations could have motivated this choice.[17] By using a first layer made of cheap pigments, the painter could reduce the production costs as only a thin layer of the more expensive lead white would be needed to obtain a suitable base tone for painting. This idea can indeed be found in contemporary sources, such as *Pictoria, sculptoria et quae subalternarum artium*, published in 1620 by Theodore Turquet de Mayerne (1573–1654/1655), which mentions double oil-based grounds several times: 'Ceste imprimeure [made of lead white] sera bonne pour dernière, car si on veut espargner on pourra faire la première d'ocre jaune comme dessus.'[18] On the other hand, Karin Groen suggested that the use of a first red layer derives from a long tradition practised in other forms of artistic production, such as polychrome sculpture, mural painting and gilded objects.[19] Nonetheless, these scholars do agree that the first layer serves to fill the interstices of the canvas, while the second layer gives the painting the desired overall tonality. The visual impact of the red underlayer on the shade of grey depends on the thickness and opaqueness of the second layer; in most cases the red is not visible. The examination of the paintings by Van Loon confirms the weak impact of the red undercoat; it is rather the cool, grey tone of the second ground layer that dominates (Fig. 6).

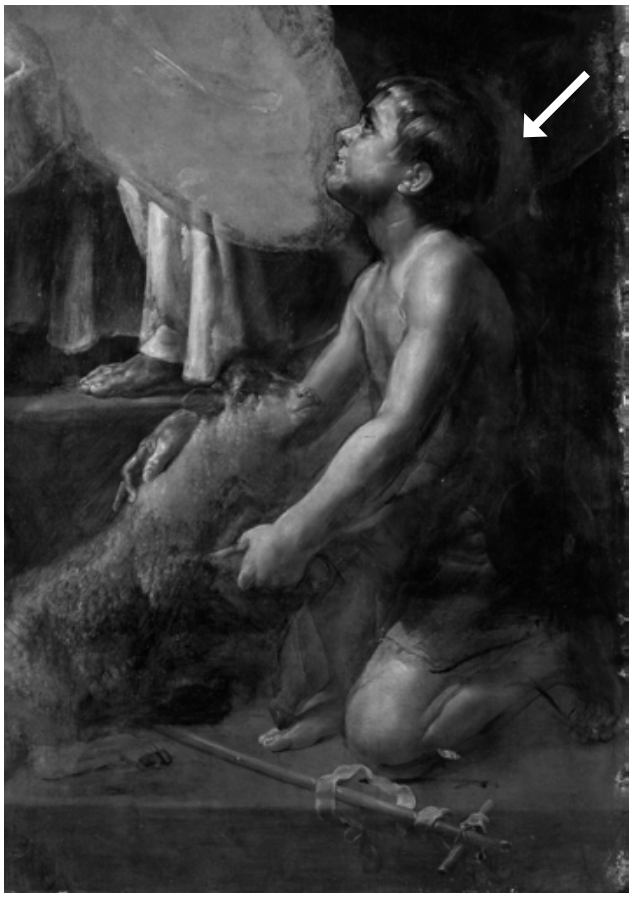


Fig. 9 Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels* (Fig. 7): detail from the infrared reflectogram image. The arrow indicates the reserve for the head of St John the Baptist. (Photo © KIK-IRPA.)

Fig. 10 Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels* (Fig. 7): detail from the infrared reflectogram. The angels in the background are painted on a dark underlayer. (Photo © KIK-IRPA.)

In his later works, the *Assumption of the Virgin Mary*, painted around 1622, and the *Holy Trinity with Mary, St John the Baptist and Angels*, dated to 1623 (Fig. 7), Van Loon no longer used a red underlayer, employing instead a grey ground tinted with brown, applied in several thin layers (Table 1). The

Fig. 11 Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels* (Fig. 7): detail. The ground layer is not visible. (Photo © KIK-IRPA.)

pigments include lead white, carbon black, chalk and earth pigments, the proportions of which vary from one painting to another and within the layers.[20] The choice to abandon coloured double grounds for several layers of the same greyish ground may represent an evolution in the artist's technique, but it is perhaps also related to the imposing dimensions of the works, as applying a single colour makes it possible to quickly and easily obtain a smooth surface on which to paint.

The upper ground layers of the *Adoration of the Shepherds*[21] and the *Annunciation of the Virgin Mary* (Fig. 8), dated to around 1620, are made of the same type of tinted grey colour, but they are preceded by another type of layer: in the *Adoration*, the first layer is white, comprising chalk and earth pigments in a glue-based binding medium, while the grey layers applied on top are in oil medium (Table 1).[22] The *Annunciation* consists of two pieces of canvas joined together vertically; both pieces have a grey preparation. While it was brushed directly on the canvas of the left piece, the right piece has an extra white layer underneath consisting of lead white and chalk (Table 1).[23] The presence of this white layer on the right canvas could be explained by the use of a pre-primed canvas – either done in the workshop for another project or purchased from a supplier – on top of which the desired grey preparation was applied.[24]

A Caravaggist?

The paintings studied demonstrate that Van Loon used simple and double coloured grounds. The colours of the first layer of the double grounds are different, but it seems that from his first stay in Rome onwards, Van Loon always chose medium grey as the final tint. This differs from Caravaggio's usual practice – he also experimented with light grey grounds at the beginning of his career, but mostly painted on dark brown, red or ochre preparations.[25]

Like the Italian master, Van Loon played with strong contrasts between light and shade but unlike Caravaggio, Van Loon's *chiaroscuro* is not defined by the choice of ground

Fig. 12 Theodoor van Loon, *Holy Trinity with Mary, St John the Baptist and Angels* (Fig. 7): detail. An ode to colour. (Photo © KIK-IRPA.)

colour, but by his specific use of dark brown underpainting, which defines the forms and the division of light and shade in the composition.[26] Infrared reflectography of the *Trinity*, for example, revealed how Van Loon reserved a space for St John the Baptist thereby allowing him to stand out from the dark shadows brushed around him at the underpainting stage (Fig. 9). However, the singing angels in the left background are painted on a dark underlayer to accentuate the contrast with the figures in the foreground (Fig. 10).

Furthermore, unlike Caravaggio, the Brussels artist covered the entire surface with paint without leaving parts of the ground exposed to serve as a mid-tone (Fig. 11). This suggests that for Van Loon, ground layers merely acted as smooth supports for the underpainting and the paint layer, as opposed to Caravaggio, who used the ground as part of the paint layer. Perhaps Van Loon's ground composition was determined by local tradition. Although many artists changed the colour of their ground layer during their careers or according to subject matter, grey tones were more common in northern Europe as opposed to Italy, where red-brown preparations dominated.[27] The importance of local traditions in the choice of materials can be seen in the oeuvres of travelling artists. Rubens, for example, painted on dark grounds during his stay in Italy, but adopted lighter grounds after his return to Antwerp.[28] Similarly, Ashok Roy's study revealed that the Utrecht *Caravaggisti* often worked on double tinted grounds with a grey top layer.[29]

However, although local trends influence artists, their personal preference should not be underestimated. Van Loon was certainly inspired by Caravaggio, but his desired aesthetic effect is different as is his choice of materials and painting process. The colour of the ground has a significant influence on the final perception of the painting: dark grounds accentuate the contrast between shadows and lights, magnifying the three-dimensional effect, whereas a lighter, grey underlayer allows for contrast, but preserves more of the brilliance of the colours. This idea was indeed recognised at the time and later in the century. Roger de Piles, for example, taking part in the debate between *disegno* and *colore*, praises the merits of light grounds against dark grounds because they 'conserve toujours un éclat sous le transparent des couleurs'.[30] Paintings by Caravaggio are not characterised by bright colours: as already noted by critics from the 17th century, such as Giovanni Pietro Bellori in 1672, the artist preferred to use a restricted palette of brown and black punctuated by red and yellow,[31] whereas Van Loon's paintings are an ode to colour. Their differing palettes are related to the type of religious painting the artist intended to create. Caravaggio's religious subjects are depicted in an ordinary context, in a sober but dramatic way. Van Loon also sought dramatic effect, but with a more sophisticated aesthetic. Although the physiognomy of the characters is common, they are richly dressed, with silk fabrics and brocades, and they often feature elaborate hairstyles (Fig. 12).

Conclusions

This paper has documented the type of grounds used in eight paintings by an artist active in the southern Low Countries at the very beginning of the 17th century. Although the corpus is not sufficiently large to draw firm conclusions, this study of Van Loon's grounds seems to indicate a chronological evolution in their types, from double to simple. It is an interesting avenue of research as it could facilitate the dating of other paintings, which is why it is hoped that future examination of other works will enrich these first results.

The results raise questions as to the relevance of classifying artists under modern labels such as 'Caravaggist'. It is true that Van Loon quotes compositional elements from Caravaggio – using strong contrasts of light and shade, and placing massive and non-idealised figures in the foreground on a dark and neutral background – but this study shows that his use of the ground layer and, therefore, his whole painting process is different. This could be because Van Loon was unaware of the Italian master's technique. The question of what exactly contemporaries knew of Caravaggio's painting technique is indeed essential, but *in fine* Van Loon made deliberate and considered aesthetic decisions for his own oeuvre. His choices regarding ground layers, and consequently his whole painting technique, suggest that Van Loon strove to achieve different pictorial effects, with a much greater emphasis on the importance of shimmering colour. What the designation of 'Caravaggist' obscures is that he created a proper technique and style, rich in influences and references, which fully met the requirements of a new religious art: *dolcere, movere, et delectare* (to teach, to move and to delight).[32]

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Notes

1. S. van Sprang, 'À la recherche de Théodore van Loon, entre Rome et Bruxelles', in S. van Sprang (ed.), *Théodore van Loon*, Brussels, BOZAR, 2018, pp. 19–36.
2. R. Suykerbuyk, '*Theatro miraculorum*. Théodore van Loon et la culture religieuse dans les Pays-Bas méridionaux', in Van Sprang 2018 (cited in note 1), pp. 73–85.
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4. Ibid., pp. 19–36.
5. C. Strinati and A. Zuccari (eds), *I caravaggeschi: Percorsi e protagonisti*, 2 vols, Milan, Skira, 2010.
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7. A. Roy, 'Caravaggio's influence in the north', in M. Ciatti and B.G. Brunetti (eds), *Caravaggio's Painting Technique: Proceedings of the CHARISMA Workshop*, Florence, Nardini Editore, 2012, pp. 85–94; A. Roy, 'The Utrecht painters: Caravaggism, technique and expression', in B. Ebert and L.M. Helmus (eds), *Utrecht, Caravaggio, and Europe*, Utrecht, Centraal Museum/Munich, Bayerische Staatsgemäldesammlungen, 2018, pp. 81–96.
8. The importance of the ground layer is emphasised by Claudio Falcucci, who writes: 'the colour of the preparation in Caravaggio's paintings not only influences the general tone but is in fact an essential part of the work itself': see C. Falcucci, 'Practices and processes, from the Odescalchi *Conversion of Saint Paul* to the *Adoration of the Shepherds*', in Ciatti and Brunetti 2012 (cited in note 7), pp. 31–40, p. 31; M. Ciatti and C. Lalli, 'Caravaggio's *The Beheading of Saint John the Baptist in Malta*: investigation into execution, technique, style and restoration', in Ciatti and Brunetti 2012 (cited in note 7), pp. 11–22; L. Keith, 'Caravaggio's painting technique: a brief survey based on paintings in the National Gallery', in Ciatti and Brunetti 2012 (cited in note 7), pp. 23–30.
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10. Van Sprang 2018 (cited in note 1).
11. D. Coekelberghs and P. Loze, *L'église Saint-Jean-Baptiste au Béguinage à Bruxelles*, Brussels, Ministère de la communauté française, 1981, p. 190; R. Suykerbuyk and C. Toussat, 'Théodore van Loon, Pietà avec saint Jean l'Évangéliste et Marie-Madeleine', in Van Sprang 2018 (cited in note 1), pp. 110–112.
12. Analyses of the ground layers carried out at the Royal Institute for Cultural Heritage (KIK-IRPA) in Brussels by Steven Saverwyns, KIK-IRPA file no. 2016.13328.
13. No technical documentation on the *Pietà* by Marco Pino has been found.
14. For the exact composition of the ground layers of *Holy Trinity, Worshipped by St Teresa*, see the report by Steven Saverwyns, KIK-IRPA file no. 2016.13329. A double ground was observed under the microscope in *Christ Gives the Keys of Heaven to Peter,* but was not analysed. See the conservation report by Claire Toussat, KIK-IRPA file no. 2016.13329.
15. For the exact composition of the ground layers see the report by Steven Saverwyns, KIK-IRPA file no. 2016.13103. The dating of the painting is discussed in Van Sprang 2018 (cited in note 1), pp. 29, 131; see also Cornil 1936 (cited in note 6), p. 205; D. Coekelberghs, 'Le Martyre de saint Lambert (1617), tableau caravagesque de Théodore van Loon', *Bulletin de l'Institut royal du Patrimoine artistique* 7, 1978–1979, pp. 144–145; Coekelberghs and Loze 1981 (cited in note 11), pp. 190–193.
16. M. Stols-Witlox, *A Perfect Ground: Preparatory Layers for Oil Paintings 1550–1900,* London, Archetype Publications, 2017.

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18. 'This ground will be suitable as last layer, because if one wishes to save, one can apply a first layer made of ochre', in T. De Mayerne, M. Faidutti and C. Versini, *Pictoria, sculptoria et quae subalternarum artium: Le manuscrit de Turquet de Mayerne,* Lyon, Audin imprimeurs, 1977, p. 123. The author mentions several recipes, see p. 14: 'Imprimeur toile pour huyle'; p. 103: 'Pour imprimer la toile pour peindre a huile'; p. 115: 'Pour imprimer excellement une toile'; p. 123: 'De la manière de préparer la toile, carton, bois, et aultres matieres sur quoi on veult peindre, et des appareils pour imprimer avant que peindre'.
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21. Theodoor van Loon, *Adoration of the Shepherds*, *c*.1620, oil on canvas, 207 × 154 cm, Royal Museums of Fine Arts of Belgium, Brussels (inv. no. 228).
22. The composition of the ground of the *Adoration of the Shepherds* is described in Sanyova *et al*. 2011 (cited in note 9), pp. 83–84.
23. Report by Steven Saverwyns. KIK-IRPA file no. 2016.13326.
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30. 'Always retain their force under transparent colours'; R. De Piles, *L'art de peinture de C.A. du Fresnoy, traduit en François, enrichy de remarques, augmenté d'un dialogue sur le coloris, & de plusieurs figures d'academie*, 2nd edn, Paris, Langlois, 1673, p. 215.
31. G.P. Bellori, *Vie du Caravage, traduit de l'italien par Brigitte Pérol*, Paris, Gallimard, 1991, p. 40; C. Seccaroni, 'Some considerations on Caravaggio's palette', in Ciatti and Brunetti 2012 (cited in note 7), pp. 79–83.
32. Humanistic-rhetorical principle reused by Cardinal Gabriele Paleotti, Archbishop of Bologna, who defined the new rules of counter-reformation art in *De pictura sacra* in 1582: see Van Sprang 2018 (cited note 1), p. 20.

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PREPARATORY LAYERS IN BRITISH PAINTINGS FROM THE 16TH TO THE EARLY 18TH CENTURY

Joyce H. Townsend and Rica Jones

ABSTRACT Technical examination and analysis of 120 paintings from the 16th to the early 18th century (known in Britain as the Tudor-Stuart period) has been carried out at the Tate Gallery. This paper presents and discusses the results of that work relating to grounds and primings: their colour, structure, composition and the prevalence of lead soap aggregates, presented in a table with the paintings listed in date order.

The Tudor Stuart cataloguing project

Tate's works from the Tudor Stuart period currently number some 120 paintings including several in the process of acquisition. The cataloguing of Tate's Tudor Stuart paintings and works on paper has been a long-standing endeavour. From its inception in the late 1990s the catalogue was intended to include a detailed and illustrated technical entry for each painting, this part of the project being led by senior conservator Rica Jones, and since her departure from Tate in 2012 by senior conservation scientist Joyce Townsend. The first phase, funded by the Getty Grant Program, ran concurrently with art historical research on each painting by Tate curators. The project has been published solely online, with almost all art historical entries completed,[1] most technical entries already available,[2] and the outstanding technical entries currently being compiled. There is now a process in place for examining works acquired since 2012 and for future acquisitions.

The date range for Tudor Stuart paintings extends from 1545, the earliest painting in Tate's collection, to the 1730s. In practice, this covers artists born before 1675, who were therefore painting during the reigns of Tudor and Stuart monarchs. The 17th-century works make up a large proportion of the group; these are predominantly portraits and family groups, mostly painted on canvas and larger in scale. In addition, the collection contains 27 paintings on panel and one with a copper support.

Tate holds the national collection of British art as well as international and modern art. The description 'British' covers artists who were active in Britain for significant periods of their lives: in fact, a number of these artists in the Tudor Stuart period were born and usually trained in present-day Belgium, France, Germany, the Netherlands or Italy. Dutch and Flemish paintings of the period have been studied in more detail than British ones, so there should be interesting comparisons to be made with other projects. Other public collections have also been examining and cataloguing paintings of a comparable date range since the late 1990s: the National Portrait Gallery, London;[3] the National Gallery, London; the Royal Collection and the National Trust, both UK; and the Yale Center for British Art (Mellon Collection), New Haven, USA.

The methodology for the Tate study is standard: art historical research has been combined with imaging techniques such as X-radiography[4] and infrared reflectography (IRR), dendrochronology of the panel supports, and microscopical examination to elucidate the painting technique. Paint samples were taken and cross-sections made from all paintings, while pigment identification was carried out using a combination of polarised light microscopy (PLM) and energy dispersive X-ray (EDX) analysis applied to samples viewed in a scanning electron microscope (SEM). The ground colour (reported here) was assessed from the cross-sections and from earlier observations of the paintings with a stereomicroscope. Medium analysis of the preparatory and paint layers was not appropriate for many of the paintings as nearly all those on canvas have been lined at least once, usually using glue paste. Furthermore, all have been cleaned of varnish, revarnished, retouched and consolidated locally many times over the centuries, by a variety of undocumented methods. Treatment histories have to be inferred from the paintings themselves,

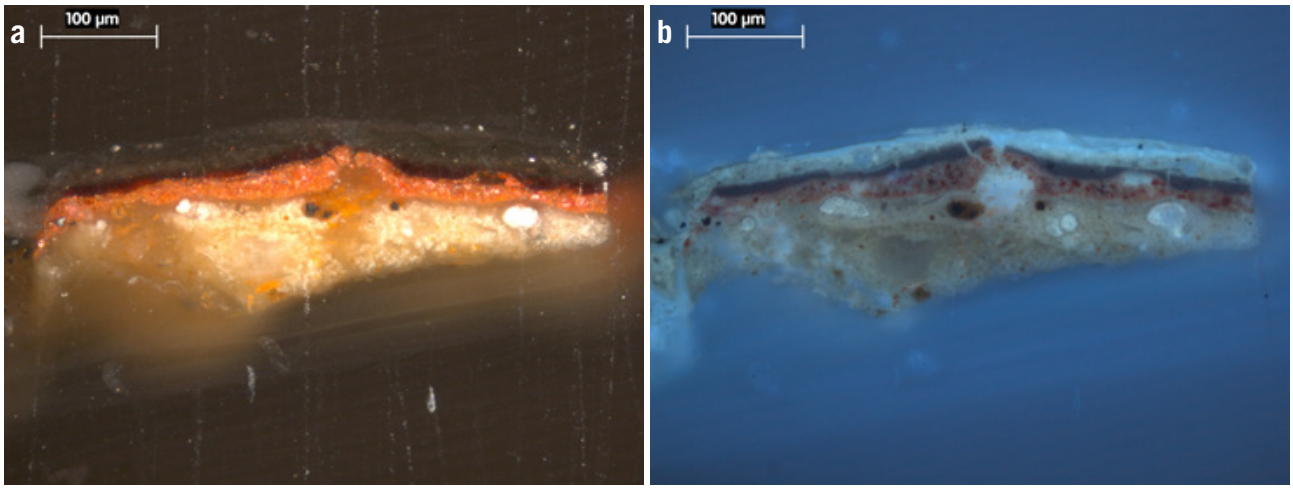

Fig. 1 British School, *Portrait of Gertrude Sadler c.*1620–23, Tate Britain, London, inv. no. T03030: cross-section imaged at ×250 taken from an unfaded area of red curtain at the left edge, with an off-white ground composed of marine chalk, lead white, red lead, umber, Cologne earth and bone black all bound together in oil in (a) visible light and (b) ultraviolet light. Lead soap aggregates from the ground are pushing through the red paint.

since detailed and illustrated conservation records only began in the mid-1950s.

Separate studies of some Tudor Stuart artists have been published by the authors during the project,[5] but rather few technical studies of individual paintings.[6] The Tudor Stuart technical study has contributed to studies in the Netherlands in the 2000s on the phenomenon of lead soap formation and its prevalence.[7] A few Tudor Stuart paintings have been described in more detail to illustrate the present understanding of metal soap formation,[8] which can lead to a 'worn' or 'darkened' appearance of the paint.[9] Such alterations in appearance are often found to be due to lead soap formation in the ground applied to the canvas as well as any priming present on top of the ground.

We have defined the ground as a field on which to paint, usually a lean, opaque paint applied as a single, unmodified colour to the support in readiness for painting. The priming, when present, is a thin layer of self-coloured paint applied to the ground to modify its colour. The colour and nature of such preparatory layers in Tudor Stuart paintings is the subject of this paper.

Issues with describing the colour of a layer

It is apparent from assessing a project of many years' duration that there is a degree of inconsistency in colour descriptions for preparatory layers, even from a small team. It is probably the case that Tate as an institution regularly uses a limited number of terms to describe the colour of grounds, primings and local underpainting, and that long-serving staff have tended to adopt them almost unconsciously. These terms include: 'off-white' but rarely 'white' for these earliest works in the collection; 'grey' sometimes qualified as warm/cool as well as light/mid/dark or bluish and always including lead white and bone black where the medium is oil; buff/beige/tan/brown/biscuit which implies the presence of yellow and brown ochres, umbers and Cologne earth but not red ochres, and which are probably all used by the same person at different times to describe a similar colour; 'red' which does imply that red ochres and/or red lead are present as well as the brown/yellow earth colours; 'salmon pink' which tends to suggest significant amounts of lead white as well as red pigments, and which occasionally includes a red lake. The authors have assessed whether any red lead that can be seen in a layer viewed in cross-section is likely to have been present originally, or if it has developed during the natural ageing of the paint. Lead soap aggregates can develop an outer shell of red lead and turn into red/orange spots of red lead if they are fully mineralised. If the red lead occurs in this non-original form, that is to say as rings and spots in cross-section, then the colour description for the original ground should be closer to 'brown' than 'red', regardless of the prevalence of the red lead now in a coloured ground.

Lead soap aggregates and their effects

It is evident that the formation of lead soap aggregates is very common in the grounds and primings of Tudor Stuart paintings – it is exceptional not to see some evidence for it in cross-sections whenever the medium of the ground or priming has not been indicated as proteinaceous by the use of microscopical stains. Indeed, it acts as a good default indicator in medium analysis that almost all the paintings on canvas must have an oil-based ground, and if a priming is also present it is almost always oil-based. The latter also applies to panel paintings: lead white is always present even in grounds that are described as 'dark' brown or red or grey. While lead white or lead-based driers are obviously a necessary precursor for lead soaps, the most dramatically large lead soap aggregates occur when the ground and/or priming include (from EDX analysis) a noticeable or larger than usual proportion of chalk. Lead soap aggregates that have formed in the ground layer alone are often small, 50–100 µm in diameter, therefore smaller than the thickness of the layer and evenly

Fig. 2 William Segar, *Portrait of a Man in a Slashed Doublet*, *c.*1605, oil on canvas, 1000 × 806 mm, Tate Britain, inv. no. T03576. (Photo © Tate 2020.)

Fig. 3 William Segar, *Portrait of a Man in a Slashed Doublet* (Fig. 2): detail showing the left cuff. (Photo © Tate 2020.)

Fig. 4 William Segar, *Portrait of a Man in a Slashed Doublet* (Fig. 2): closer detail showing the left cuff. (Photo © Tate 2020.)

scattered through it. When they are thus concealed beneath the paint surface, they can reveal themselves as opaque, lead-rich spots in the X-radiograph.

Aggregates occur more frequently in canvas paintings than in panel paintings, and are more common in paintings with both a priming and ground than in those with a ground alone. Since the panels in this study are generally painted more thinly than works on canvas, these observations confirm that formation in thick preparatory layers is more prevalent. The typical ground thickness for a Tudor Stuart painting is 50–250 μm, while the typical priming thickness is 50–150 μm, the thinner layers of priming being more common on panel supports. It is obvious that the largest aggregates, which can attain a diameter of 500 μm, will be wider than the paint layer in which they developed, so that they deform the layers above (Fig.1).

Lead soap aggregates are most obvious to the viewer at close and even normal viewing distance when they have broken through the topmost paint layer, which has occurred to some degree in more than half of the Tudor Stuart paintings. Quite a number are densely covered in obvious 'protrusions' that have emerged through all surface colours and therefore must have originated in the ground and/or priming. When the paint surface is dark coloured and the aggregates have been truncated by an undocumented, harsh cleaning treatment in the past, they are visible on the surface as white spots, and sometimes as orange spots of red lead, up to 0.5 mm (500 μm) in diameter. Some early treatments have partly dissolved such protruding aggregates, enlarging them and leaving a hollow in the paint, which has generally been filled with now-discoloured varnish and/or dirt. The result is yellow/brown spots on the darker paint surface and dark spots in light areas. Such losses of lead-containing material appear as dark spots on X-radiographs.

When the spots are small, they have been described in older entries in Tate conservation records as 'surface blanching' or 'surface is rather/very worn', and when they are large enough to be visible without a microscope, they have often been called 'soft protrusions'. Their abundant presence can make images rather difficult to interpret. One of the most difficult examples encountered in this project is William Segar's *Portrait of a Man in a Slashed Doublet* (Fig. 2). At normal viewing distance it is clear that this gentleman possesses an elegant and clearly expensive lace collar, but from the same distance he seems to lack the lace cuffs that would be expected to complement it, while his black doublet appears excessively plain, lacking in embroidery or brocaded fabric. Close and microscopical examination reveals that he does in fact have intricately constructed and delicately painted lace cuffs, painted over the black fabric, but that white spots fill the areas of black between the white brushstrokes for the lace (Figs 3 and 4). Likewise, lines of spots follow and break up the grey and coloured linear brushstrokes that defined the costly black brocaded fabric of the doublet. The overall effect is to desaturate the intense black of the surface, and to 'defocus' the detail of the costume. A more widespread change in appearance that they cause is increased transparency of paint layers where they develop in large numbers, which has the effect of making the whole composition appear darker than when first painted.[10]

Table 1 Published/yet to be published colour descriptions for the preparatory layers of 109 Tudor Stuart paintings.

Inv. no.	Artist	Title	Probable date range	Support	Ground (oil likely if no medium given)	Priming
N04252	British School, 16th century	*Portrait of a Gentleman, probably of the West Family*	*c.*1545–60	oak panel	off-white chalk/glue	white
N01496	John Bettes	*A Man in a Black Cap*	1545	oak panel	white gesso	bright salmon pink
T01569	Hans Eworth	*Portrait of Elizabeth Roydon, Lady Golding*	1563	oak panel	off-white chalk/glue	very pale grey
T00606	Hans Eworth	*Portrait of an Unknown Lady*	1565-68	oak panel	off-white chalk/glue	very pale grey
T03896	Hans Eworth	*Unknown Lady*	*c.*1565–68	oak panel	off-white chalk/glue	very pale grey
T00400	British School, 16th century	*A Young Lady Aged 21, Possibly Helena Snakenborg, Later Marchioness of Northampton*	1569	oak panel	off-white chalk/glue	grey
N06090	George Gower	*Sir Thomas Kytson*	1573	oak panel	off-white chalk/glue	greyish-white
N06091	George Gower	*Lady Kytson*	1573	oak panel	off-white chalk/glue	greyish-white
N04811	British School, 16th century	*Portrait of a Lady*	1576	oak panel	off-white chalk/glue	
T00402	British School, 16th century	*Portrait of Sir Henry Unton*	1586	oak panel	off-white chalk/glue	
T01872	Marcus Gheeraerts II	*Portrait of Mary Rogers, Lady Harington*	1592	oak panel	off-white chalk/glue	pale bluish-grey
T03028	Marcus Gheeraerts II	*Captain Thomas Lee*	1594	canvas	off-white chalk/glue	off-white
T05729	British School, 16th century	*An Allegory of Man*	1596 or later	oak panel	off-white chalk/glue	
T07699	Marcus Gheeraerts II	*Portrait of an Unknown Lady*	*c.*1596	oak panel	off-white chalk/glue	pale grey
T00069	British School, 17th century	*The Cholmondeley Ladies*	*c.*1600–1610	oak panel	off-white chalk/glue	off-white
T03576	William Segar	*Man in Slashed Doublet*	*c.*1605	oak panel	off-white chalk/glue	greyish-brown
T03466	Marcus Gheeraerts II	*Portrait of a Man in Classical Dress, possibly Philip Herbert, 4th Earl of Pembroke*	*c.*1610	oak panel	off-white chalk/glue	streaky brownish-grey
T03031	British School, 17th century	*Portrait of a Lady, called Elizabeth, Lady Tanfield*	1615	canvas	off-white	pale grey
T00068	Robert Peake	*Lady Anne Pope*	1615	oak panel	off-white	streaky cream
T00398	Paul van Somer	*Lady Elizabeth Grey, Countess of Kent*	*c.*1619	oak panel	off-white chalk/glue	
T03033	British School, 17th century	*Portrait of Anne Wortley, later Lady Morton*	*c.*1620	canvas	salmon pink	salmon pink
T03030	British School, 17th century	*Gertrude Sadler, Lady Aston*	*c.*1620–23	canvas	off-white	translucent, unpigmented layer, probably oil
T03250	Cornelius Johnson	*Portrait of Susanna Temple, later Lady Lister*	1620	oak panel	off-white chalk/glue	streaky grey
T03456	Marcus Gheeraerts II	*Woman in Red*	1620	oak panel	off-white chalk/glue	salmon pink
T06995	Nathaniel Bacon	*Cookmaid with Still Life of Vegetables and Fruit*	*c.*1620–25	canvas	mushroom	pale grey
T12919	Peter Paul Rubens	*The Apotheosis of James I and Other Studies: Multiple Sketch for the Banqueting House Ceiling, Whitehall*	*c.*1628–30	canvas	white	streaky pale grey
N03474	Daniel Mytens	*1st Duke of Hamilton*	1623	canvas	tan	dark grey
N06247	John Souch	*George Puleston (?)*	*c.*1625–30	canvas	warm beige	
T00744	Cornelius Johnson	*Portrait of an Unknown Gentleman*	1629	oak panel	off-white chalk/glue	pale grey
T00745	Cornelius Johnson	*Portrait of an Unknown Lady*	1629	oak panel	off-white chalk/glue	pale grey
T02139	Anthony van Dyck	*Lady of the Spencer Family*	*c.*1633–38	canvas	pale dull pink	translucent buff colour, quartz-based
T03029	British School, 17th century	*Portrait of Thomas Pope, later 3rd Earl of Downe*	*c.*1635	canvas	light reddish-brown	double, both grey
T06640	William Dobson	*Portrait of the Artist's Second Wife*	*c.*1635–40	canvas	double, tan	
T02308	British School, 17th century	*Portrait of William Style of Langley*	1636	canvas	pale orange	beige
T02020	David des Granges	*The Saltonstall Family*	*c.*1636–37	canvas	double, off-white	cream
T07896	Anthony van Dyck	*Sir William Killigrew*	1638	canvas	warm light grey	warm light grey
T07956	Anthony van Dyck	*Mary Hill, Lady Killigrew*	1638	canvas	off-white chalk/glue	pale grey
T04168	Alexander Keirincx	*Distant View of York*	1639	oak panel	off-white chalk/glue	pale grey
T03237	Gilbert Jackson	*Lady of the Grevillle Family with her Son*	1640	canvas	pale orange	warm grey
N01249	William Dobson	*Endymion Porter*	*c.*1642–45	canvas	mid-grey	
N01320	Cornelius Johnson	*Apolonius Veth*	1644	canvas	double, red then grey	biscuit colour

Inv. no.	Artist	Title	Probable date range	Support	Ground (oil likely if no medium given)	Priming
N01321	Cornelius Johnson	*Cornelia Veth*	1644	canvas	double, red then grey	biscuit colour
N06175	Peter Borseller	*Portrait of a Lady*	1644–87	canvas	pinkish-brown	
N04619	William Dobson	*Portrait of an Officer*	*c.*1645	canvas	light beige	
N02530	Cornelius Johnson	*Portrait of an Unknown Lady*	1646	canvas		dark grey
T00500	Edward Bower	*Sir John Drake*	1646	canvas	yellow	opaque grey
T00884	Peter Lely	*Boy Playing a Jew's harp*	*c.*1648	canvas	buff	
T00885	Peter Lely	*Man Playing a Pipe*	*c.*1648	canvas	buff	
T01402	Francis Barlow	*A Roller, Two Peregrine Falcons and a Long-eared Owl with her Young*	*c.*1646–1704	canvas	reddish-brown	
T14495	Joan Carlile	*Portrait of an Unknown Lady*	1650–55	canvas	pale brown	pale pink
T00452	Peter Lely	*Susanna and the Elders*	*c.*1650–55	canvas	mid-grey	
T06782	Henry Gibbs	*Aeneas and his Family fleeing burning Troy*	1654	canvas	off-white	pale grey
T03543	Henry Anderton	*Mountain Landscape with Dancing Shepherd*	*c.*1650–60	canvas	off-white	
T06993	John Hayls	*Lady and a Boy with Pan*	1655–59	canvas	tan	warm grey
N05927	Cornelius Johnson	*Portrait of an Unknown Lady*	1659	canvas	double, orange then mid-grey	dark grey
T07113	Unknown artist, Britain, attributed to John Greenhill	*Portrait of Richard Colman*	*c.*1660	canvas	pinkish-grey	
T04162	Gilbert Soest	*Gentleman and his Dog, probably Sir Thomas Tipping*	*c.*1660	canvas	off-white chalk/glue	pink
T00056	Isaac Fuller	*Portrait of an Unknown Man*	*c.*1660	canvas	off-white	salmon pink
T00058	Peter Lely	*Two Ladies of the Lake Family*	*c.*1660	canvas	off-white	
T05572	Francis Barlow	*Monkeys and Dogs Playing*	1661	canvas	yellowish-buff	
T06455	John Michael Wright	*MaryVilliers, Duchess of Richmond, with her late Son Esme and her Daughter Mary*	*c.*1661	canvas	deep pink	
T00620	Francis Le Piper	*Hudibras' First Encounter with the Bear-Baiters*	1664–67	oak panel	salmon pink	pale grey
T00621	Francis Le Piper	*Hudibras' Discomfiture at the Hands of the Skimmington*	1664–67	oak panel	pinkish-brown	pink
T00247	Francis Le Piper	*The Combat of Hudibras and Gordon*	1664–67	oak panel	salmon pink	
T00248	Francis Le Piper	*Hudibras and Ralph taken Prisoner*	1664–67	oak panel	salmon pink	
N02878	British School, 17th century	*A Lady of the Horton Family*	*c.*1655	Canvas	reddish-brown	white, thin
N03546	British School, 17th century	*Portrait of a Man*	*c.*1670	canvas	warm orange	opaque pale pink
T00746	Gilbert Soest	*6th Duke of Norfolk*	*c.*1670–75	canvas	pink	
T14102	Gilbert Soest	*Portrait of a Lady as a Shepherdess*	*c.*1670	canvas	pink	
T14039	Peter Borseller	*Portrait of Katherine Hoby*	*c.*1670	canvas	pale pink	
N01016	Peter Lely	*Girl with a Parrot*	*c.*1670	canvas	salmon pink	
N03583	Peter Lely	*Frans Mercurius Van Helmont*	1670–71	canvas	greyish-beige	
T00755	Peter Lely	*Portrait of an Unknown Woman*	*c.*1670–75	canvas	buff	
N06222	Godfrey Kneller	*Elijah and the Angel*	1672	canvas	beige	dull grey
T00901	Jacob Huysmans	*Portrait of a Lady as Diana*	?1674	canvas	warm grey	
N02986	Jan Wyck (follower of)	*Italianate landscape*	1672–1700	canvas	double, reddish-buff	buff
T06750	John Michael Wright	*Mrs Salesbury and her Grandchildren*	1675–76	canvas	salmon pink	
T05019	Godfrey Kneller	*John Banckes*	1676	canvas	pale grey	dark pink
T00070	Peter Lely	*Elizabeth, Countess of Kildare*	*c.*1679	canvas	bright pink	
T00916	Antonio Verrio	*Sketch for a Ceiling Decoration: An Assembly of the Gods*	*c.*1680–1700	canvas	reddish-brown	
T00132	John Michael Wright	*Sir Neil O'Neill*	1680	canvas	double, salmon pink	
T06612	Mary Beale	*Portrait of a Young Girl*	*c.*1681	canvas	warm grey	
T07469	Simon du Bois	*Portrait of a Gentleman, probably Arthur Parsons MD*	1683	canvas	yellow	pale red
T00061	William Gow Ferguson	*Still Life with Dead Birds*	1684	canvas	reddish-brown	
T12029	Godfrey Kneller	*Philip, 4th Lord Wharton*	1685	canvas	warm mid-grey	tan
T07241	Harman Verelst	*Dionesse Cullum*	*c.*1685	canvas	double, pale grey	
T06897	Benedetto Gennari	*Elizabeth Panton, later Lady Arundell of Wardour, as Saint Catherine*	1689	canvas	red	dark salmon pink

Inv. no.	Artist	Title	Probable date range	Support	Ground (oil likely if no medium given)	Priming
T00899	Jan Siberechts	*Landscape with Rainbow, Henley-on-Thames*	*c.*1690	canvas	brown	
T00057	John Riley	*James Sotheby*	*c.*1690	canvas	tan brown	
T07240	Unknown artist, Britain, attributed to Mary Beale	*Portrait of Robert Colman*	*c.*1690	canvas	reddish-brown	
N03272	Godfrey Kneller	*First Marquess of Tweeddale*	1695	canvas	triple, streaky greyish-tan	
N05916	Edward Collier	*Still Life with a Volume of Wither's 'Emblemes'*	1696	canvas	reddish-brown	
N00273	Godfrey Kneller	*John Smith the Engraver*	1696	canvas	pale bluish-grey	
T06996	Jan Siberechts	*View of a House and its Estate in Belsize, Middlesex*	1696	canvas	brown	light tan
N05856	Edward Collier	*Still Life*	1699	canvas	warm grey	cool grey
T03853	Edward Collier	*A Trompe l'oeil of Newspapers*	*c.*1699	canvas	pinkish-grey	
T02266	James Hamilton	*Two Hounds Chasing a Hare*	*c.*1700	canvas	double, bright red	
T00408	John Griffier the Elder	*Hampton Court Palace*	*c.*1700	copper panel	white	
T15483	John Closterman	*Portrait of a Gentleman c.1700*	*c.*1700	canvas	mid-brown	pale brown
T06488	Marmaduke Cradock	*A Peacock and Other Birds in a Landscape*	*c.*1700	canvas	pinkish-beige	fawn
T14106	John Closterman	*Unknown Lady*	*c.*1700–1702	canvas	brown	
T06499	Michael Dahl	*Portrait of Mrs Haire*	1701	canvas	orange-brown	
T03982	Godfrey Kneller	*John Smith, Speaker of the House of Commons*	*c.*1707–8	canvas	tan	cool grey
T04129	John Griffier the Elder	*Turkey and other Fowl in a Park*	1710	canvas	double, pinkish-mushroom	
T00894	Unknown artist, France, 18th century	*Apollo*	*c.*1720	canvas	red	grey
T07615	Godfrey Kneller	*The Harvey Family*	1721	canvas	tan	pale grey
T01894	Jonathan Richardson	*Unknown Gentleman*	*c.*1730–40	canvas	double, pale grey	
T13207	Jonathan Richardson	*Portrait of the Artist's Son, Jonathan Richardson the Younger, in his Study*	*c.*1734	canvas	beige	
T03032	British School, 17th/18th century copy?	*Portrait of George Talbot, 6th Earl of Shrewsbury*	1600–1799	canvas	dark grey	lighter grey

Interim conclusions for ground layers and primings

Colour descriptions for the preparatory layers of 109 Tudor Stuart paintings, both published and awaiting publication, are given in Table 1. The group of 27 solid supports includes nearly all of the 16th-century works in the collection; most of this group are dated before *c.*1625, with a few much later exceptions such as those in this study by Francis Le Piper (1640–1695). In every case with one exception – a work on copper – the panel supports are oak. The majority of these panel supports have an off-white ground made from chalk and glue, with small admixtures of bone black and yellow ochre[11] noted in roughly half of them. The description 'off-white ground' has been adopted for both the purely chalk and glue and the admixed off-white glue grounds because chalk/glue grounds are often thin and never a pure white in appearance even when thickly applied. The addition of bone black and yellow ochre alter the shade relatively little compared to pure chalk. In a number of these, SEM images at magnifications of ×1000–1500 suggest marine chalk containing coccoliths and other nanofossils, but in others the medium makes their observation difficult.

The majority of these 27 panels also have an oil-based priming over the ground, mostly either very thin or half the thickness of the ground and commonly described as 'grey' (11) with 3 called 'pink' and another 3 'greyish-white', the balance being 'white' or 'brownish-grey'. A handful of panels by different artists are described as having a coloured, streaky priming, a noticeable feature of paintings made by artists associated with Antwerp, either by origin or training, as can be seen in a study of the streaky priming in *The Apotheosis of James I and Other Studies: Multiple Sketch for the Banqueting House Ceiling, Whitehall* (Rubens, *c.*1628–30, T12919).[12]

As mentioned above, most of the paintings in this group (81 of those in Table 1) have a canvas support. The supports of which the fibres could be identified were made from linen. Lining and stretcher replacement being almost universal in the group, the tacking margins are no longer present – indeed a number have been cut down on one or more sides, making it difficult to remove a sample for fibre identification. The ground and/or priming are rarely readily visible at the edges, but can often be discerned in a few areas of the composition during examination with a microscope. When these preparatory layers are coloured, they sometimes serve as a mid-tone. Most of the grounds can be described as 'buff/beige/tan/brown' (approximately one-third), followed by 'grey', 'salmon pink' or 'red' and 'white' or 'off-white'. Around 10 of the canvas supports have a double ground (mostly with a priming in addition): the two

ground layers are often separated by glue size. The upper layer of most double grounds can be described as either 'red' or 'grey', the lower layer being the opposite, either grey or red. There is one example of a triple ground. A little more than a third of the paintings on canvas have a priming, sometimes thinner but often not vastly different in thickness from the ground. 'Grey' is used to describe about half of these primings, with 'buff/beige/tan/brown' as the next most common description, followed by 'pink' sometimes further qualified either as 'salmon pink' or 'pale opaque pink'. Only two of the primed canvases are described as having a 'white/off-white' priming.

Many artists are represented by only a single work in the collection. At this stage ground/priming colour preferences by artists within Tate's collection have not been evaluated, and will only ever be possible for a few well-represented artists such as Marcus Gheeraerts II (1561–1635), Cornelis Jonson van Ceulen I (1593–1661), Godfried Kneller (1646–1723) and Peter Lely (1618–1680), whose works in other collections have also been investigated and published extensively. Paintings of the Tudor Stuart period, often depicting royalty, the aristocracy and wealthy private individuals, are found in greater numbers outside the national collection of British art than in, and are well represented in the Royal Collection, the National Portrait Gallery, numerous historic palaces and houses, and in family collections. Nevertheless, the technical findings of the Tate's Tudor Stuart project largely chime with those from elsewhere. The authors welcome any information on these artists from other researchers.

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Notes

1. See https://www.tate.org.uk/about-us/projects/tudor-stuart-technical-research.
2. See https://www.tate.org.uk/about-us/projects/tudor-stuart-technical-research/entries.
3. See https://www.npg.org.uk/research/programmes/making-art-in-tudor-britain/; T. Cooper, M. Howard, A. Burnstock and E. Town (eds), *Painting in England: Artistic Practice, Patronage and Display*, Oxford, British Academy for Oxford University Press, 2015.
4. All X-radiographs prior to 2017 were film-based, but the films have been scanned at high resolution, balanced in contrast, and mosaiced for online publication.
5. R. Jones, 'The methods and materials of three Tudor artists: Bettes, Hilliard and Ketel', in *Dynasties*, London, Tate Gallery, 1995, pp. 231–240; ·R. Jones, 'A note on the techniques of painting found in Gheeraerts's portraits in the Tate Collection', in K. Hearn (ed.), *Marcus Gheeraerts II: Elizabethan Artist in Focus*, London, Tate Publishing with the support of the Paul Mellon Center for Studies in British Art, 2002, pp. 53–58 and notes p. 61; L. Woesten, R. Jones and C.S. Kimbriel, 'A study of three paintings by George Gower', *Hamilton Kerr Institute Bulletin* 5, 2014, pp. 121–136.
6. N. Walker, K. Hearn and J.H. Townsend, 'Tate's painting of a man in Tudor costume: a sixteenth-century portrait or a nineteenth-century pastiche?', *Tate Papers*, 20, 2013, https://www.tate.org.uk/research/publications/tate-papers/20/tates-painting-of-a-man-in-tudor-costume-sixteenth-century-portrait-or-a-nineteenth-century-pastiche.
7. An initial assessment of paintings examined by 2006 led to a summary publication which has been extended here in terms of grounds: see J.H. Townsend, R. Jones and K. Stonor, 'Lead soap aggregates in sixteenth- and seventeenth-century British paintings,' *AIC Annual Meeting 2006, Paintings Specialty Group Postprints*, pp. 24–32.
8. J.H. Townsend and K. Keune, 'Microscopical techniques applied to traditional paintings', *In Focus: The Proceedings of the Royal Microscopical Society*, 1 March 2006, pp. 54–65; K. Keune and J.J. Boon, 'Analytical imaging studies of cross-sections of paintings affected by lead soap aggregate formation', *Studies in Conservation* 52, 2007, pp. 161–171.
9. A. van Loon, P. Noble and A. Burnstock, 'Ageing and deterioration of traditional oil and tempera paints', in J.H. Stonor and R. Rushfield (eds), *The Conservation of Easel Paintings*, Oxford, Routledge, 2012, pp. 214–241, esp. p. 227 *et seq*. For an introductory lecture on metal soaps and their effects on the appearance of paintings, see K. Keune, 'Metal soaps', in *Conservation: Together at Home* webinar series, April 2020, https://www.youtube.com/watch?v=_pkDKjESiPU&feature=emb_title.
10. Y. Shimadzu, K. Keune, J.J. Boon, J.H. Townsend and K.J. van den Berg, 'The effects of lead and zinc white saponification on surface appearance of paint', in J. Bridgland (ed.), *Preprints of the ICOM-CC 15th Triennial Meeting, New Delhi, 22–26 September 2008*, New Delhi, Allied Publishers Pvt Ltd, pp. 626–632.
11. By the 17th and 18th centuries, the mixture of white pigment, bone black and yellow ochre would be known to decorators as 'stone colour', but this term has never been used in the context of paintings or their grounds, although it would be apt here. P. Baty, in *The Anatomy of Colour* (London, Thames and Hudson, 2017) illustrates traditional compound colours such as 'stone' and 'dark stone' on p. 21.
12. Jones 2002 (cited in note 5), p. 55.

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