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Experiments on Painting Viking Age Woodwork

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Traditionally, studies on Viking Age pigmentation have focused on the minerals used to produce colours. The research conducted in this article concerns other factors, that might have influenced painted wood such as surface treatments, outlines, and paint components. With an experimental archaeological approach, it investigates material interactions prevalent during the Viking Age. The study, conducted as part of the "Experiments with Painting Viking Age Woodwork" course in 2023 at the University of Copenhagen, aimed to unravel the

choices made by craftsmen during the Viking era regarding wood treatments prior to painting. By examining painted woodwork artifacts from notable sites like Grimstrup, Horning, Jelling, Ladby and Trelleborg, this research offers valuable insights to Viking society: more precisely the skilled craftsmen producing art for the elite. Rather than attempting to replicate these ancient artworks, the study focuses on the potential, experiences, and capabilities inherent in Viking-Age color usage, which laid the foundation for the vibrant Middle Ages.

> “ Wood was a vital resource in the Viking Age, providing the raw material for various essential items in everyday life. Its availability and versatility made wood the primary choice for constructing longships, houses, and numerous other utilitarian objects.

Introduction

Experimental Archaeology is taught every spring at the University of Copenhagen as part of the MA in Knowledge, Technology and Crafts. This brief article presents an experiment carried out in connection with the Experiments with Painting Viking Age Woodwork course in 2023.

The archaeological sources for the experiment

Two central sources are found for Viking Age painted woodwork: the fragmented interior panels from the North Mound in Jelling, Denmark (Kornerup, 1875; Krogh and Leth-Larsen, 2007), presumably painted around AD 958/959 and from the Hørning Plank, a hammer brace, from Hørning Church (Christensen, 2006; Petersen, 1894). The hammer brace was painted several times, initially in the period between 1060 and 1070. But painted woodwork has also been observed on a shield from Trelleborg (Christensen 2013), in the ship burial at Ladby (Thorvildsen, 1957) and in the horseman’s grave at Grimstrup (Stoumann, 2009).

The interior panels at Jelling

Fifteen of the sixteen fragments of panels preserved to this day are carved from oak, while one frame moulding is of maple (Krogh and Leth-Larsen, 2007, fig. 115. Today, the original colours have changed, but Jacob Kornerup’s watercolours, which were made in 1861, shortly after the discovery of the find, suggest what the painted surfaces looked like before they were conserved (See Figure 1). What function the panels had is unknown, but they are wood carvings with incised motifs on open-work and were painted so they can be seen from both sides without being the same on the two sides. The dominant motifs are stylised plant tendrils with side shoots and enclosing rings as well as a profiled human with a dragon or serpent (Krogh and Leth-Larsen, 2007, p.173). Marxen and Moltke, 1978). The surface of the wood panels was probably pre-treated with an abrasive of finely ground quartz, after which the detailed motifs were incised with a knife or other sharp tool. These incisions are not covered with paint, indicating the wood is not primed. Still, an undercoat is found under some colours. That only one of the overpainted colours – a green – is transparent is thought-provoking. After the undercoat, centre fields and contours were added and, finally, little details such as dot ornamentation and circular strokes. Traces of a brush that is somewhat finer than the one known from Viborg Søndersø (Hjermind, 1998, p.294) are evident in the paintwork. The little dot ornamentation could have been freehand or dabbed on through a template, and the circular strokes were made with a compass-like tool (Krogh and Leth-Larsen, 2007, Fig. 110). Eight different pigments have been identified. Most prominent among the red colours are earth colours, though charcoal black, lead white, a green copper pigment, orpiment and a yellow colour, probably based on resin, also occur (Christensen, 2018, table 1).

The hammer brace from Hørning

The other central source for the painted woodwork of the Viking Age is the hundred-year-younger plank from Hørning Church. (See Figure 2). It is a 91 x 57 x 12 cm hammer brace, a type of beam to hold the vertical planks in place, from a wooden church. It is painted on both the inside and outside and the motifs on the two sides are very different. Urnes-style relief is carved on the outside and the background is painted black, while the serpent's eye, tongue and ear are red. The motif is bordered by an astragal with red bands at the top and a red-painted moulding at the bottom. Examinations show (Christensen, 2006, p.38) that the serpent's body was originally yellow and that the entire serpent was painted over with red vermilion – something that presumably happened while the wooden stave church was in use. The pigments used on the outside were vermilion, charcoal, lead oxide red and orpiment, and the binder was linseed oil, which was probably heat treated.

The flat inner side of the hammer brace is decorated in a different style and with a different technique than the outside. The motif is scored as a frieze of vines with leaves, grapes and flowers. On each side of the vines is an egg-and-dart motif with double red lines on a white background. In addition to orpiment, lead oxide red, hematite, green copper pigment and charcoal black – which are also used on the panels from Jelling – a number of other pigments were used here including yellow ochre and vivianite.

The shield from Trelleborg

The red earth colour, hematite, is also used on a shield found at Trelleborg in west Zealand (See Figure 3). The shield is made of seven boards of pine with handles of beech. Paint has only been found on the pine, which is dendrochronologically dated to around AD 1000 (Bonde et al., 1991; 2013, p.225). Lead carbonate was also identified as a pigment.

Ladby and Grimstrup

Other, more fleeting evidence of the colour history of the Viking Age are traces of colour from the Ladby Ship (first half of the 10th century) and from the horseman's grave at Grimstrup (second half of the 10th century).

During the excavation of the Ladby Ship on Funen, traces of colours were observed just as on the embroidered ships on the Bayeux Tapestry (See Figure 4). The colours occurred in several places along the side of the ship and on loose pieces of wood lying where the burial chamber may have been located. The excavation diaries contain at least nine records indicating the finding of colours in connection with the completely decomposed wood. These were primarily colours that, at the time of excavation, were perceived as blue and yellow, but also blue-green, green and red (Sørensen, 2001, pp.239-240). Several pieces of painted woodwork were also found at the Gokstad burial in Norway (dated to AD 895), including a tiller and perhaps 64 shields made of conifer wood (Nicolaysen, 1882, p.63 and pl. XIII,7).

In a horseman's grave at Grimstrup in west Jutland, the interred was laid stretched out in the supine position with the head and upper body covered by an approximately 90 x 90 cm heavily decomposed layer of leather and alder wood (Stoumann, 2009, p.38) (See Figure 5). Evidently the layer was originally larger and painted, as parallel brush strokes were identified. But it was impossible to determine the pigments (Stoumann, 2009, p.36). The bottom colour of the layer was seen at the time of excavation as blue-black, and the intertwining bands were light grey-green with a 1–2 mm white contour line on each side, white dots and indefinable reddish-brown stripes.

Experiments with Painted Woodwork

Such knowledge of painted woodwork from Grimstrup, Hørning, Ladby, and Trelleborg, provides a modest insight into the technical painting knowledge and skills available in the elite environments of the Viking Age. The students' experiments did not aim to copy this painting, but rather to interpret its possibilities, experiences and potentials and to view the Viking Age's use of colour as the prerequisite for the colourful Middle Ages (Kristiansen, 2014).

Experiments on Sanding

Scientific analyses of painted wood from the Viking Age and early Medieval focus mainly on pigmentation, grounding, and decoration. A total of 25 pieces of fragmented painted wood and wood carvings was found in the excavations in 1820 and 1861 from *Nordhøjen* grave chamber in Jelling (Christensen, 2018, p.61), and their pigmentation and decorations have been informatively and thoroughly accounted for (Krogh and Leth-Larsen, 2007).

However, analyses on fragment 2.22, a painted wood carving piece, revealed a small fine white layer of fine ground quartz between the layer of paint and the wood surface (Krogh and Leth-Larsen, 2007, p.205). Presumably, this stems from sanding the wood as a surface preparation before the decoration and painting, and it thus seems likely that sanding has been done to all the wood.

Grounding makes the paint stick but also smooths an uneven wood surface (Christensen 2018, 63) and is especially found on painted wood from the Medieval period. No grounding was used on the painted wood from Jelling (Christensen, 2018, p.63), leaving the question whether sanding could achieve the same result or perhaps even a better one. Today, knowledge about Viking Age sanding methods is lost, and the amount of time, type of equipment, and preferences between materials are unknown.

This experiment tests the difference between wet and dry sand on the surface of red alder.

Experiment Setup

The piece of wood selected for the experiment measured 26 cm * 12 cm * 2 cm. It was commercially purchased lumber, sawn to size. One side was already sanded by modern machinery, thus the rough and uneven side was used for the experiment. The pre-sanded side was used for comparison along the experiment. The materials used for sanding were water, two pieces of cotton cloth and fine grey beach sand, typical for east Danish coastlines. The slightly rough cotton cloth was the best available option for this study, as handwoven linen- or wool fabric was not available. The sanding was done to compare whether moisture affected the final result, and since both samples of sand were worked with the same type of cloth, the comparisons between the sands are viable (See Figure 6).

Five minutes were used respectively on both methods, which included photo documentation, and collecting the sand that fell off in the motion of the sanding and re-applying water to the sand, which dried out due to friction. The working position was standing, crouching over the wood to apply bodyweight pressure.

Sanding

A handful of dry sand was applied to the surface to the right and made wet with two spoonsful of water. The sanding was conducted with a cotton cloth in an up and down movement across the annual growth rings. The method resulted in the wooden surface getting wet, consequently prolonging the process as the wood needed time to partially dry prior to further processing. Sanding with wet sand was not only more time consuming, but also left the as the wet sanding clearly ruins the surface of the wood. The wet sand was left to dry for three days, before comparing the final results (See Figure 7).

A handful of dry sand was placed on the surface to the left. On this side it felt natural to work in circular movements. This way the sand didn't fall off, although this may have been due to friction difference as the sand was dry. It made the sanding homogenous, although not as evenly conducted as with the up and down across movement on the left side (See Figure 8).

Results

The results showed that dry sand provided the better finished look. The surface felt smoother and more evenly sanded. It proved difficult to evaluate whether sanding across the growth rings of the wood was more effective than the circular movements. The latter was easier to perform, however. Once dry, both sides were left with a greyish colour, from the residual sand stuck in the wood. If sand gets stuck in the structure of the wood surface upon sanding, it may explain why a small fine layer of quartz was detectable underneath the layer of paint in the scientific analyses of fragment 2.22 from Jelling (See Figure 9).

Reflections

The archaeological remains on which this experiment was based, used oak and not alder wood as base layer prior to painting. Future studies might benefit from using this same material, as is customary in experimental archaeology (Jespersen, 2018, p.18; Lyngstrøm, 2018, p.115; Ravn, 2016, p.19; Vadstrup, 1997, p.75). Still, the observations, gained here on using wet or dry sand, respectively, may be useful for further experimenting with sanding.

Understanding priming methods and how they affect the structure of the wood, provides knowledge about the work invested into the materials prior to the final paint job. The idea that wood was primed prior to the colourful motifs, suggests a shift in fashion between the late Viking Age and the early Medieval. The older snake motif on the exterior of the Hørning plank does not show signs of sanding, whereas the younger flower motifs on the planks interior side does show signs of sanding. Prepping the material takes some investment of time, however it provides a smoother surface potentially better suited for the colourful medieval arts. (Christensen, 2006, p.37-38; Christensen, 2018, p.69; Lemonnier, 2011, p. 300; Wendrich, 2013, p. 3).

Experiments on Visual Guidelines

The floral motif found on the inside of the Hørning plank is carved into the wood, making a relief like surface structure. Unlike the outer side of the plank, the pattern was not carved like actual reliefs but rather worked as incised outlines created by a sharp instrument (Christensen, 2006, p.40). The following experiment investigates why outlines were cut into the wood as opposed to drawn.

Our modern day assumption was that drawing the motif would be far easier and save time, and potential cuts in fingers, compared to cutting an outline out with a sharp tool. The purpose of cutting was unclear, but the hypothesis was, that it might prevent colours from mixing on the surface. The setup was simple: The two different outlining methods were used on a piece of wood (elm), and then covered with the same type of paint found on the original archaeological material.

Priming the Wood

With a cloth and dry sand, the wooden surface was roughly sanded prior to adding the motifs. The plank was divided into sections, and on the left section of the plank the flowers were cut into the surface by knife. The everyday carry knife was run over the wood a single time, creating a thin line. The process was physically tiring, and the round shapes found in the pattern proved to be particularly trying. Adding to that, potential mistakes could not be undone, and high level of focus was necessary to avoid wasting materials.

For the middle section of the plank, I used a thin piece of charcoal to draw the outline. As expected, it was much easier and faster to do it this way, and the result initially came out better (See Figure 10).

I left the right section blank. This part of the wood was used to experiment with different widths of incisions.

Pigment and Paint

Several colours of paint have been detected on the inside of the Hørning plank. Under the paint, a layer of chalk-based ground has been applied. This white ground also acts as a background colour in areas where it is left uncovered by other paint (Christensen, 2006, pp.38-40). The chalk and pigments for the paint, were crushed finely.

Remains of egg has been detected on the inside of the plank (Christensen 2006, p.38). Therefore, I used egg whites as a binding material for my paint, as it contained the necessary levels of protein without the colours of the yolk. To create a dense white ground, I used as little egg as possible. Unfortunately, I had only a limited amount of chalk available, and some of it was already mixed with egg white. Therefore, I could not crush it as finely as wished for, resulting in a clumpy paint. The aesthetics suffered, but the results were still clearly visible.

All three sections of the plank were painted, with a total of three layers and then left to dry to achieve full coverage.

Results

Once the paint had dried, the results were visible: The lines drawn with charcoal were no longer visible., The high coverage of the white chalk-paint provided a surface suitable for further, more colourful, painting. Consequently, the white base layer also covered the charcoal outlines, making the outlines useless as references (See Figure 11).

The very thin incised outline was also hidden, but the wider incisions were clearly visible through the layers of paint. It is possible that a smoother paint would have revealed the thinner lines. In the deeper and wider incisions, the paint had run into the cuts instead of covering them, leaving the guidelines clearly visible (See Figure 12).

Although cutting the outlines was more costly in terms of time and physical strength, it resulted in a surface suitable for further paint. By creating a cut, with a certain width, the craftsman had a guideline to follow when applying the colours to the wood. To test this out, the wood was later painted again with colours, proving the success. These later paintjobs revealed that colours mixing on the surface was not problem, disproving one of the earlier hypothesis.

Experiments on Iron Ore Pigmentation, Treatment and Painting Techniques

Wood played a significant role in Viking age society, being readily available and versatile. The Vikings utilized wood to construct houses, ships, tools, and everyday objects (Breitenstein, 2011). However, the specific treatment and painting techniques used on wooden constructions have been subject to debate and speculation among researchers. In this context, experimental archaeology offers a valuable approach to recreate and understand the practices of the past (Costin, 2017). Moreover, Christensen's study on the decoration techniques employed on wooden artifacts from King Gorm's grave in Jelling and the Hørning plank (2018) highlights the importance of analysing painting practices to decipher the meanings and cultural contexts of these ornate objects.

The significance of experimental archaeology lies in its ability to bridge the gap between theory and practice and by conducting experiments based on historical evidence and archaeological findings, researchers can gain first-hand knowledge of the processes and challenges faced by ancient artisans (Bourdieu, 1977; Høgseth, 2013). To gain deeper insights into the techniques and material choices employed by prehistoric craftspeople, this chapter will focus on an experiment investigating the pigmentation of wood using iron ore during this era.

Experimental Aims

The research study explores the unique pigment binding properties on both rough and sanded wood surfaces during the Viking Age. In this investigation, we examine why surfaces were intentionally painted, both treated and untreated, during that era. The experiment aims to understand how colour pigments behave when applied to different wood textures. The research involves the use of myrrh pigment mixed with linseed oil and applied to prepared planks of alder wood. The results show distinct differences in pigment absorption and distribution between the sanded and rough wood surfaces. Understanding these historical painting techniques is crucial for gaining insights into the artistic and cultural practices of the Viking Age.

Materials

The primary material used in the experimental archaeology study is a red alder wood plank. This wood was chosen because alder was commonly available and utilized by the Vikings for various purposes, including shipbuilding and everyday objects (Ravn, 2016). The plank serves as the substrate for the pigmentation experiments. To investigate the effects of different wood textures, the plank was divided into two sections: one left in its natural state and the other sanded down to create a smooth surface.

Iron ore pigment is a crucial component in the Viking Age pigmentation process. Crushed to a fine powder, this pigment offers a rich and deep coloration when mixed with linseed oil. The choice of iron ore pigment is based on its historical significance, as the Vikings extensively utilized natural pigments derived from minerals and other organic sources to adorn their wooden artifacts. This experiment aims to understand how the iron ore pigment interacts with the wood surfaces and how its appearance differs between the rough and smooth sections of the plank.

Linseed oil plays a vital role in saturating the iron ore pigment to create the paint used for decorating the wood. Known for its durability and ability to enhance colours, linseed oil was a favoured medium for pigmentation in the Viking Age. The mixture of iron ore pigment with linseed oil creates a paint with a thick consistency that can be easily applied to the wood surface. The use of linseed oil ensures that the pigment adheres well to the wood and retains its vibrancy over time.

Fine-grained sand serves as a tool for creating different wood textures during the experimental process. By sanding down one section of the plank, a smooth surface is achieved, providing a contrast to the rough texture of the untreated section. Sanding is conducted using fine-grained sand to ensure precision and uniformity in the surface preparation. The sanding process aims to explore how the application of pigmentation behaves differently on each wood texture.

During the sanding process, a textile cloth made of flax is employed to apply wet sand to the plank's surface. The wet sand is gently rubbed onto the wood to create a smooth texture, allowing for a controlled and consistent result. The use of textile ensures even distribution of the wet sand, contributing to the accurate preparation of the smooth wooden surface for pigmentation. Wet sand was used in this experiment because tests have shown that the presence of water allows sand grains to pack together more closely, increasing the density and stability of the sand. It is then easy to apply and control when sanding a surface. Dry sand has a minimal cohesion between them, meaning they can easily move past each other. This allows for easy pouring and shifting which makes it difficult to very difficult to use and apply (See Figure 13).

Experimental Procedure

In this study, a plank of alder wood was used as the substrate for the pigmentation experiments. To create a controlled environment, the plank was divided into two sections - one left in its natural state and the other sanded down to a smooth surface using fine-grain wet sand. The sanding process lasted for 15 minutes and was carried out with a textile cloth.

After sanding, the plank was allowed to dry for 40 minutes to achieve a consistent level of moisture on both rough and smooth surfaces. This process of sanding and drying was repeated twice to ensure uniformity in the treatment. Once the preparation was complete, the pigment for painting was produced. The hematite iron ore was ground into a fine powder and mixed with linseed oil to form a thick paste. The paste was further diluted with the oil in a 1:3 ratio to achieve the desired consistency (See Figures 14, 15 and 16).

After the paint was ready it was applied on to the sanded wood. The pigment was brushed in smooth strokes, against the grain of the wood. Afterward, the same process was carried out on the rough surface. The plank was allowed to dry for 20 minutes between all three layers of paint.

Results

Upon the first application of paint, no noticeable difference in pigment absorption between the sanded and rough surfaces is observed. However, after the second application, a distinct variance in the pigment distribution becomes apparent. On the sanded left side, the pigment is evenly distributed, resulting in a consistent colour layer with no discernible variations. In contrast, the pigment behaves differently on the rough surface, creating an uneven colour layer with darker nuances in several areas (See Figure 17).

Discussion

The experiment conducted on alder wood provides compelling evidence that the texture of wood indeed influenced the distribution and appearance of pigments during the Viking Age (Christensen, 2006). In this project the smooth surface facilitated a more even distribution of the pigment, resulting in a uniform colouration, while the rough surface led to a mottled appearance with varying shades. This result aligns with Godal's (1996) work on documentation related to handicrafts, emphasizing the importance of understanding the material properties when interpreting artistic choices in the Viking Age.

The deliberate use of both treated and untreated wooden surfaces in Viking Age artifacts speaks to the craftsmanship's technical complexity and the artisans' aesthetic sensibilities.

The contrast between rough and smooth surfaces may have been utilized to create visually striking patterns or to accentuate specific design elements on the artifact. This is in line with Krogh and Leth-Larsen's (2007) work on the findings from the royal burial mound in Jelling, which underlines the significance of material choice and design in Viking monuments.

This research study provides an idea of painting techniques and material interactions during the Viking Age. The differences observed in pigment absorption and distribution between sanded and rough wood surfaces shed light on the mechanics actively employed by prehistoric craftspeople to create an artistic variation of colour by applying it on various treated surfaces. Understanding these historical practices contributes to a broader understanding of Viking-age culture and artistic expression. Future research can build upon these findings by investigating the specific tools and painting techniques used during that era.

Experiments on Binders: Seeing Colours Through Numbers

To produce paint in the Viking Age, pigments needed a binder. This study investigates the binders' influence on colours, using the software IrfanView and its 'histograms'. With this tool colours can be described through numbers, making them easier to compare and study on a larger scale (Pietka, 2000). The purpose is not to disregard how people interpret and understand colour, as colours would lose all sense of meaning without the human aspect. Instead, I argue that a mathematical approach can contribute with a different perspective with less potential for human error or miscommunication.

Experiment Setup

The experiment was based on four paint samples with roasted iron ore and yellow ochre as pigments. Egg and linseed oil served as binders, as is seen on the Hørning Plank (Christensen 2006, p.38). All binders and pigments were carefully measured on a scale, before being mixed at room temperature. The paint was then applied to a log of birch, cleaved with an axe but otherwise untreated.

Once the paint had dried the log was photographed in three different types of natural lighting: Direct sunlight, shade, and twilight, with a Nikon D5600. Artificial light and a studio background could potentially have provided images with less pollution from the surrounding environment. However, this would have skewed with the notion of experimental archaeology, as colour perception in the Viking Age would be reliant on natural light sources. Fire-based light sources would require a different setup, as flames move and cast shades different from daylight. The pictures captured in shade were the most qualified for further analysis.

Enhancing What We See

It is possible to see the difference between the paints using only the naked eye, but with photo distortion the differences are enhanced. The two images below show the painted log and are identical, except for the saturation. The saturated image on the right highlights how the ochre- and egg-based paint gave a brighter, more yellow colour, with less coverage than its darker and smoother oil-based counterpart (See Figure 18).

The iron-based paints varied noticeably: With egg as binder the paint turned out darker than with oil. Surface textures also differed significantly between the two, with the egg-based paint being uneven and grainy compared to the oil-based paint. This difference became more noticeable once the images were converted to negatives, as seen below. The left image shows a grainier surface with an abundance of white specs. The egg made a thick and sticky paint, that piled grains together but did not sink into cracks in the surface, resulting in an uneven colour and texture. The right image is smoother, as the oil seeps into the wood, dragging pigment with it. Distributing the oil-based paint was easy, resulting in a thinner and lighter layer of paint (See Figure 19).

References and Coverages

The colour of the wooden log must be included as a factor. Paints without 100% coverage will be affected by the colour of the surface they were painted on, and this applies to this experiment. A setup with no influence from the surface is possible with bleached paper, but the result is not necessarily in line with the method of experimental archaeology. Viking Age paintjobs would have been made with varying degrees of colour pollution from the surfaces they were applied to. Therefore, the surface colour must be taken into the equation through reference points in the image material.

Figure 20 shows how all colour samples and references were cut out of the original image to be analysed separately with image histograms. The reference areas had to be smooth, without traces of paint or larger areas of shade (See Figures 20 and 21).

Histograms

In short, image histograms show the distribution of coloured pixels and their brightness (Pietka, 2000). All four paint samples had the same size of 24.530 pixels. The colour of each pixel is determined by three underlying pixels coloured red, blue, and green. The histogram shows the relation between the 73.590 underlying pixels found in each image sample. The underlying pixels vary in brightness, thus determining the colour (Ramskov, 2023). The variation happens on a scale from 0 – 255, where the lower end makes a dark pixel and the higher end a light one (0 = black and 255 = white). Brighter colours of red, green, and blue are found on the middle of the scale, but as the final pixel colour is determined by all three underlying pixels, they must be understood in relation to one another. By comparing the number of pixels and their brightness, the software provides a raw statistical picture of the colour components in the different paints. The data provided by the histograms show which paints are darker or lighter, and which are more colourful or grey. Figure 22 and 23 shows all histograms used in this study..

The graph describing area A, the iron and egg combination, shows all three colours following the same pattern the X- and Y-axis (X-axis: Light intensity, Y-axis: Number of pixels). When pixels follow the same pattern, it makes for a grey colour tone. Confusingly enough, the grey average listed in each histogram indicates the image brightness more so than colour. To calculate differences in brightness, each paint's coverage were included. I combined the grey average of both reference areas and compared them to the grey averages of area A, B, C, D. Area B had lower coverage and was 11,67% brighter than area A. The graph pattern of area B revealed that it was not only brighter but also more colourful than area A. The brightness between area C and D varied with 7%, area C being the lighter one. Both graph patterns were similar, with smoother lines and separated colours than the previous ones.

Results

Both types of pigment were affected by the binders, and the distribution of colour averages shows how. The two iron-based paints are not ideal for comparison, as the consistency and coverage of these leave room for flaws.

	Grey average	Red average	Green average	Blue average
Area C (egg)	147,97	203,46	133,55	74,05
Area D (oil)	130,05	180,9	116,6	63,7

TABLE 1.COMPARISON OF THE COLOUR AVERAGES FROM THE OCHRE-BASED PAINTS, AREA C AND D.

The table 1 compares the colour averages from the ochre-based paints, area C and D. The closer an average is to 127,5 the brighter the colour. The table shows that area D has a redder colour than area C, whereas area C has a higher blue and green average. Both areas have a dominating green average, but the combination of green and blue found in area C suggests a more yellow colour. (See Table 1) The experiment behind these data do have its uncertainties, most attributed to the surface of wood and the lighting conditions. However, these potential colour- and light pollutions would have existed in the past as well, making the eyes, or in this case lens, experience of the colours similar. The differences shown in the table above are due to differences in the paint, and the only real variable is the binder. The paint based on yellow ochre and egg were 7% brighter than its counterpart and had a higher average of blue pixels, resulting in a more yellow colour. The paint based on yellow ochre and oil was darker, with a better coverage and more red pixels, resulting in an orange colour-tone. This concludes that binders did affect the colours of the two ochre-paints, therefore adding this factor to list of reasons behind choice of binder.

To fully understand the correlation between binders, pigments and paint-colours, experiments must be done on a larger scale. In this study alone ochre- and iron pigments resulted in very different types of paint, and it remains to be seen whether the results can be recreated using other pigments.

The goal of this experiment was not only to investigate binders, but also to introduce software meant for image analysis as a tool. IrfanView is a free tool that can be used by anyone. In this study it confirmed the differences already visible to the eye and offered an understanding of what exactly we are seeing based on numbers.

Conclusion

Wood was a vital resource in the Viking Age, providing the raw material for various essential items in everyday life. Its availability and versatility made wood the primary choice for constructing longships, houses, and numerous other utilitarian objects. Additionally, wood was employed for creating aesthetically appealing artifacts, reflecting the Viking Age's keen sense of craftsmanship and artistic expression (Breitenstein, 2011).

Experimental archaeology has emerged as a powerful tool to explore the practical aspects of Viking age woodwork, including treatment and pigmentation. By replicating historical techniques and conducting controlled experiments, researchers gain valuable insights into the craftsmanship and creative choices of Viking artisans (Høgseth, 2013).

The experiments described in this article were all centred around paint, pigments, and the wooden surface on which they were applied. Firstly, the wooden surface itself was explored through sanding. Archaeological examinations of Viking Age paint showed small amounts of quartz under the paint, leading to the theory of sanding before painting. The experiment showed how sand behaves differently when wet or dry, and that this seemingly small difference affected the wooden surface. Sanding was possible and provided a smooth surface in a short amount of time, although it left the wood slightly dirtier.

The second experiment briefly compared the difference between drawing or cutting reference outlines prior to painting. The results were surprising, and the initial thought of drawing being the smarter option was disproved. Although cutting was more comprehensive, the result was remarkably better. The outlines cut with a knife were clearly visible, when the charcoal lines had all disappeared.

The third experiment showed how a sanded surface, upon the application of a second layer of paint, ensured a more even distribution of pigment. Therefore, the bigger workload associated with sanding made a noticeable difference and gave the paintjob a smoother final look.

Lastly, the effect of binders on the finished look of paint colours was investigated, using the image analysis software IrfanView. The software did detect noticeable statistical differences in colour, that were the result of different binders. Since binders did affect the colour, the choice of binders was potentially made with the final look in mind.

Understanding the historical practices surrounding pigments contributes to a broader understanding of Viking Age cultural- and artistic expression. Looking ahead, this research serves as a platform for future investigations into the specific tools and techniques employed by Viking-era craftsmen, further enriching our understanding of this intriguing period in history.

Keywords painting
woodworking
experimental archaeology

Country Denmark

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Gallery Image

FIG 1. ONE OF THE PANELS FROM JELLING. TODAY, THE ORIGINAL COLOURS HAVE CHANGED, BUT JACOB KORNERUP'S WATERCOLOURS, WHICH WERE MADE SHORTLY AFTER THE DISCOVERY OF THE FIND, CLEARLY SHOW WHAT THE PAINTED SURFACES LOOKED LIKE (AFTER: KORNERUP 1875).

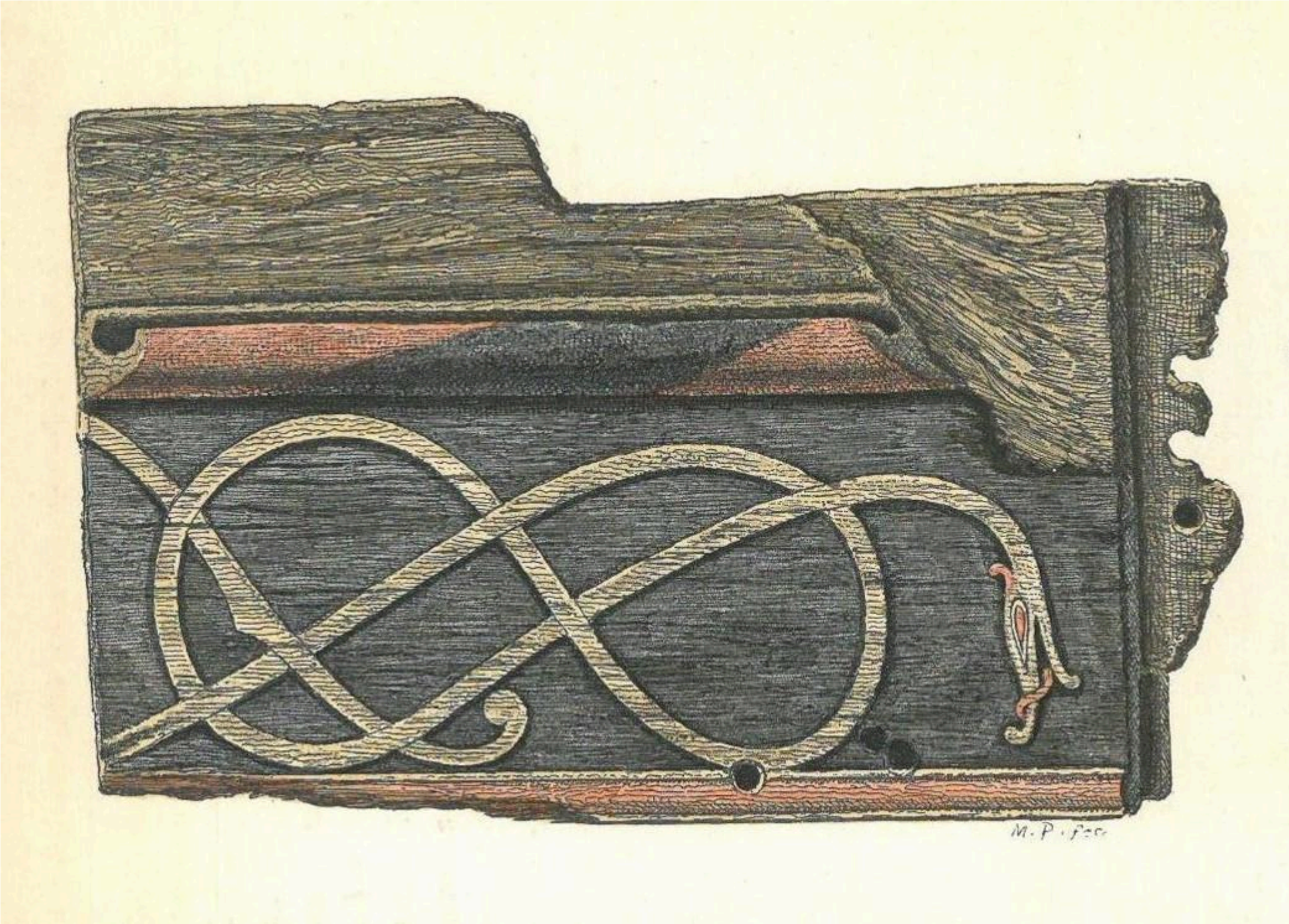

FIG 2. THE PLANK FROM HØRNING CHURCH IS PAINTED ON BOTH THE INSIDE AND OUTSIDE AND THE MOTIFS ON THE TWO SIDES ARE VERY DIFFERENT. THIS IS THE OUTSIDE (AFTER: PETERSEN 1894, P. 88).

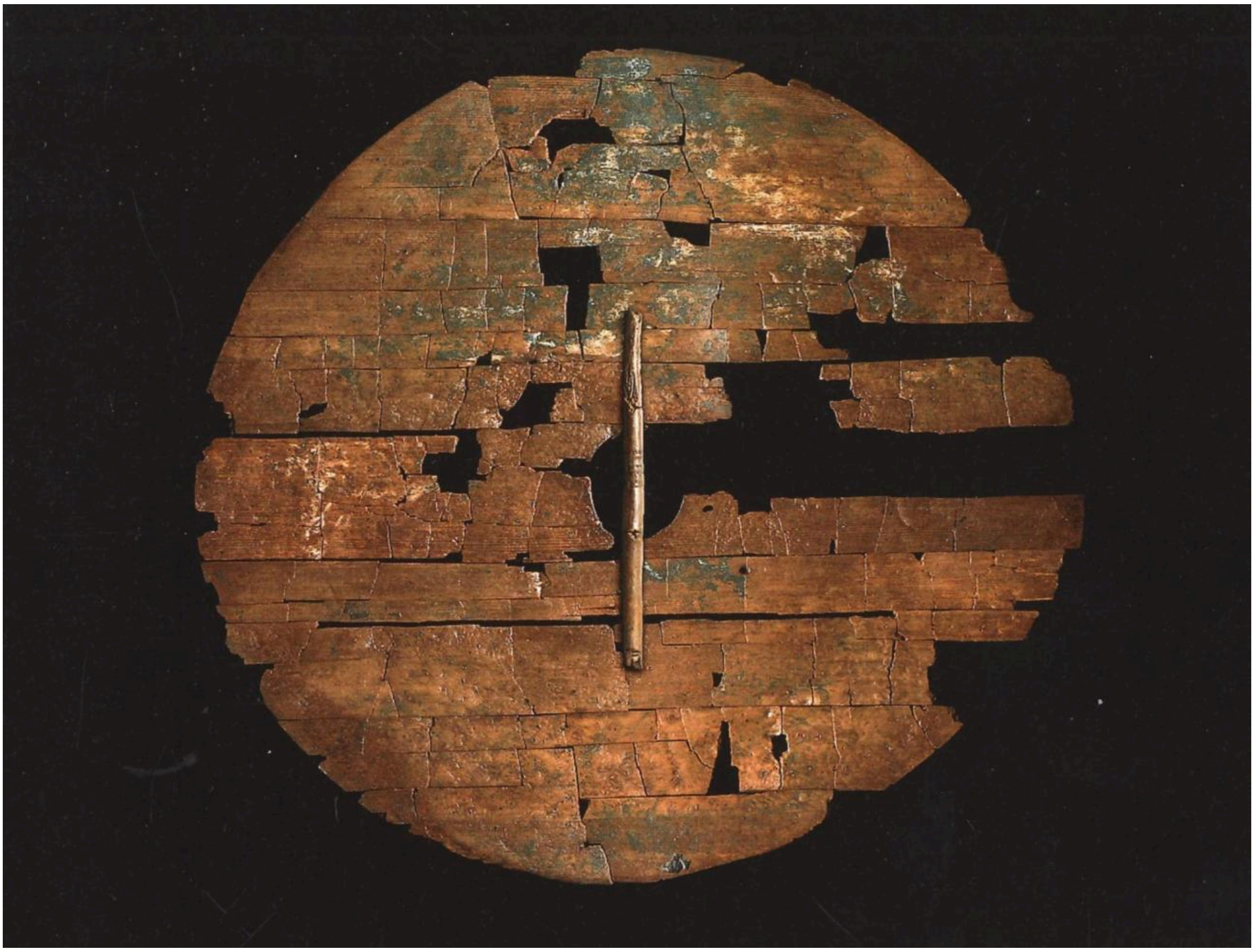

FIG 3. THE SHIELD FROM TRELLEBORG IS MADE OF SEVEN BOARDS OF PINE WITH HANDLE OF BEECH. HEMATITE AND LEAD CARBONATE IS ONLY FOUND ON THE PINE (AFTER: BONDE ET AL. 2013, FIG. 148).

FIG 4. TRACES OF COLOURS WERE ALSO OBSERVED DURING THE EXCAVATION OF THE LADBY SHIP. THE COLOURS OCCURRED IN SEVERAL PLACES ALONG THE SIDE OF THE SHIP AND ON LOOSE PIECES OF WOOD LYING WHERE THE BURIAL CHAMBER MAY HAVE BEEN LOCATED (AFTER: THORVILDSEN 1957, TAVLE II).

FIG 5. IN A HORSEMAN'S GRAVE AT GRIMSTRUP THE BODY WAS COVERED BY A HEAVILY DECOMPOSED LAYER OF LEATHER AND ALDER WOOD. THE LAYER WAS ORIGINALLY PAINTED, AS PARALLEL BRUSH STROKES WERE IDENTIFIED (AFTER: STOUMANN 2009, FIG. 20).

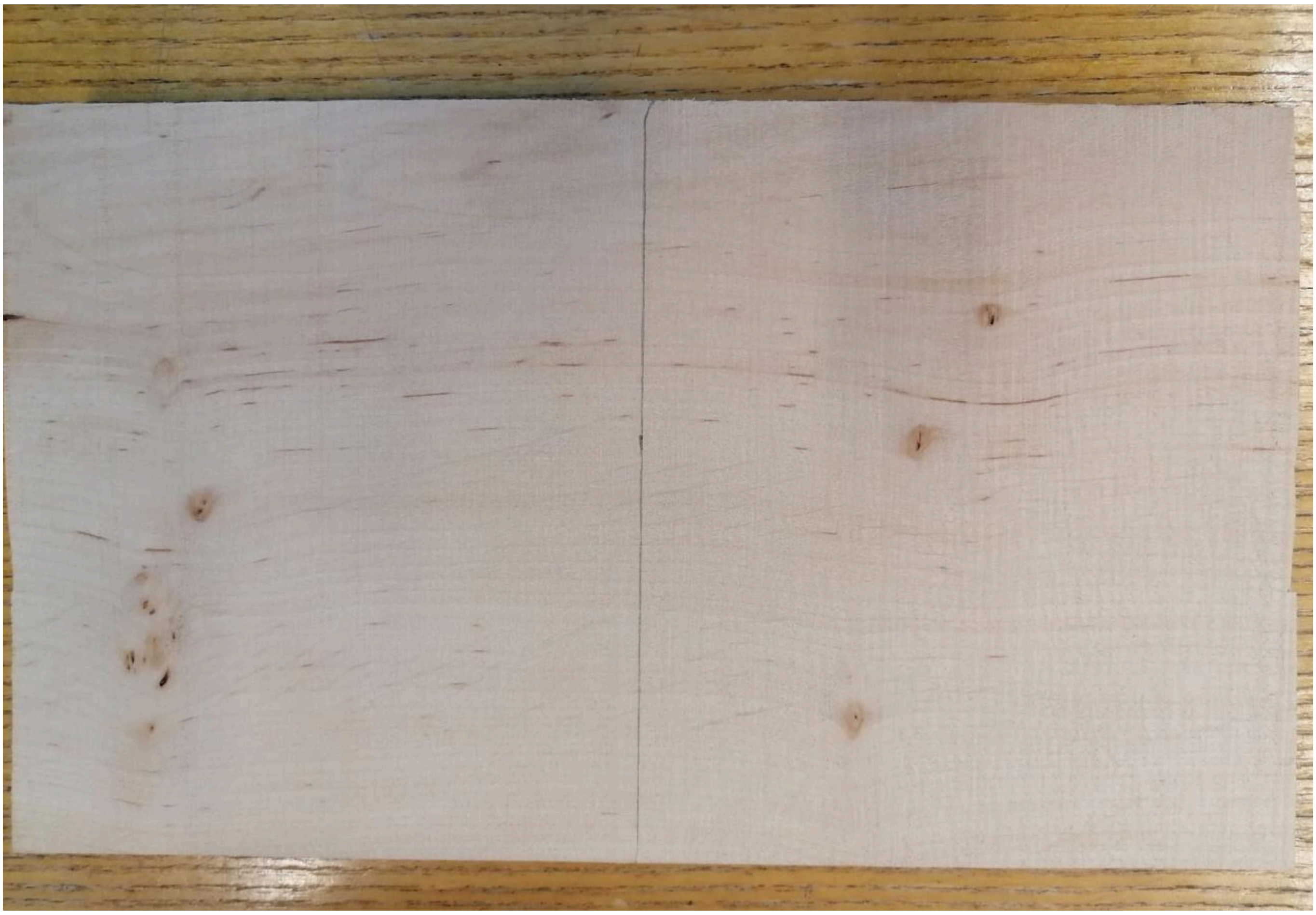

FIG 6. THE WOOD USED FOR THE EXPERIMENT WAS ALNUS GLUTINOSA (RED ALDER). PHOTO: C. RELAND

FIG 7. THE WOOD GETS WET BY THIS METHOD AND NEEDS TO DRY BEFORE FURTHER PROCESSING, AS THE WET SANDING CLEARLY RUINS THE SURF. PHOTO: C. RELAND

FIG 8. TESTING THE DRY SAND. PHOTO: C. RELAND

FIG 9. IMMEDIATE RESULT AFTER BOTH SANDING METHODS. PHOTO: C. RELAND

FIG 10. THE PLANK WITH ITS THREE SECTIONS. PHOTO: A.V. GELSKOV

FIG 11. WHITE GROUND OVER CHARCOAL LINES. PHOTO: A.V. GELSKOV

FIG 12. WHITE GROUND OVER INCISION WITH A WIDTH OF 1 MM. PHOTO: A.V. GELSKOV

FIG 13. PLANK OF RED ALTER WOOD. SANDED DOWN ON THE LEFT SIDE. PHOTO: S.L. ANDERSEN

FIG 14. LINSEED OIL AND IRON ORE FOR PIGMENTATION. PHOTO: S.L. ANDERSEN

FIG 15. LINSEED OIL MIXED INTO POWDER MADE FROM FRESHLY GRINDED IRON ORE. PHOTO: S.L. ANDERSEN.

FIG 16. PIGMENT MADE FROM LINSEED OIL AND IRON ORE POWDER. PHOTO: S.L. ANDERSEN

FIG 17. PAINT APPLIED ON BOTH SIDE OF THE PLANK FOR COMPARISON. PHOTO: S.L. ANDERSEN

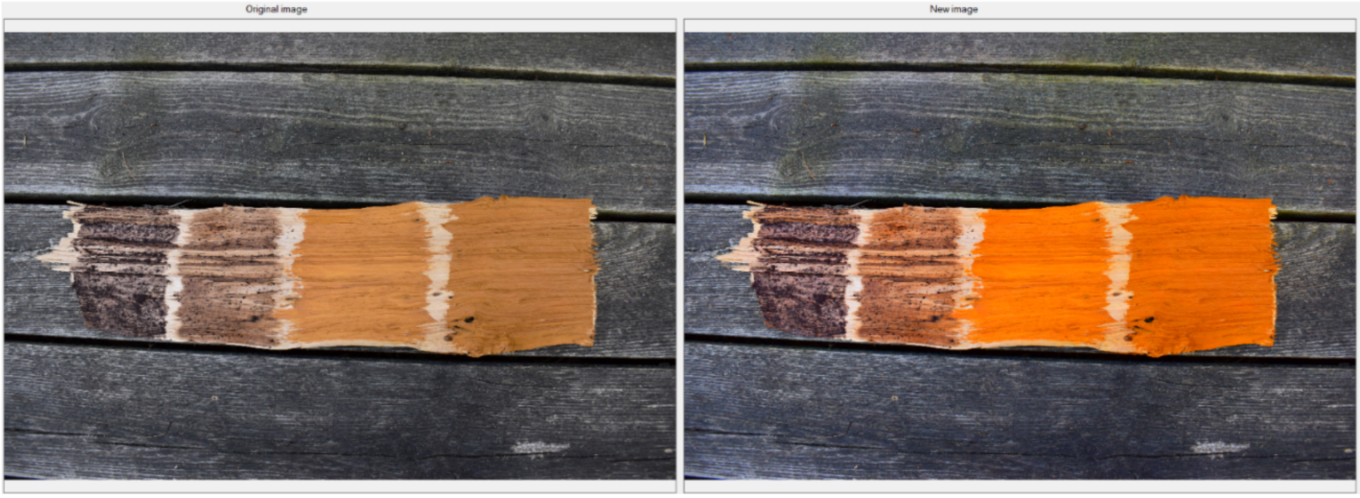

FIG 18. FROM LEFT TO RIGHT: ORIGINAL IMAGE AND SATURATED IMAGE. THE PIGMENT-BINDER COMBINATIONS FROM LEFT TO RIGHT ARE AS FOLLOWS; IRON + EGG; IRON + OIL; OCHRE + EGG; OCHRE + OIL. PHOTO: N. F. HELLSTRÖM

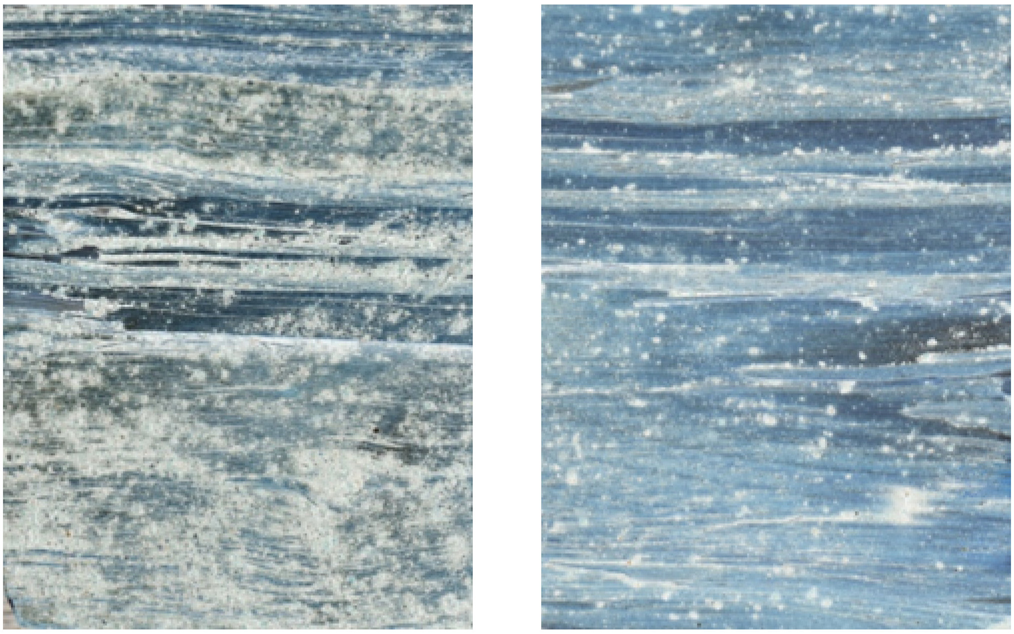

FIG 19. NEGATIVE IMAGES OF IRON-BASED PAINTS. FROM LEFT TO RIGHT: IRON + EGG, IRON + OIL. THE COLOURS ON NEGATIVE IMAGES ARE REVERSED TO REVEAL PATTERNS OTHERWISE HARD TO SPOT. THE LIGHTER AREAS BECOME DARK, AND THE IRON GRAINS BECOME BRIGHT WHITE SPECS. PHOTO: N. F. HELLSTRÖM

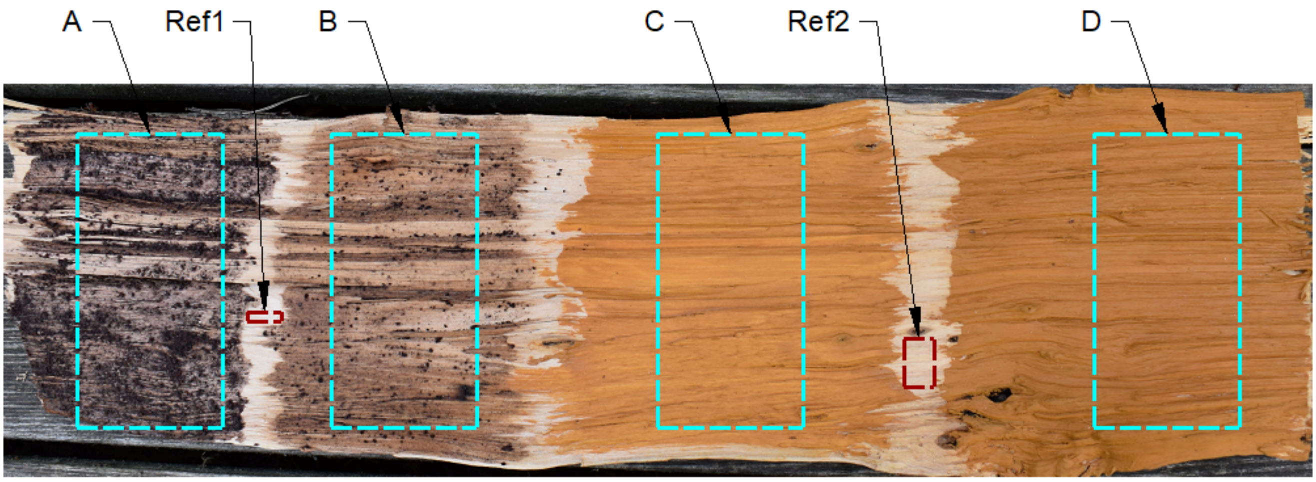

FIG 20. ORIGINAL PHOTO OF PAINTJOB ON THE LOG WITH MARKED COLOUR SAMPLES AND REFERENCES. PHOTO: N. F. HELLSTRÖM

FIG 21. ALL SAMPLES AND REFERENCES USED IN IRFANVIEW SEEN ON A DARK BACKGROUND. PHOTO: N. F. HELLSTRÖM

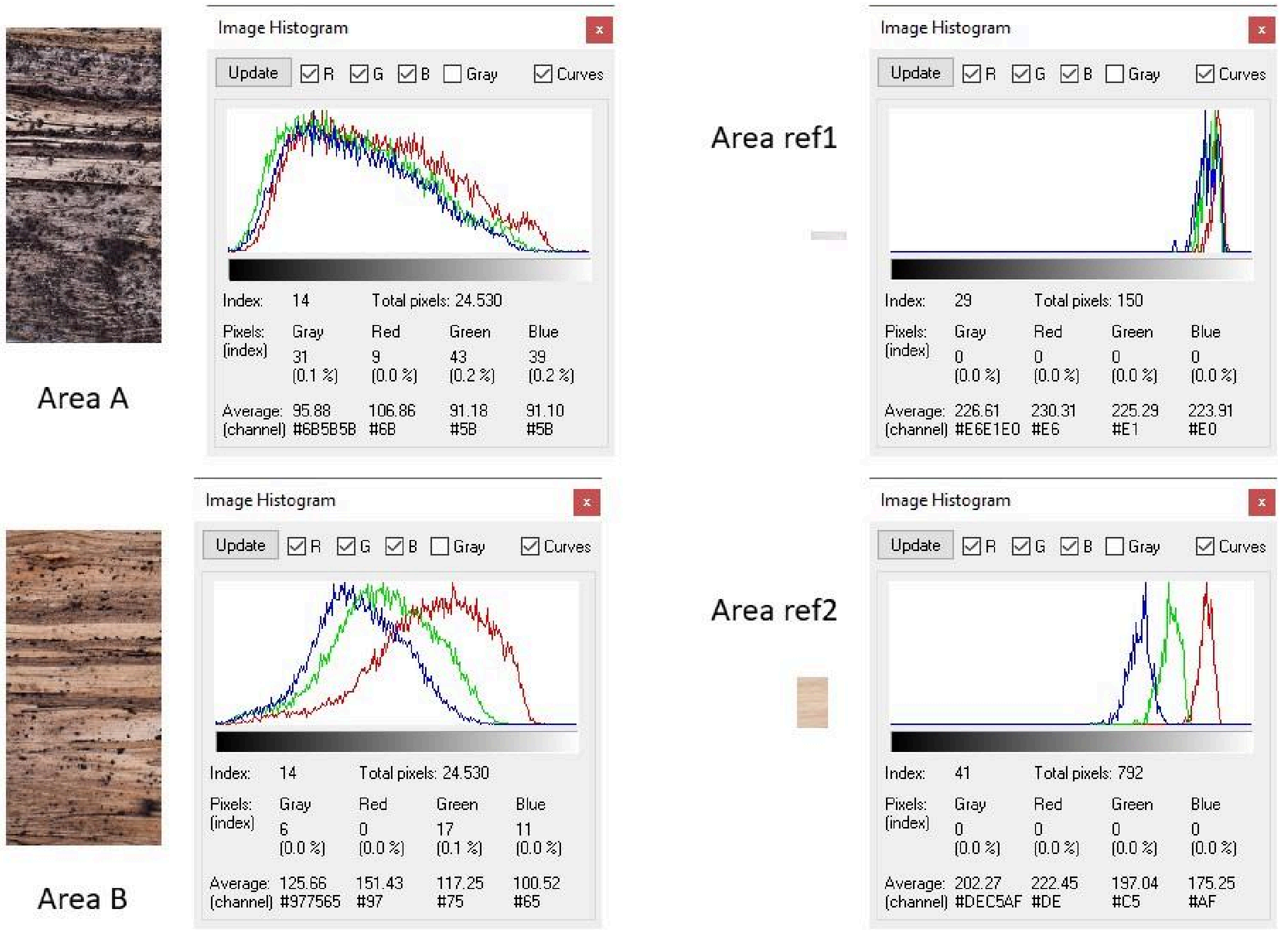

FIG 22. IMAGE HISTOGRAMS OF IRON- AND OCHRE-BASED PAINTS. AREA A: IRON + EGG; AREA B: IRON + OIL; AREA C: OCHRE + EGG; AREA D: OCHRE + OIL. AREAS ON THE RIGHT SIDE ARE THE TWO REFERENCE POINTS. X-AXIS: LIGHT INTENSITY, Y-AXIS: NUMBER OF PIXELS. PHOTO: N. F. HELLSTRÖM

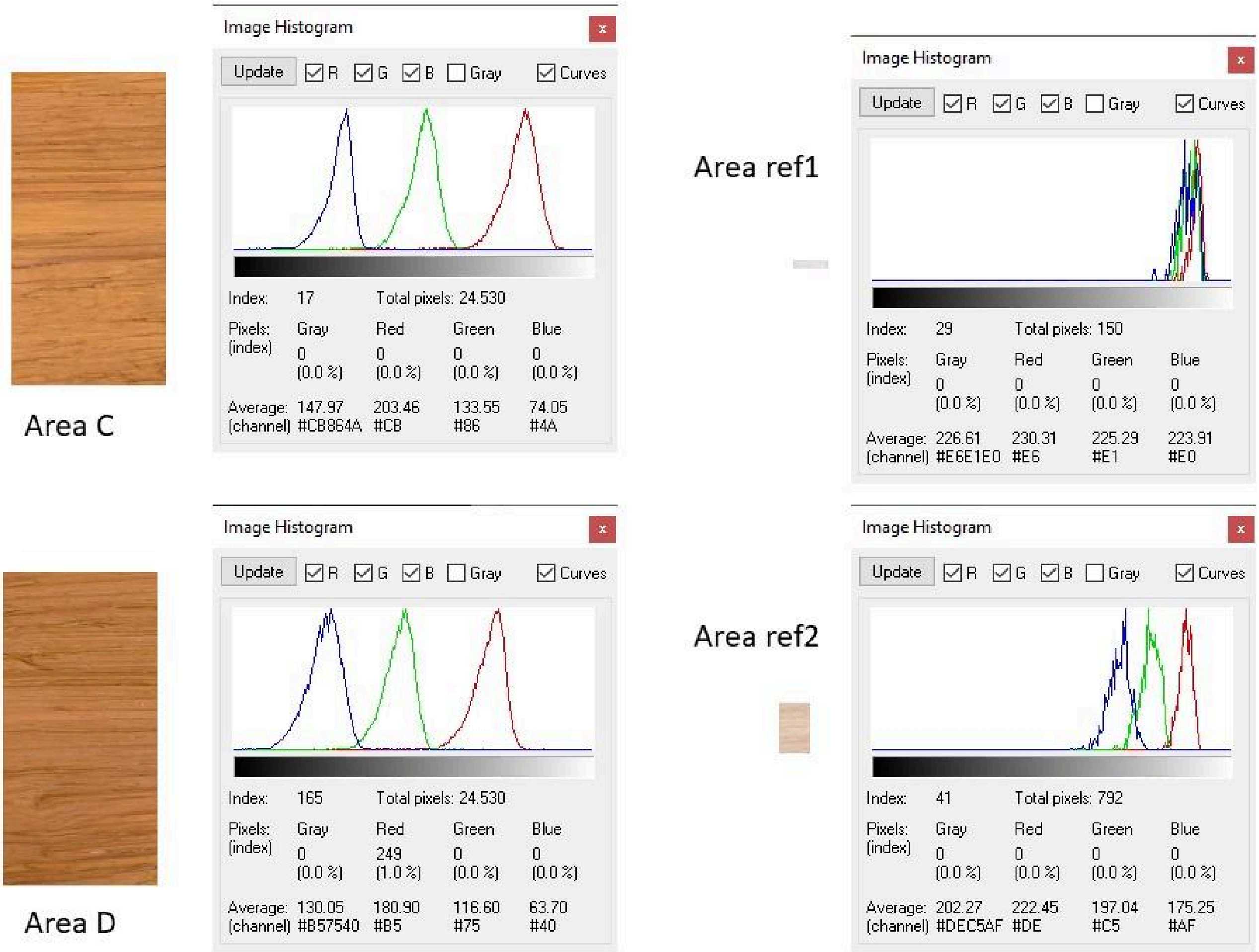

FIG 23. IMAGE HISTOGRAMS OF IRON- AND OCHRE-BASED PAINTS. AREA A: IRON + EGG; AREA B: IRON + OIL; AREA C: OCHRE + EGG; AREA D: OCHRE + OIL. AREAS ON THE RIGHT SIDE ARE THE TWO REFERENCE POINTS. X-AXIS: LIGHT INTENSITY, Y-AXIS: NUMBER OF PIXELS. PHOTO: N. F. HELLSTRÖM