Osaamista
ja oivallusta
tulevaisuuden
tekemiseen

Emilia Laaksovirta

Material Study, Conservation and Plan for Restoration of a 17th Century Oil Painting on Canvas

”Judith and Her Maidservant” in the Helsinki Art Museum Collection

Metropolia University of Applied Sciences

Conservation

Paintings conservation

Thesis

15.5.2020

Tekijä Otsikko Sivumäärä Aika	Emilia Laaksovirta 1600-luvun kankaalle maalatun HAM:n kokoelmien öljyvärimaalauksen “Judith ja palvelijatar” tutkimus, konservointi ja restaurointisuunnitelma 53 sivua + 8 liitettä 15.5.2020
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Ohjaajat	Maalaustaiteen konservoinnin lehtori Tannar Ruuben Huonekalukonservoinnin lehtori Paula Niskanen

Opinnäytetyön päätavoitteena oli suorittaa materiaalitutkimuksia Helsingin taidemuseon (HAM) kokoelmissa olevalle kankaalle maalatulle öljyvärimaalaukselle *Judith ja palvelijatar*. Teos on tullut Helsingin taidemuseon kokoelmiin lahjoituksena Helsingin kaupunginmuseolta, johon sen oli lahjoittanut Otto Wladimir Furuhjelm. Furuhjelm oli hankkinut teoksen Venäjältä 1800-luvulla.

Teos on ajoitettu 1600-luvun alkuun ja attribuoitu ranskalaiselle taiteilijalle, Pierre Mignardille, perustuen 1800-luvulla laadittuun ja notaarin vahvistamaan luetteloon Furuhjelmin taidekokoelmasta. Norjan kansallismuseon kokoelmissa Oslossa on kuitenkin lähes identtinen teos, joka on attribuoitu materiaali- ja taidehistoriallisten tutkimusten perusteella Orazio tai Artemisia Gentileschille.

Materiaalitutkimusten tavoitteena oli selvittää, ovatko HAM:n maalauksen materiaalit ja tekniikat 1600-luvulla käytössä olleita ja ovatko ne samankaltaisia kuin Oslon vastaavassa teoksessa. Materiaalitutkimuksen osana selvitettiin myös teokselle aiemmin tehtyjä konservointi- ja restaurointitoimenpiteitä.

Materiaalitutkimuksien lisäksi teokselle tehtiin opinnäytetyön aikana konservointitoimenpiteinä maalinkiinnitystä ja lakan osittainen poisto tai ohennus. Osana opinnäytetyötä esitetään suunnitelma konservoinnin ja restauroinnin loppuun saattamiseksi.

Tehdyt materiaalitutkimukset vahvistivat, että HAM:n maalauksessa käytetyt materiaalit ja tekniikat ovat sellaisia, jotka ovat olleet yleisesti käytössä 1600-luvun öljyvärimaalauksissa, ja että ne suurilta osin ovat samankaltaisia Oslossa olevan teoksen kanssa. Jatkossa maalausmateriaalien ja -tekniikoiden vertaileva tutkimus Oslon *Judithin* ja muiden Gentileschiin liitettyjen maalausten kanssa voisi antaa lisää tietoa HAM:n maalauksen attribuointiin.

Avainsanat	öljyvärimaalaus, materiaalitutkimus, konservointi, 1600-luku, attribuointi, Judith ja palvelijatar

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The main aim of the thesis was to conduct material analysis for an oil painting on canvas *Judith and Her Maidservant* in the Helsinki Art Museum (HAM) collections. The painting was donated to the Helsinki Art Museum by the Helsinki City Museum which had received the painting as a donation from Otto Wladimir Furuhjelm, who had purchased the painting from Russia in the 19th century.

The painting is dated to the early 17th century and attributed to a French painter, Pierre Mignard, based on a notarized list of the Furuhjelm art collection written in the 19th century. A nearly identical painting is in the collections of the National Museum in Oslo, Norway, which has been attributed to Orazio or Artemisia Gentileschi based on material and art historical analysis.

The aim of the material analyses was to study, if the materials and techniques used in the HAM painting are in line with those of the 17th century and with the similar painting in Oslo. Earlier conservation and restoration measures done to the painting were also investigated as a part of the material analysis.

In addition to the material studies, consolidation of paint and partial varnish removal or thinning of the varnish were done as conservation treatments during the thesis work. A plan for the completion of the conservation and restoration is suggested as a part of the thesis.

Material analyses done confirmed, that the materials and techniques of the HAM painting are those commonly used in the 17th century oil paintings on canvas, and that they in most parts match the ones found in the Oslo painting. Further comparative analysis of painting materials and techniques with the *Judith* in Oslo and other Gentileschi paintings could provide interesting information for the attribution of the HAM painting.

Keywords	oil painting, material analysis, conservation, 17^{th} century, attribution, Judith and Her Maidservant

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1 Introduction

The aim of this thesis was to conduct a material study of a 17th century painting, *Judith and Her Maidservant,* attributed either to Pierre Mignard or, alternatively, Orazio or Artemisia Gentileschi in the collections of the Helsinki Art Museum (HAM) (figure 1.). The provenance of the painting can be credibly traced back to the late 19th century, but material evidence suggests, that the painting has been painted in Europe during the 17th century.

Figure 1. *Judith and Her Maidservant,* (oil on canvas, 146 x 117 cm) before conservation, symmetrical daylight. Photo: Hanna Kukorelli / HAM.

Figure 2. *Judith and her Maidservant with the Head of Holofernes*, (oil on canvas, 136 x 160 cm) Orazio Gentileschi, Artemisia Gentileschi (assistant), ca. 1608. Oslo Nasjonalmuseet. Photo: Børre Høstland / Oslo Nasjonalmuseet.

A painting attributed to Orazio and Artemisia Gentileschi titled *Judith and her Maidservant with the Head of Holofernes* with similar composition and some alterations in details is in the National Museum in Oslo, Norway (figure 2.). Through this thesis, the Helsinki Art Museum hopes to get new information for the possible attribution of the painting in their collections and establish a more accurate dating through the investigation of the used materials. Material studies of the painting are the main focus of this thesis, but it also includes practical conservation work as well as recommendations for the restoration of the painting. The painting most probably has a history of around 400 years and its materials have previously been subjected to conservation treatments and long years in storage.

Material studies of the HAM painting aim to clarify, if the materials used in the painting are consistent with those used in 17^{th} century European oil paintings on canvas. The material studies include analytical photography, analysis of pigments and paint layers, binding media and varnish analysis as well as fibre analysis from original paintings support and lining canvas.

The painting is structurally in relatively good condition, so it does not require an extensive humidity treatment for flattening or re-lining. The main problem with the painting was the brittle paint layer which requires consolidation with craquelures and cupping in some areas. The painting also had a brittle, strongly yellowed and darkened varnish, which was obscuring the brilliant colours and flattening the image. The aim of the conservation done during this thesis work was to stabilize the paint layer by consolidating it and to remove or thin down the discoloured old varnish and, at least partially, remove or reduce some of the most disturbing retouching and overpainting. Recommendations for the restoration work are included as a part of this thesis. The painting has a 19th century style gilded and ornate frame which will not be included in this work.

First the paintings provenience, attribution history and similarities to the painting in Oslo is discussed. Then the material studies, including analytical photography, pigment and paint layer analysis, binding medium, varnish and fibre analysis, are presented. The structure and condition of the painting before conservation are discussed before the conservation plan. The conservation report up to a partial varnish removal is presented. A plan for restoration is suggested for the future.

2 Art historical review of the painting

2.1 Provenience of the *Judith and Her Maidservant* in the Helsinki Art Museum (HAM)

The painting was acquired by an art collector, Otto Wladimir Furuhjelm (1819–1883), from the Martynov or Martynoff (two different ways of spelling are found in texts written by Antero Sinisalo about the Furuhjelm collection in the 1950’s) collection in Saint Petersburg, Russia during the 19th century along with 11 other paintings which were listed and notarized in 1895. Furuhjelm donated the works to the Helsinki City Museum in 1912 and the painting was further donated to and listed as part of the Helsinki Art Museum collection in 2015. The painting has also been on display in the Ateneum Art Museum in Helsinki at some point in the early 1910’s. The oldest known record of the painting to date is the handwritten Furuhjelm’s collections list notarized in 1895 stating the purchase price of the painting (10 000 fr), which made it the most valuable painting in the collection and attributing it to Pierre Mignard. (Nenonen, 2019.)

2.2 History of attribution of the painting

The attribution to Pierre Mignard remains a mystery. It is not clear whether the painting was sold as a Pierre Mignard or was attributed to him at a later date. Clarifying the attribution history would require information from the Martynov collection, if any such records can be found.

The similar painting in Oslo has recently been attributed to Artemisia Gentileschi (Papi et al. 2019). In 1984 during a work visit to Oslo, Helsinki City Museum researcher Kerttuli Wessman saw the painting and noticed the similarity with a painting in the Helsinki City Museum collection. According to a letter by Wessman to the Oslo National Museum staff member Ellen J. Lerberg, a pigment analysis of the HAM painting was done in 1992, and it proved that the pigments used in the painting were consistent with those used in the 17^{th} century. (Nenonen 2019.)

An exhibition of Italian paintings was organised in Sinebrychoff Art Museum in Finland in 1992 and some paintings underwent material studies as a part of the exhibition. No records of the painting, which belonged to the Helsinki City Museum at the time, being a part of these studies has been found but it was part of the exhibition described as a painting "in the style of Artemisia Gentileschi" (ibid.). Helsingin Sanomat Kuukausiliite published an article about the painting, explaining that it would undergo more studies, such as X-radiography, and that the attribution of the painting would be decided by experts in Italy (Hietanen 1992). No such X-radiograph image can be found and apparently the painting was completely left out of the technical and material studies related to the exhibition. In 2015 the painting was donated from the Helsinki City Museum to the Helsinki Art Museum.

Art historian Synnöve Malmström has studied the painting and considers it to be a copy of the Oslo painting based on the differences in the details between the Oslo painting and the HAM painting. After the 1992 exhibition, the painting was attributed to Artemisia Gentileschi instead of Pierre Mignard. Malmström notes, that it is not impossible that Artemisia copied her father's work, but sees that the rising interest in women artists and the new feminist readings on Artemisia might have had an influence on the changed attribution (especially since there were no technical analysis done on the painting before 2019). Malmström draws attention to the different formats of the two paintings, the Oslo version being horizontal and the HAM version vertical in size. She points out, that if the HAM painting had been cut, there could be evidence of a different format of “stretch-marks” in the canvas (cusping).

Judging by photographs, Malmström sees a difference in the quality of details but notes that since the Oslo painting has gone through conservation and analysis, the comparison is not quite “fair” for the HAM painting. She notes that the HAM painting is missing the greed curtain in the background, and that Abra’s sleeve is grey and not “sky blue” as in the Oslo painting, but points out that this could be due to dirt or colour change in pigment or varnish. She notes that the jewellery in Judith’s hair has been painted with less detail in the HAM painting: in the Oslo painting a figure of Minerva can be made out but this detail is absent in the HAM painting. Malmström stresses, that further analysis on the materials and pigments of the HAM painting is needed to determine if the painting is indeed a Gentileschi or not. However, with the similarities between the Oslo and the HAM painting, Malmström would not completely exclude the possibility of the painting being by Pierre Mignard. (Malmström 2017.)

2.2.1 Pierre Mignard

Pierre Mignard (1612-1695) was a French painter, who has become known for his portraits of the French Royal family and of the many copies he made of the paintings of Old Masters. He has notably been to Italy in the 1630’s (Scott 1990), and there is a chance he has been in contact with either Gentileschi paintings or indeed with Artemisia Gentileschi herself. There has been little research done on Pierre Mignard, even though he has been considered to be a great painter with a large studio and many students. He was taught by another French painter, Simon Vouet (1590-1649) (Malmström 2017), who has a more credible and affirmed connection to Artemisia, having painted her portrait during his stay in Italy between 1613 and 1627 (Brejon de Lavergnée 2009). It is possible that Vouet has introduced Migrand to the works of the Gentilechis. Whether this connection exists and has anything to do with the HAM paintings attribution is uncertain.

2.2.2 Gentileschi father and daughter

Artemisia Gentileschi (1593-1656) has been a subject to art historical and conservation studies for decades. Artemisia's art and authorship were rediscovered by feminist art history in the 1980's and has since been studied extensively. The attributions of art works to either Artemisia or her father Orazio (1563-1639) has proved to be difficult, as some of the paintings lack signatures. Orazio may have instructed Artemisia in his studio and father and daughter could have worked together, although Patrizia Cavazzini (2001, 290) is sceptical of this collaborative working, at least up until Artemisia left Rome in 1613 (Christiansen and Mann 2001). This assumed collaboration has made it difficult to attribute paintings in the early 17th century to either of the Gentileschis. Instead, many of the earlier paintings linked to Artemisia have been attributed as a collaborative effort of the two painters. Some distinctions have been made regarding the compositional differences and attention to details (Gram Bischoff 2015). Artemisia has been thought to have paid much more attention to details and is suggested to include hidden meanings in her paintings unlike Orazio. Judith's hair jewel with the figure of Minerva or Athena in the Oslo painting has been seen as an example of these kinds of minute details with hidden meanings (ibid.).

To further complicate the exact attribution of Gentileschi paintings, it should be kept in mind, that the practice of making several versions of the same composition through the use of tracing cartoons was already a common practice in art in the 16th century and that Orazio was known to use this method routinely in his work. By comparing compositional tracings done of Orazio's and Artemisia's works, it seems clear that Artemisia made use of tracings made from Orazio's compositions. (Christiansen 2001, 21-33.) This known use of the tracing method might explain the striking similarity between the Oslo and the HAM paintings. Tracing cartoons made it possible for the composition to be revisited even in the absence of the "original" painting.

2.3 *Judith and Her Maidservant* in the Oslo National Museum collection

The first documentation of the Oslo painting can be found in a letter by the previous owner, Antonio Scarpa, in 1817 (Papi et al 2019, 534). The *Judith* in Oslo was attributed to Caravaggio until 1951 when it was reattributed to Orazio or Artemisia Gentileschi. The painting was purchased by "Wang Kunsthandel" in Paris in 1895, was then sold to a private collection in Norway and eventually donated to the National Museum of Art, Architecture and Design, Oslo. The pigment analysis done on the Oslo painting pointed to those in use in the 17th century (Ford 2015). A master's thesis done on the painting in 2015 suggests, that a stylistic and a comparative analysis of the painting points towards the Gentileschi studio. In the thesis work, the Oslo painting is compared with 12 other known *Judiths* by the Gentileschis, and it concentrates on the comparison of composition, use of "dramatical and psychological instruments" and the use of jewellery and symbols. (Gram Bischoff 2015.) Whether the Oslo painting is by Orazio or Artemisia is discussed further in an article from 2019 in The Burlington Magazine. The article claims that stylistic and iconographical analysis of the painting points more to Artemisia than Orazio. (Papi et al. 2019.)

The Oslo painting is painted on a single piece of coarse linen canvas with a simple weave pattern typical for early 17th century Italian paintings. The paint layer was found to have a double ground structure which is similar to the preparatory layers found in other Gentileschi paintings (Ford 2015; Papi et al. 2019, 535). The pigments found were lead white, orpiment, iron earths, copper acetate or Verdigris, bone black, lead-tin yellow type I, yellow earths, a very pure natural ultramarine in the maidservant's sleeve and a red (cochineal) lake glaze on Judith's dress (Papi et al. 2019, 535-536). No underdrawings were detected with infrared examination (ibid., 537).

3 Material studies and analysis

The aim of the material analysis of the HAM painting is to find out, whether the materials and techniques used are typical for a 17th century European oil painting on canvas. Material analysis may give some assistance for a more accurate dating and possible authorship of the painting. Examining the materials of the painting will also give more insight to the current state of the painting and the treatments and changes it has previously gone through.

3.1 Analytical photography

The painting was photographed from the front and reverse using symmetrical daylight and sidelight before conservation treatment at HAM by Hanna Kukorelli and the images can be found from the appendix (Appendix 1, 2 and 3). Ultraviolet fluorescence image (UV-fluorescence), Infrared reflectography image (IR-reflectography) and X-radiography images (X-radiography) were taken at the Metropolia University of Applied Sciences Conservation department.

3.1.1 UV-fluorescence, IR-reflectography, and X-radiography

The UV-fluorescence photography (Appendix 4) was used as an analysing method to try to determine the material and thickness of the varnish layer. It also shows the areas of previous restorations and retouching as these usually show as darker areas on top of or in between layers of varnish (De la Rie 1986, 96–99).

IR-reflectography (Appendix 5) was used to determine, whether the painting has any underdrawings. Especially drawings done with charcoal would probably show up under the paint layers, if there is enough contrast between the ground colour and the material, used in the drawing. Most pigments are infrared transparent, so if underdrawings are done in infrared transparent paint, there is no contrast with the ground layer. If the underdrawings are done with a carbon-based pigment on top of a reflective ground layer, they show up in the infrared image due to the contrast. (Cosentino 2016, 3.) Highly reflective pigments, such as lead white and titanium white, block the infrared from reaching the ground layer's surface. An infrared transmitted image could possibly show underdrawings, since this method has the infrared radiation source behind the painting penetrating all the layers from reverse to front. (Cosentino 2016, 4.)

X-radiography imaging (Appendix 6) was used to get a better view of the painting's structure as a whole. Possible alterations invisible to the naked eye or to UV-fluorescence and IR-reflectography, such as possible underlying composition or modification of the subject by the artist. X-radiography shows all the layers of the painting in one image, so a clear distinction between the original painting support and the new lining canvas is quite challenging if not impossible.

3.1.2 Results of analytical photography

The UV-fluorescence image showed a light blue or green fluorescence typical for natural resins (figure 3). This was confirmed by a FTIR-analysis (Fourier-transform infrared spectroscopy). Large areas of retouching or overpainting were visible in the background, and a very peculiar area of retouching can be seen next to Judith's head (figure 4). The varnish seems to be spread unevenly in some areas and there is possibly more than one layer of varnish on the painting, as is seen in a cross-section sample taken from a yellow colour area in Abra's dress.

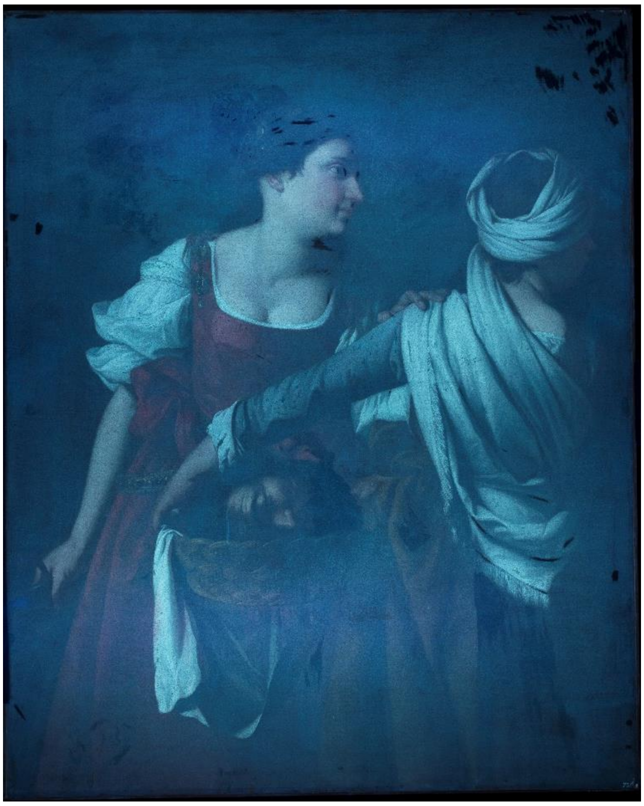

Figure 3. (A) UV-fluorescence image before conservation. Thick varnish is giving a strong fluorescence typical to natural resins. Recent retouching on top or between possible varnish layers can be seen as darker areas.

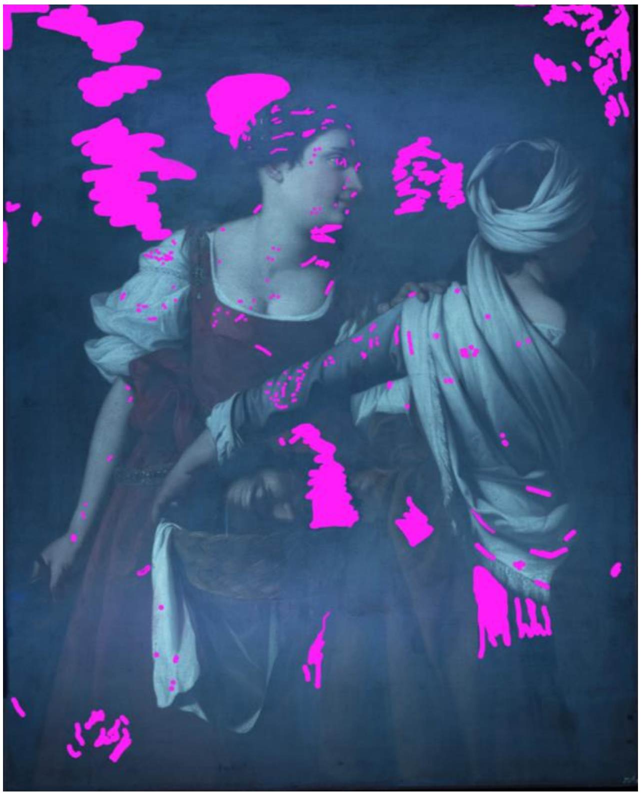

Figure 4. Areas of retouching and overpainting marked on the UV-image.

IR-reflectography images were taken with a modified Canon EOS 6D camera. According to Antonio Cosentino digital cameras with the in-built hot mirror filter removed should be sensitive of infrared light with a wavelength up to 1100 nm (2016, 1). Images taken before conservation proved to be of poor quality because of the reflections caused by the thick and glossy varnish. Another set of images was taken in a larger studio with the glossy varnish partially removed or thinned down (Appendix 5). Some faint hints of possible underdrawings were visible, for example, tracing along the profile of Judith's face (figure 5).

Figure 5. (A) Detail image of IR-reflectography showing faint hints of a possible underdrawings following Judith's profile (after varnish removal). (B) A daylight picture of the same area (before conservation).

X-radiography (figure 6) was taken with a Shimadzu MUX-10 X-ray machine designed for hospital use. The machine uses digital imaging plates and, to cover the entire surface of the painting, 23 separate images were taken and then compiled digitally to form one image. X-radiography was done with the painting being attached to its stretcher. This was done in order to protect the large painting and to make it easier to handle. However, the painting was so large that a small area of Judith's chins was left outside the X-ray plate.

X-radiography revealed another composition under the HAM painting (figure 7). The underlaying composition is also detectable by naked eye, since the ageing oil paint has become more translucent with the refractive index of the oil binding medium increasing with ageing (van Eikema Hommes, 1998, 116). X-radiography shows heavy chemical elements, such as lead and other metals, which the x-rays have difficulties penetrating. These areas show up as white or lighter areas in the image. The thick structure of the stretcher's wooden bars also shows up as lighter areas in the image.

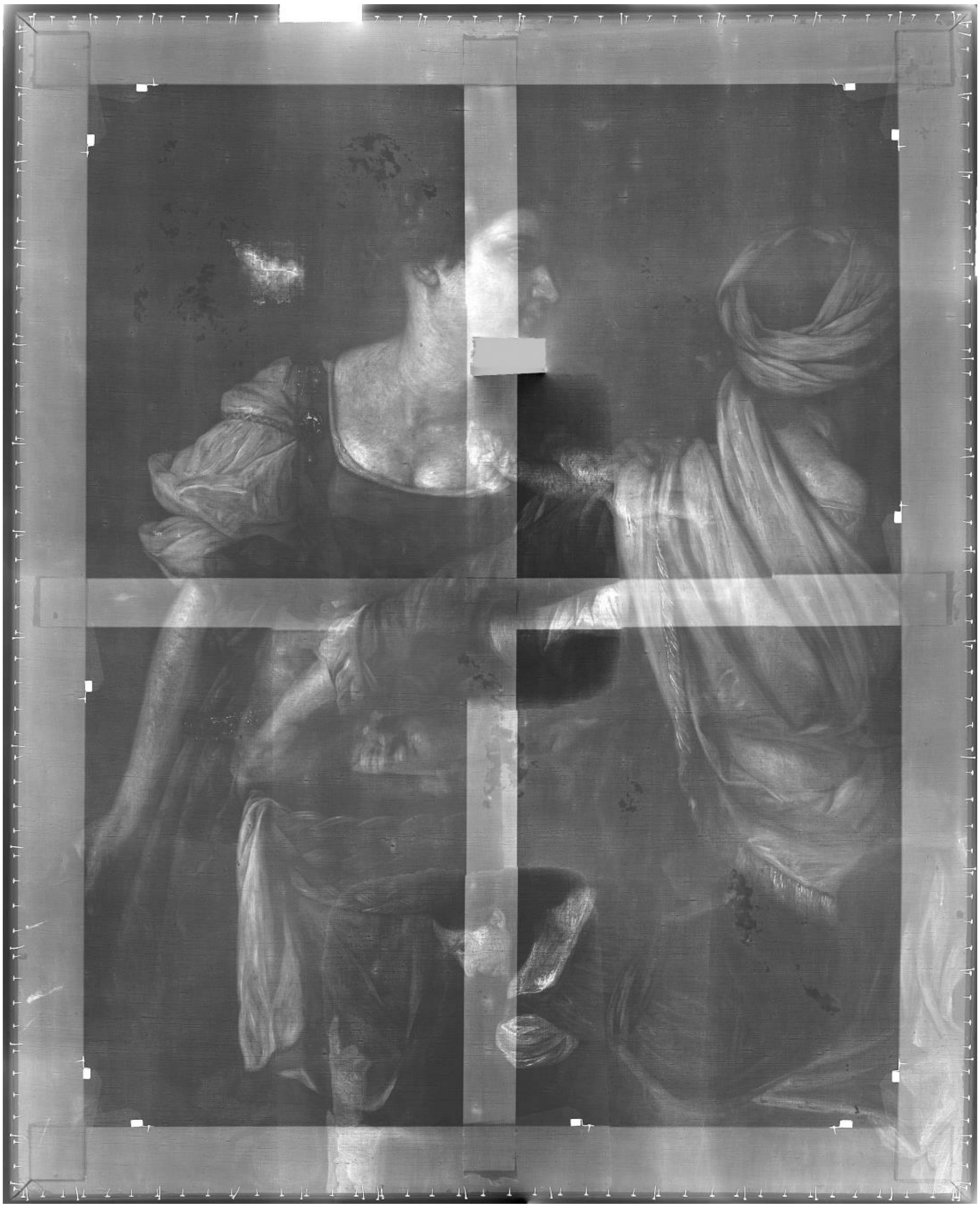

Figure 6. X-radiography image compilation showing another composition under *Judith and Her Maidservant* in the lower edge of the painting and also in the upper half situated between the shoulder lines of Judith and Abra. Metallic wedge or key holders and nails are visible around the painting as white areas. X-radiography images by Heikki Häyhä, digitally compiled by Emilia Laaksovirta.

The discovery of another painting underneath *Judith* was a surprise. However, it was not uncommon for artists to reuse canvases, since materials were not cheap. It might be assumed, that the painting underneath *Judith* was possibly either a complete painting or a discarded sketch for another painting, or that the *Judith* on top could also be a version for a similar painting. The *pentimenti* of the figure on the bottom edge are visible to the naked eye. The white areas of the underlying painting have become visible due to the ageing of the oil paint media on top.

Figure 7. (A) A detail of X-radiography image from the bottom edge showing a composition of another painting underneath *Judith*. (B) A daylight picture of the same area. (C) A detail of X-radiography image from between the shoulder lines of Judith and Abra.

3.2 Analysis of pigments and paint layers

In November 2019, a Specim IQ hyperspectral camera was used to analyse the possible pigments used in the HAM painting. The Specim IQ camera operates in the range of 400-1000 nm, covering the visible as well as a small part of the near infrared region; a halogen lamp was used as the light source. The Specim was applied in an attempt to identify and map pigments and their mixtures used in the painting. The Specim IQ gave readings indicative of possibly Prussian blue in the retouching in Abra's sleeve (figure 8) (Picollo 2019).

Because the Specim uses infrared wavelength, it also needs a source of infrared radiation, such as "halogen lamps with emission that approximates a black body radiation and follows Plank's law" (Cosentino 2016, 2) to get the measurements. Measurements were also taken from the head of Holofernes, but this gave only little information indicating the use of earth pigments in that area of the painting (Picollo 2019).

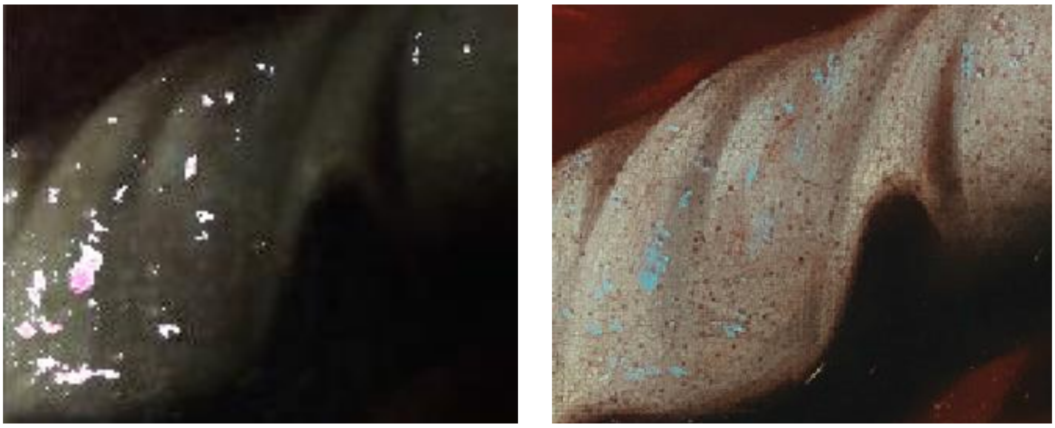

Figure 8. (A) Detail image of Specim IQ pigment analysis done in November 2019. Highlighted areas showing the presence of iron. (B) Detail image of the same area in daylight.

3.2.1 X-ray fluorescence (XRF) analysis

XRF-measurements were taken from 11 different colour areas with Innov-X Alpha Series® EDXRF spectrometer. A table with all the measured XRF-results in ppm readings (parts per million) is found in Appendix 7. Usually when analysing the chemical elements in pigments with the XRF, 10 000 to 100 000 ppm is considered a major element in the analysed area. A minor element is considered between 1000 and 10 000 ppm, but in some pigments, smaller quantities (the so-called trace elements) than these can be considered meaningful for the identification of a pigment. The XRF can be used to identify inorganic pigments by the chemical elements they typically contain. The X-rays emitted by the EDXRF-device cause the material to fluoresce in frequencies typical to each measurable element. The XRF-spectrometer gives readings of heavy chemical elements, such as lead, mercury, iron etc., enabling the identification of inorganic pigments. The XRF-spectrometer used does not give readings of elements lighter than magnesium and so it cannot be fully relied on for identifying all pigments. The XRF does not give much information about organic pigments, such as indigo or lakes since they do not contain heavy chemical elements.

All measured areas showed high levels of lead, which is most likely consistent with the use of lead white or lead red in the priming layers (figure 9). In these measurements the presence of chlorine (Cl) is high, but this is most likely caused by the shift of the spectrum inside the spectrometer and the measured points do not actually contain these high levels of chlorine (Perkiömäki 2020). No traces of copper or cobalt were found in the measured areas, which would rule out the use of pigments containing these elements, such as azurite (copper carbonate), cobalt blue, Verdigris (copper acetate), malachite (copper carbonate) and smalt (cobalt silicate). (Harley 1982.)

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11
	dark bottom egde	dark yellow dress	light yellow dress	light red dress	dark red dress	blue sleeve	blue retouching	yellow jewellery	light yellow basket	judiths cheek	dark background
P	4444	2017		6201						6170	6378
S	85292	50887	70467	217221	118531	22896	189837	9678	125434	207086	52574
Cl	43069	34029	47565	86300	71845	91828	18411	53057	73081	99964	46114
K	18332	19885	21781	7616	17924			16237	8840		20615
Ca	117597	125768	76320	30849	57235	3827	12147	90913	40089	6572	140313
Ti	2620	3528	7047					3507	2640		5231
Mn		1422									1994
Fe	84022	210816	184999	32457	85145	6185	19457	90673	87303	16383	146059
Zn							35997				
Sn	1955				1943	2526		7598	3456		
Sb			4842	2128						2811	4923
Hg	4475	1814	15162	160680	60661	2721	2395	3741		84252	5760
Pb	339405	219107	255396	276105	369069	484382	455058	343365	439326	404618	299294
Si	12240	37250	41778	12373	8627	12851	8349	20061	13277	9906	

Figure 9. XRF-measurement results marked as particles per million. Colour coded from high ppm number (red) to medium (orange - yellow) to low (blue). Lead (Pb) is the main element in all measured points.

The blue sleeve of Abra's dress gave a high indication of lead and some iron but little other information. A possible explanation for this is, that a mixture of lead white with some organic pigment, namely indigo in the 17th century, was used and then possibly glazed over with indigo. Because indigo is an organic pigment, it does not show up in the XRF-results. An indigo test was carried out to determine the presence of indigo and is discussed later.

Another possible historical blue pigment for the sleeve is natural ultramarine (that would possibly show aluminium, silicate, and sulphur in the XRF), the most expensive pigment an artist could use. Ultramarine was produced by grinding and washing the mineral ore (Harley 1982, 44). One batch of the ore would produce at least three different qualities of ultramarine, the last and least colourful being an "ultramarine ash" (ibid., 45). According to some sources, ultramarine cannot be mixed with lead white, since it forms a black sulphide in contact with lead ruining the blue colour (Knuutinen 1997, 95). However, artists have used a mixture of ultramarine and lead white and the colour has remained in good condition (for example Lehikoinen 2012).

Seppo Hornytzkyj (senior research scientist, Finnish National Gallery) was invited to take further EDXRF-readings of the HAM painting. Measurements taken from the light-yellow areas in Judith's jewellery, belt and the basket with Holofernes's head showed the presence of lead, tin and antimony. Lead (Pb) and tin (Sn) would be indicative of a lead-tin yellow. The presence of antimony (Sb) at the same time suggests the use of another yellow pigment, lead-tin-antimony yellow (Hornytzkyj 2020). In the 17th century lead-tin and lead-antimonate yellow were produced in ceramic workshops (Wallert 1999, 7) and recently lead-tin-antimony yellow has been found in a Gentileschi painting in Ferrara depicting a Judith holding the head of Holofernes (Impallaria 2019). The yellow could also be a mixture of a lead-tin yellow and Naples yellow.

Other measured areas were consistent with the findings of the previous XRF-measurements, showing major readings of lead (from lead white or red lead), iron and some manganese (from iron oxide pigments and umber) and calcium (chalk or gypsum). The light red area in Judith's dress showed both lead and mercury, indicating vermillion and lead white. The dark red in the dress gave a lower reading on mercury and higher in iron, indicating a red ochre and vermilion and maybe a red lake finishing. In the three measured points of the blue sleeve of Abra's dress, one point gave an indication of zinc, but the other two measured points gave major readings only for lead, iron and calcium. It was deducted, that the indication of zinc came from a residue of a previous blue re-touching. The yellow and the blue pigments will be analysed further by Hornytzkyj under a polarised light microscope. (Hornytzkyj 2020.)

An indigo test was carried out to clarify the presence of indigo in the blue sleeve. Small sample particles were taken from the paint surface, grinded and treated first by submerging them in solutions of NaOH and $Na_2S_2O_4$ in water and warming the test tube in a warm water bath to reverse the indigos oxidation to blue resulting in a yellow solution. Ethyl acetate was added to get the indigo to oxidise back to blue. (Hofenk de Graaff, 1974.) The indigo test was negative with no blue phase appearing in the test solution. However, this does not fully rule out the use of indigo. The tested samples could well have been too small to give a perceivable outcome, or the indigo could have been so encased in the lead white that it did not react with the acids used in the test.

3.2.2 Microscopic analysis of pigments and paint layers

The painting has clearly undergone some heavy cleaning at some point in its history. Abrasions of the paint layer in dark areas along the upper edge and the blood trails under the basket holding the head of Holofernes are clearly visible to the naked eye (figure 10).

Figure 10. Detail image of abrasion marks and paint loss under the basket holding Holofernes´s head.

Cross-section samples of the paint layer were taken from 10 different colour areas and photographed in daylight and UV light using a Leica DMLS light microscope, and Leica DFC 420 microscope camera. The areas where the cross-section samples were taken are marked in Appendix 7 and microscope images of all cross-sections are in Appendix

8. All cross-sections showed two layers of brownish orange or light red priming (figure 11). In figure 11 (B) a total of nine different layers including the varnish are visible. Being located at the bottom edge of the painting, some of the layers might be from an earlier painting that was painted over with the now visible one.

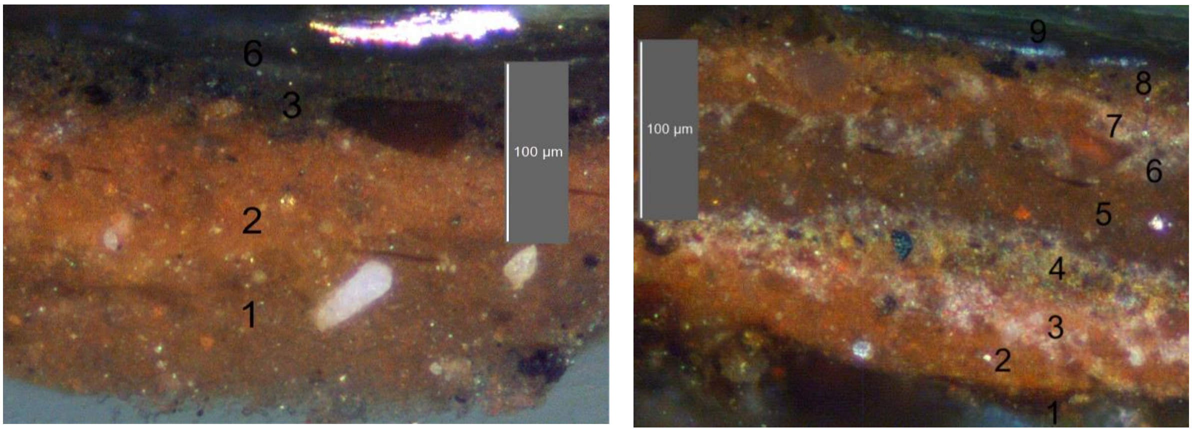

Figure 11. Cross section samples from HAM painting. (A) CS 1 Dark brown background bottom right . (B) CS 3 Dark yellow, Abra's dress, bottom edge. Both samples have a brown ground layer and a more red layer on top of the ground.

These red and brownish ground layers in the HAM painting seem to be very similar to those found in the Oslo painting (figure 12; Ford 2015, 29). The HAM painting does not have the light grey layer on top of the priming that is present in the Oslo painting, presumably covering most of the canvas and is seen as an opaque layer in the X-radiograph image (figure 13; Ford 2015, 23).

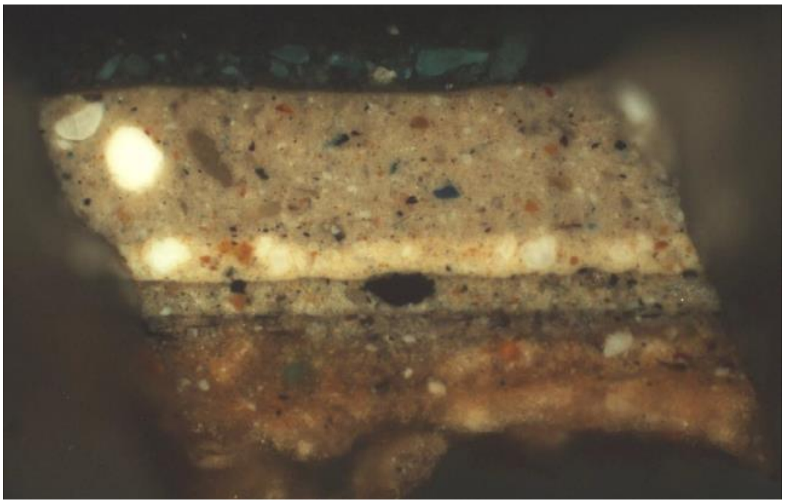

Figure 12. Detail image from the Condition report of the Oslo painting. Cross section sample taken from the green background. 400x magnification. (Ford 2015, 29.) Photo: Thierry Ford, Oslo Nasjonalmuseum.

Figure 13. Detail image from the Condition report of the Oslo painting. X-Ray, composite image without stretcher – photo edges trimmed (Ford 2015, 23). Photo: Thierry Ford, Oslo Nasjonalmuseum.

3.3 Binding media and varnish analysis

Binding media of the oil paint and the varnish was analysed by FTIR to determine the type of binder and the type of varnish used in the HAM painting. Typically, 17th century oil paintings had a walnut, linseed, or poppy seed oil media (Wallert 1999, 13).

The HAM painting has undergone at least two previous conservations since it has been lined, cleaned, retouched, varnished, and retouched again. Retouching can be seen under the new varnish and on top of it (for example the bright blue spots on Abras's sleeve). This means that the varnish is not original and has been previously either fully or at least partially removed, most probably more than once, given the paintings long life span. Paintings have been cleaned of yellowed and darkened varnish and re-varnished regularly through centuries. A cross-section sample (figure 14) taken from the yellow dress of Abra shows more than one layer of varnish, so it is possible that not all of the varnish has been removed or that some varnish has been added later on to the painting.

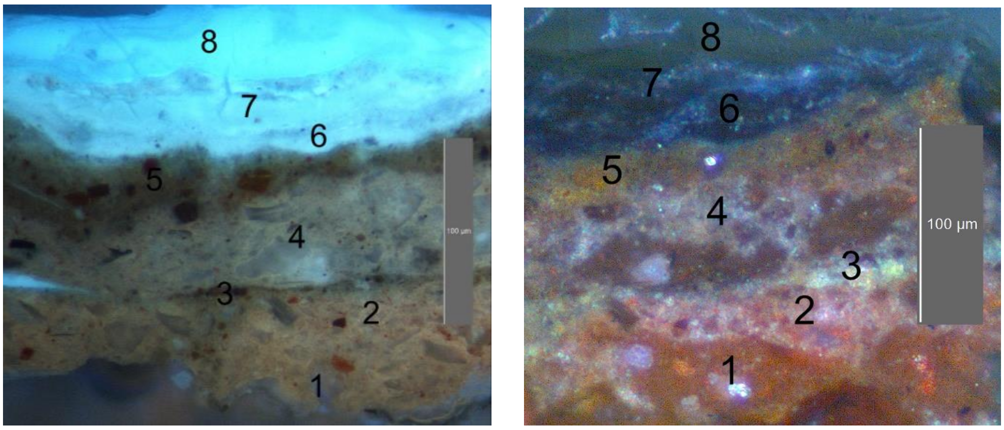

Figure 14. (A) UV-fluorescence image of a cross-section sample (CS 9) showing three different layers of varnish 200x magnified. (B) Same sample in visible light 100x magnified.

3.3.1 Binding media analysis

The FTIR-analysis done on the binding media gave a result indicating the presence of oil, but it is impossible to determine which oil in particular is used in the HAM painting (figure 15). The sample was a loose fragment of a paint layer from a dark brown pigment area in the lower edge of the painting. The fragment most likely contained sizing glue, ground, paint layers and varnish, all of which interfere with the spectrum making it difficult to interpret.

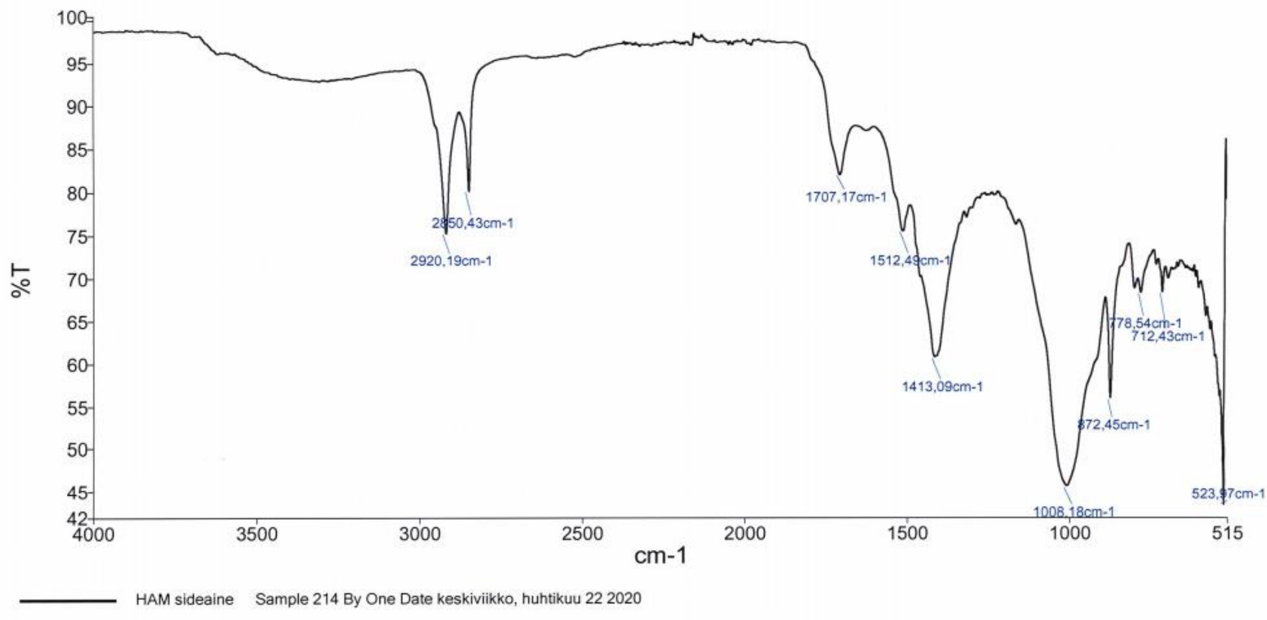

Figure 15. FTIR-spectrum from HAM paint layer particle.

The sample fragment was placed directly on to the crystal of the ATR-unit (Perkin Elmer Spectrum 100 FTIR/ATR), without any preliminary processing of the sample. A correlation to burnt umber was also detected, which would correlate with the dark brown pigment. Given that the sample contained so many different elements and impurities, it is not very reliable, beyond indicating the presence of oil by the double spikes emerging in the 2800-3000 cm^{-1} region. (Perkiömäki 2020.)

3.3.2 Varnish analysis

Since the UV-fluorescence photography of the painting showed a relatively clear fluorescence for a natural resin, samples of varnish were taken with a cotton swab infused in a solvent mixture of petroleum benzine and ethanol. The swabs were left in ethanol to dissolve the resin from the swab. The ethanol containing the varnish was then poured on to a watch-glass to evaporate. After the evaporation, the varnish sample was scraped off the glass and analysed by FTIR (figure 16) by placing the scraped varnish sample on the crystal of the ATR-unit.

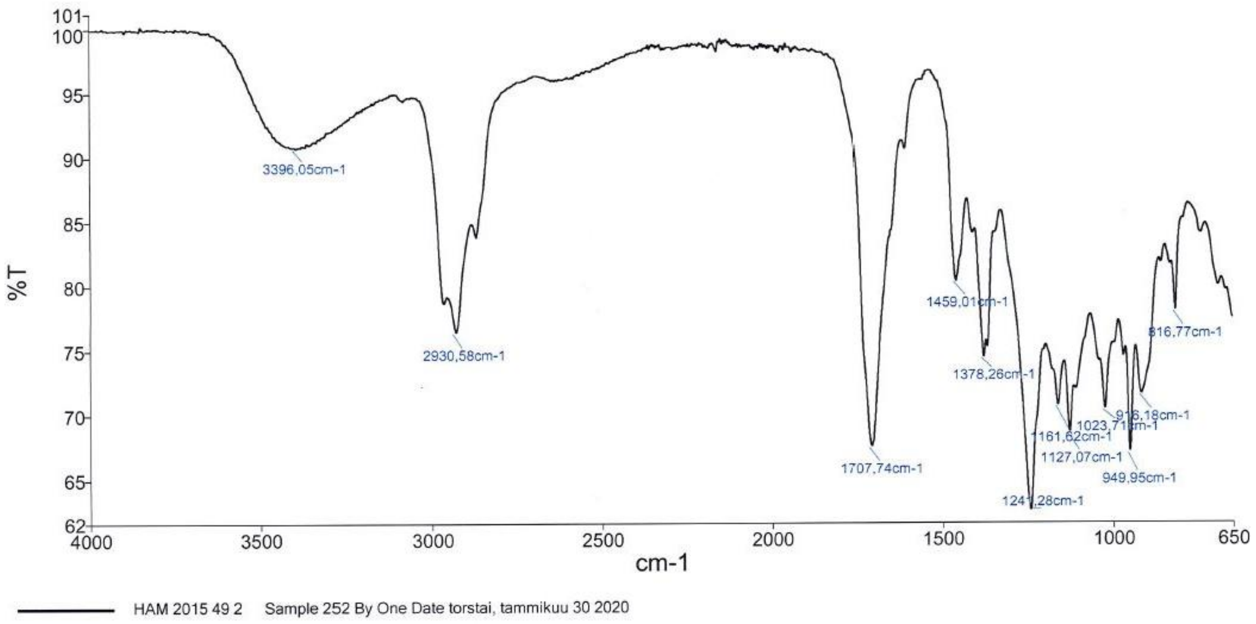

Figure 16. FTIR-spectrum from HAM varnish sample.

The sample spectrum was compared with reference spectra from the Metropolia conservation department FTIR data library (figure 17). The data library comparison showed strong correlation with both mastic and dammar. Resins can be distinguished from oils by the strong C-H stretching vibrations, that are in higher wavenumbers than with oils and are found generally at 2958-2930 and 2875-2865 cm^{-1}.There are two bands typical for resins. One is in 2700-2500 cm^{-1}, a weak and broad band. The other is a carbonyl C=O stretch at 1715-1695 cm^{-1}. This second band broadens with degradation and oxidation. (Derrick et al 1999, 104.)

To further distinguish between resins, such as dammar and mastic, is done by examining the fingerprint region of a specific functional group between 1500-500 cm$^{-1.}$ However, this is difficult, since many functional groups absorb at similar wavenumbers in this region (Derrick et al 1999, 83). Whether the varnish on the HAM painting is dammar or mastic cannot be fully determined by the FTIR-analysis.

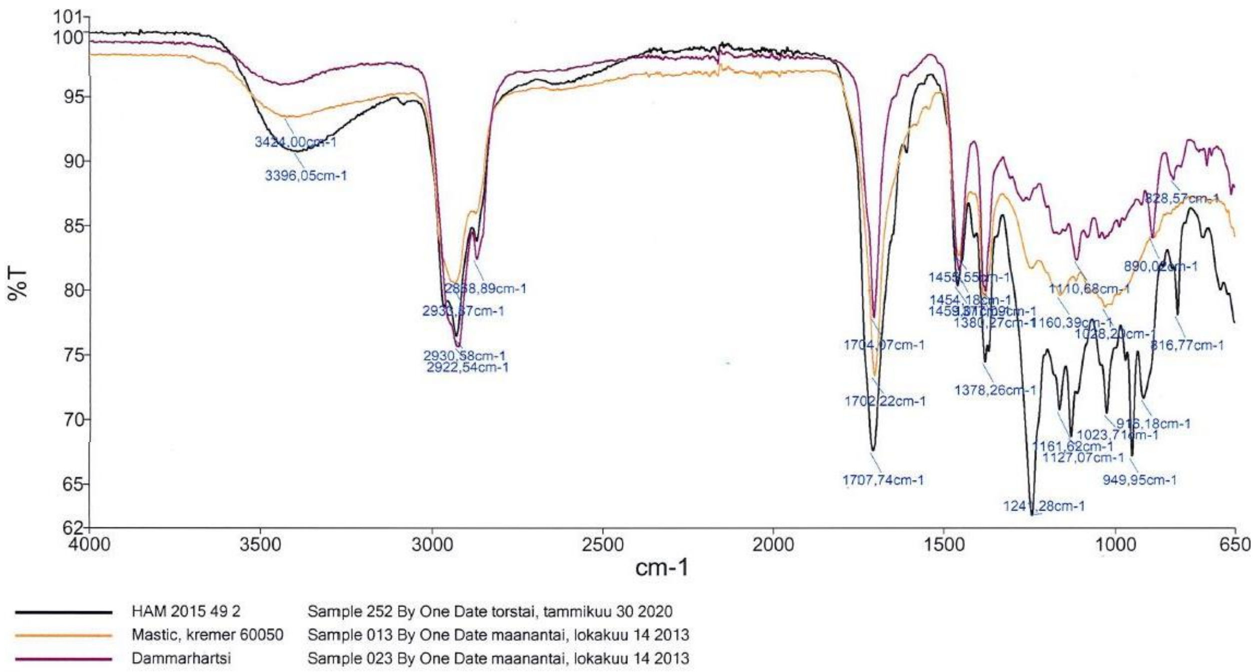

Figure 17. FTIR-spectra for HAM sample (black line), mastic (yellow line) and dammar resin (red line).

3.4 Fibre analysis

Fibre samples were taken from the original canvas support as well as the lining canvas and studied as well as photographed using a Leica DMLS light microscope and Leica DFC 420 microscope camera. Samples were taken from the areas of paint loss in the upper edge of the original painting support and from the edges of the lining canvas. The fibre samples were soaked in de-ionized warm water in order to dissolve the animal glue used in sizing of the canvas as well as from the glue used in lining and to separate the fibres from each other. The fibre samples were left to soak overnight, but there were still traces of possible resin or glue visible under the microscope, especially in the samples of the original painting support.

Both the original canvas support (figure 18) and lining canvas (figure 19) seem to be consisting of natural fibres, such as flax, hemp or jute. Distinguishing between the different types of fibres would require more sophisticated analysing methods, but we know that both linen and hemp have been widely used as painting support materials in the 17th century. From the microscopic images a hollow lumen area is clearly visible in the middle of the fibre and some faint vertical lines can be seen, indicative of possibly flax fibres (Houck 2009).

When preparing the fibres from the original painting support for microscopic analysis, they were very brittle and apparently soaked in glue and possibly resin. Some traces of this possible resin or glue can be seen in figure 18 as clumps clinging to the fibres. These clumps are not found in the samples of the lining canvas (figure 19). By visual judgement, the fibres of the original painting support seem to be more broken down by natural degradation than the fibres in the lining canvas.

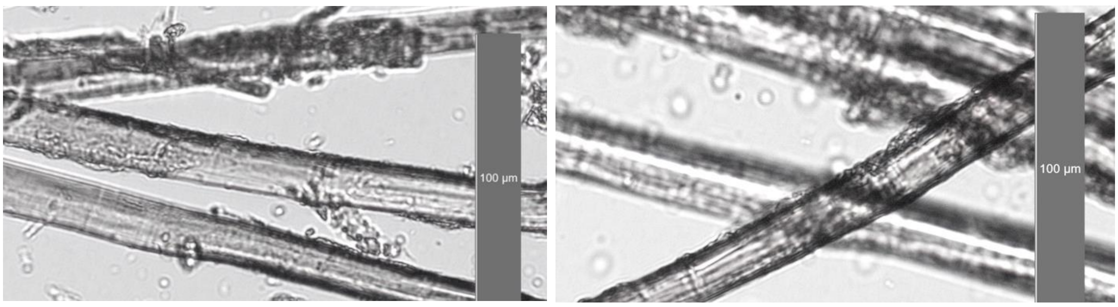

Figure 18. (A) Original canvas, vertical fibre x200 magnification, (B) horizontal fibre x200 magnification.

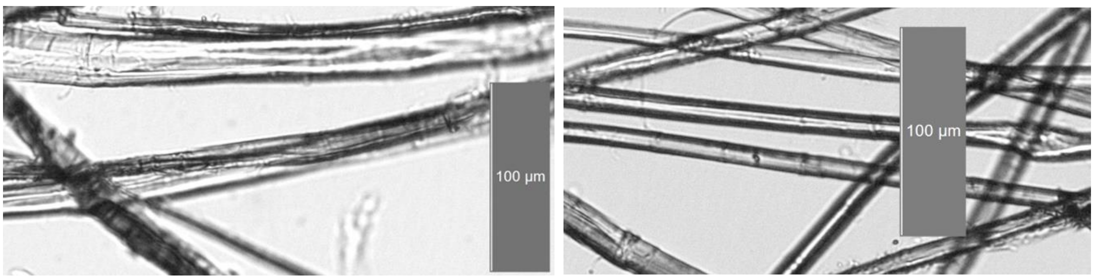

Figure 19. (A) Lining canvas, vertical fibres x100 magnification, (B) horizontal fibres x100 magnification.

4 The Structure and condition of the painting before conservation

4.1 Stretcher

The stretcher is in good condition. By visual judgement it is most likely made of coniferous tree (figure 20 (A)). It has a cross bar in the middle and some but not all of the wedges. Wedges are secured with metallic holders that have been nailed to the stretcher bars. Similar metallic holders are found in at least one other painting belonging to the Furuhjelm collection. This other painting was also bought from the Martynov collection along with *Judith and Her Maidservant* and 10 other paintings.

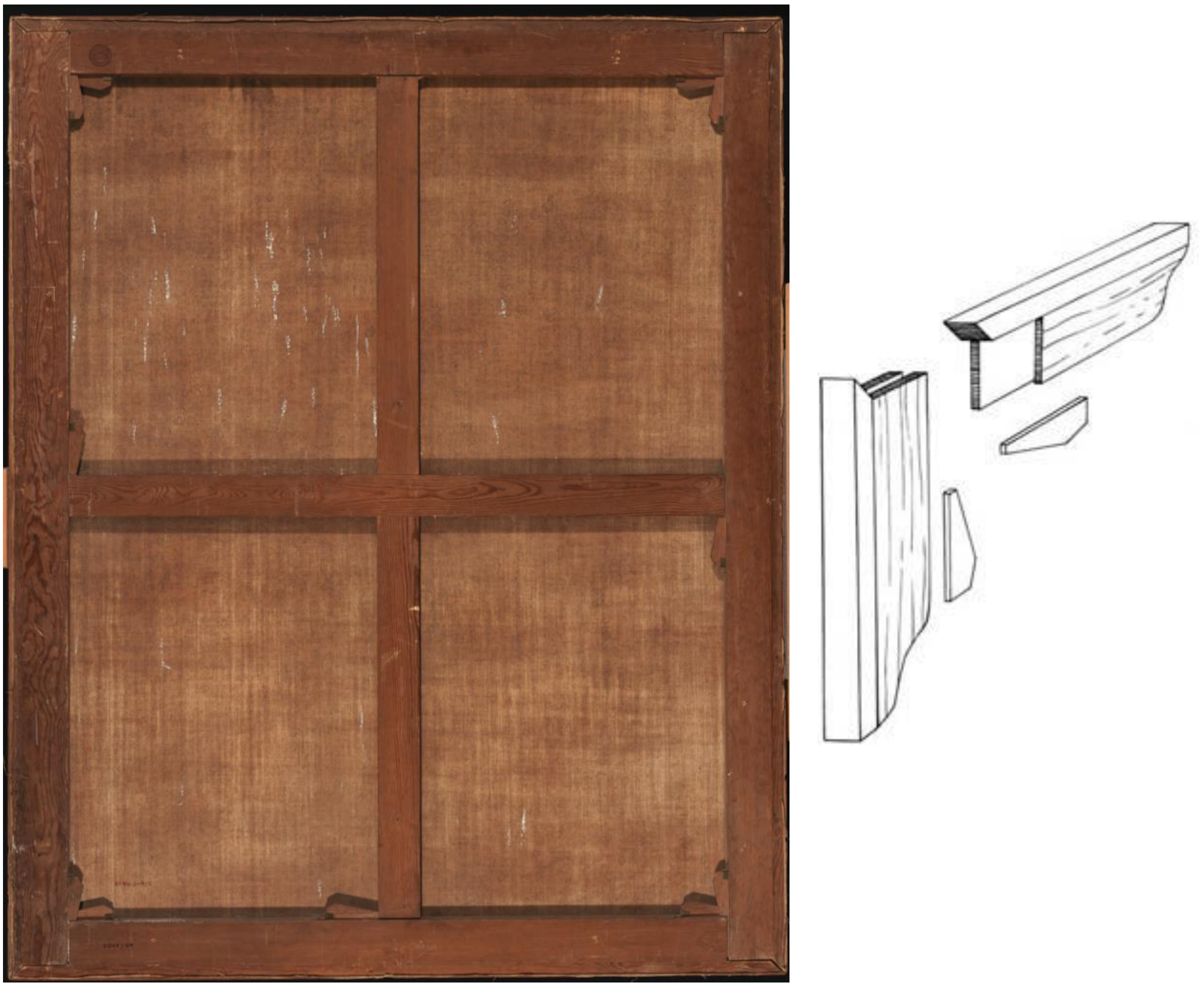

Figure 20. (A) The painting's stretcher is a typical 19th century stretcher with wedges to every corner and to the cross bar. Photo: Hanna Kukorelli / HAM. (B) Illustration of closed bridle joint with mitred corner and keys. Picture: The AIC Wiki.

The stretcher has closed bridle joints with mitred corners and keys (figure 20 (B)). It is bevelled away from the canvas toward the inside making it safe for the canvas and minimizing any stress to the paint layer. This type of stretcher is typical to the 19th century with the keys or wedges and bevelled edges, and 19th century stretchers with this kind of joint structure have been found in Russia (Buckley 2007). The stretcher is not original to the painting, since the painting has imprints of a previous strainer with support bars in the corners (figure 21).

Figure 21. Imprint patterns from a previous strainer.

4.2 Paintings original support and lining canvas

The painting's original support has been trimmed at its edges at some point, probably at the time when it has been lined, and the original tacking edges have been lost. Without the tacking edges, the direction of warp and weft cannot be determined. The weave of the original fabric support is plain, coarse, uneven and very open (figure 22). There are no visible signs of cusping in the original canvas. The original canvas in the Oslo painting is also reported being “coarse plain weave and open canvas” with no visible cusping (Ford 2015, 5).

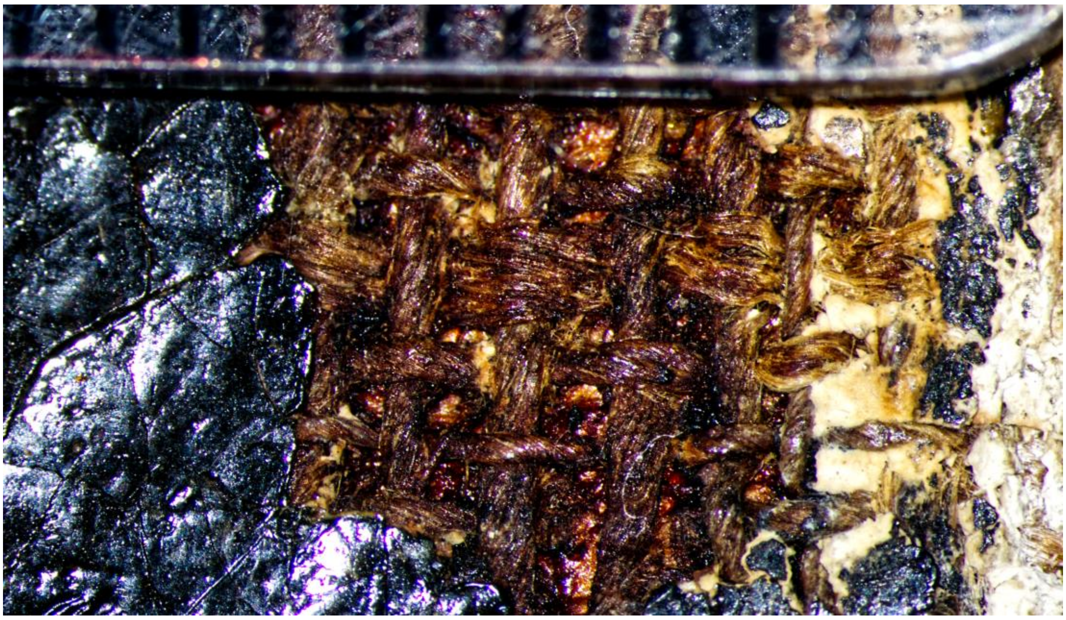

Figure 22. Microscope image of a pain loss area at the upper edge of the painting showing the original painting support (magnified 160x). Traces of glue used possibly in the lining can be seen between the weaves of the original painting support as a dark brown film. White filling from an earlier restauration is also visible.

The lining canvas is in good shape. It has some staining on the reverse side but seems very solid. The dark stains could be a result of the lining canvas having been exposed to excess humidity or water damage. The humidity has caused dirt in the lining canvas to travel and create dark rimmed island patterns. It is unlikely that these stains would be resulting from the lining procedure, since the lining canvas used would probably have been a clean one. Another explanation to these dark stains could be the ageing and darkening of the lining glue that has seeped through the lining canvas. This should be investigated more thoroughly.

There are also some white stains which seem to be spatters or runoffs of some kind (figure 23). The weave of the lining canvas is plain and tight. The tacking edges have been cut off. Some dark imprints can be seen on the lining canvas that might have come from the use of heated irons in the lining process (figure 20).

Figure 23. Detail image of dark stains on the lining canvas possibly caused by the lining process or later excess humidity, and white spatter or runoff stains.

4.2.1 Lining canvas and the method of lining

Typically, paintings were lined in the 18th and 19h century using either glue-paste or wax-resin as an adhesive between the original and the lining canvas. A method of lining with a wax resin mixture requires the use of high temperature and compression. This leaves the painting rigid and often the wax component seeps through to the paint surface affecting the colours of the painting by darkening them. The pressure and heat applied in the lining procedure has often affected in flattening the impasto of the paint layer. There seems to be no signs of this method being used in the HAM painting. Instead, it seems more likely that another method using a paste of glue and flour has been applied. The bonding of the lining is in good condition and there are no bulging areas or areas that seem to be delaminating. The lining canvas is a little dirty from the reverse, but otherwise it is in good and solid condition.

The lining of the HAM painting has probably been done using a glue paste, but this is difficult to determine since the edges of the original painting support are very neatly and precisely trimmed and no lining paste is visible from the edges (figure 24). Since the painting was purchased from Russia by Furuhjelm with several other paintings, it could perhaps be assumed that all of these paintings were treated in Russia before their purchase. The similar metallic wedge holders in another painting of the Furuhjelm collection could point to this conclusion.

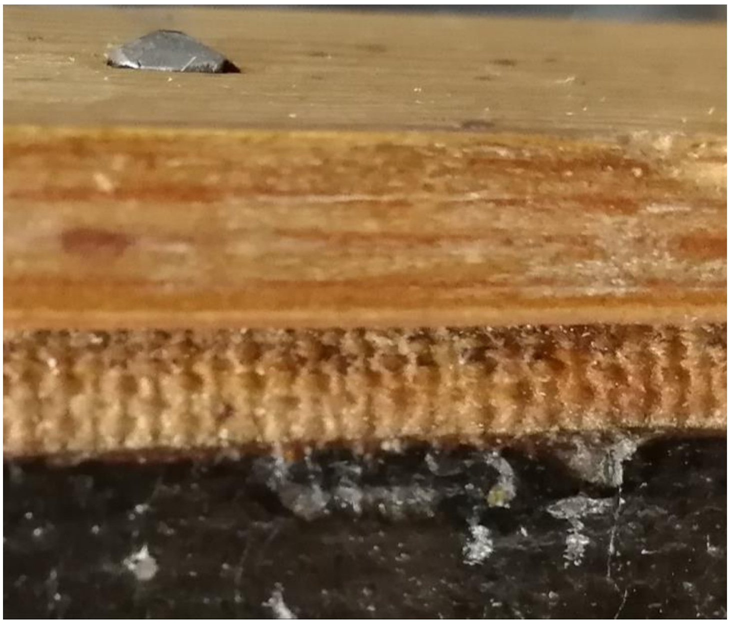

Figure 24. Detail image from the edge of the original painting support. The painting has been lined, stretched to a new stretcher and the folded edges of the lining canvas have been covered with a bar circling the painting. No lining glue or paste is visible from the edges.

A glue paste was commonly used for lining adhesive since the 17th century (Percival-Prescott 1974). Recipes for the glue paste varied containing some kind of animal-based glue, flour, water, oil, resin, Venetian turpentine and other substances. The glue paste method was carried out by applying the paste on the reverse of the original painting support and then pressing the lining canvas securely on top. Heat was recommended to be used to secure the adhesion and this required good craftsmanship and expertise, ,as the painting could be damaged by burning with hot irons or by pressing the weave pattern of the lining canvas on the paint surface if the heat was too excessive. Wax-lining became more common in the late 19th century. Linings were done routinely in the 19th century to canvas paintings, since it had been observed that the original painting support became increasingly brittle over time and thus the structural stability of the paintings was compromised. These linings were done even if the painting had not suffered major damages such as tears. (ibid.) The painting in Oslo has also been lined, but the lining was in poor condition and the lining support was delaminating (Ford 2015, 5).

4.3 Canvas painting in the 17th century

Canvas paintings from the 17th century have been studied thoroughly in conservation literature. For the purposes of this thesis, known facts related to materials and structure of easel paintings on canvas support in the 17th century will be noted, if it seems relevant for the material study of the HAM painting.

4.3.1 Canvas preparation, ground layer, *imprimatura*

Nico Van Hout (1998) writes about ground layer in the 17th century, stating that artists painting on canvas moved from heavily gessoed canvases to canvases which were sized with animal glue, a thin layer of gesso and then with a coloured ground, or *imprimatura*. The thick white multiple layered gesso priming was carried from panel paintings to canvas but was soon found to be impractical and easily flaking, although still used in some canvas paintings. This was already noted by Vasari in the 16th century. The use of thin sizing glue and gesso to only fill the interstices of the weave left the canvas more flexible and easier to transport, since the flexible ground layer allowed the canvas to be rolled for transportation. (ibid. 199-213; Percival-Prescott 1974.)

According to Van Hout the coloured *imprimatura* layer acted as a barrier between the gesso and the oil paint, preventing the oil sinking into the gesso. He also notes that the use of multiple coloured layers as ground or *imprimatura* was not uncommon (ibid., 200), and that the use of different colours of *imprimatura* within an artist's production of paintings was common: "—many painters changed the colour of their *imprimatura* according to the subject, their mood or their painting technique." (ibid., 217). According to Van Hout, Venetian painters often used *imprimatura* coloured in grey, brownish or flesh-colour and that chiaroscuro painters, such as Tintoretto and Caravaggio, "—used the red-brown *imprimatura* on purpose, since dark underlayers form an ideal basis for compositions with strong light contrasts." (ibid., 216).

4.3.2 Ground and paint layers in the HAM painting

Mentions of a red brown *imprimatura* and the use of more than one layers of coloured ground are consistent with the findings in the Oslo Judith and with the HAM Judith, both having similar double ground layers of different hues of red brown. The HAM painting lacks the grey and white layers of the Oslo painting. The canvas in both paintings is also quite thin with an open weave and prepared most likely with a thin glue sizing, keeping the large canvas as light as possible.

The HAM painting has suffered previous varnish removals and the paint layer has abrasions in many areas (figure 25), especially in the areas vulnerable to polar solvents: the dark reds in Judith's dress, the dark brown in the background, the blood stains under the basket holding Holofernes's head. These vulnerable dark pigment areas are known to have a high level of oil binding media to make the paint flow and seem translucent. Because there is more binding media in relation to the pigment particles it is more vulnerable to solvent cleaning.

Figure 25. Detail image of abrasion marks and paint loss in Judith's dress and hair.

There is a craquelure pattern visible throughout the painting (figure 26). It would seem that most of the craquelure does not penetrate the paint layer all the way to the ground. Some on the craquelure might be caused by the drying and shrinking of the varnish. This seems to be case in the areas that are most severely craquelured and have some rising of the craquelure edges or possibly cupping (figure 27).

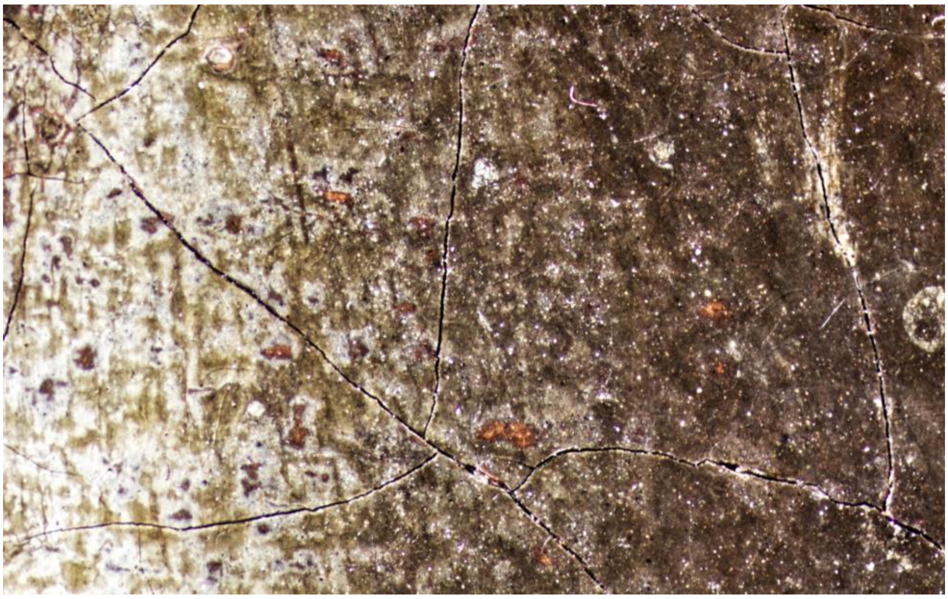

Figure 26. Microscope image of craquelure pattern typical for the HAM painting surface. Residues of a previous varnish layer can be seen pooling as darker areas on the surface.

Figure 27. Detail image of cupping in some areas of the painting surface.

4.4 Overpainting, retouching and other alterations

The HAM painting has many areas with overpainting and restoration, especially in the dark background area. In the figure 28. damages to the paint surface are marked with different colours.

Severe craquelure, cupping
Missing paint
Scratches etc.
Overpainting or retouching

Figure 28. Mapping of damages.

One especially visible and interesting retouching was on the blue sleeve of Abra's dress. The sleeve has been described grey in the 50's (Sinisalo 1952) and also by Synnöve Malmströn in 2017, but the colour used for retouching paint losses was a very bright light blue (figure 29). The choice of a retouching colour so bright in contrast to the underlying blue-grey is interesting. Was the bright blue the only shade of blue available for the re-touching? Has the underlying colour changed after the retouching was done? When the varnish removal progressed, it became clear that the strong colour change in the varnish alone could have been the reason for the bright blue retouching, if the varnish has been less yellow at the time of the retouching (figure 30). There were no fillings or paint losses found under the retouching, only some dark spots. The mechanism for these spots is unclear, but it could be a result of the earlier cleaning method leaving behind old varnish or an oil resin varnish residue, that has remained in the cavities of the paint layer and continued to darken.

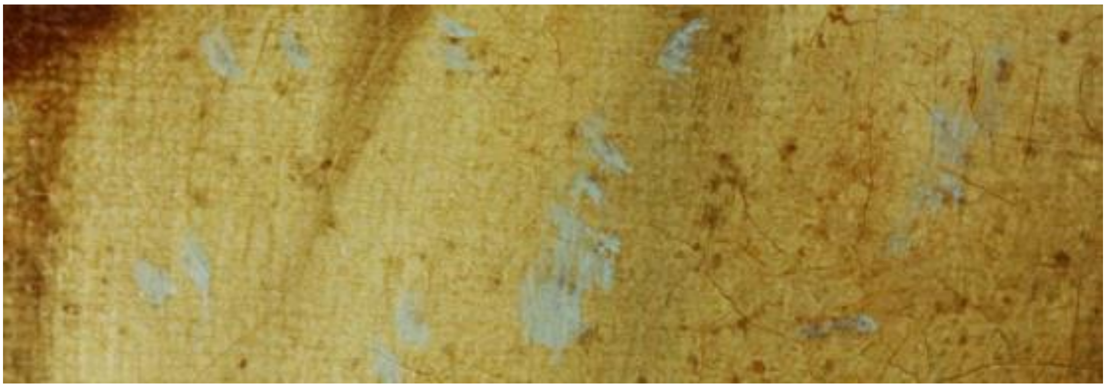

Figure 29. Detail image of light blue retouching on Abra's sleeve.

Figure 30. Detail image during varnish and retouching removal of Abra's sleeve. Varnish and retouching have been removed from the upper half of the image.

4.5 Varnish

As it has been described earlier, the varnish is not original to the painting given the abrasions that are the result of previous varnish removals. The painting has most likely been cleaned and varnished at the same time it has been trimmed and lined, possibly in the 19th century before its purchase from Russia by Otto W. Furuhjelm. The varnish proved to be a natural resin, either dammar or mastic. This cannot be determined by the FTIR-analysis since both dammar and mastic give similar results on the FTIR. The varnish has become a dark yellow film obscuring the brightness of the colours under it. When examined under UV-light, the varnish gave a light green or bluish fluorescence typical to natural resins.

4.6 Summary: Materials, alterations, and the need for conservation

Materials used in the HAM painting seem to be commonly used in European oil painting on canvas in the 17th century. The painting has been trimmed and lined at some point, probably with a glue paste and put on a stretcher typical to the 19th century. It has been previously cleaned of varnish at least once and has suffered some paint loss and abrasions in this cleaning process.

The “new” varnish coating has darkened and is affecting the brilliance of the colours and thus disrupting the visual impact of the painting. The varnish, and in some areas the paint layers have become brittle from ageing. The painting has craquelure patterns that follow the lines of an earlier strainer. The painting seems to have some deep horizontal craquelure situated mostly on the top and on the bottom edge of the painting that may be indicative to the painting having been rolled to a scroll at some point, perhaps for transportation or storage purposes. Similar damages could also be caused by excess humidity to the canvas.

The paint layer has some minor paint losses due to the craquelure and the paint layer and in some areas also the ground needs to be consolidated. The old and strongly yellowed varnish must be removed or at least thinned down to allow the brilliance of the colours to show and to bring out the contrasts. Old retouching and overpainting should be removed from areas where they are clearly visible and do not match in tonality the surrounding colour areas.

The glue paste lining and the lining canvas are in good condition and there is no need to remove the lining canvas at present. Removing the lining canvas at this point would cause unnecessary stress to the painting and could potentially result in seriously damaging the structure of the original painting support, which has become brittle by ageing and by previous treatments with gluing, lining and varnish removal. If the removal of the lining canvas becomes necessary, it should be carried out in a manner that is safe for the brittle original painting support. It is possible that the earlier varnish removal has caused some of the dissolved varnish to seep into the original painting support further enhancing the degradation process of the original painting support.

5 Conservation plan

The painting will not be detached from its stretcher, since it is in good condition and there is no need for an extensive humidity treatment or re-lining at present. The canvas will be supported with foam plates cut to fit the areas between the stretcher bars on the reverse side of the painting. The paint layer will be consolidated, old yellowed varnish will be removed or thinned down, old retouching will be at least partially removed when this is seen to be necessary. Retouching, which is in good condition and does not look too disturbing in tonality, will be left intact.

5.1 Consolidation of paint layers

The paint layer is severely cracked in some areas and seems to be cupping in some parts, especially in areas of darker shadows, such as Abra’s blue sleeve and her yellow dress. A few small paint areas have already been lost. The paint layers and ground seem to be quite dry, so some moisture will have to be introduced into the structure of the paint and ground layers in order to plasticise the materials and for good adhesion of the paint layers, especially in areas which have cupping and sharp rising edges. The moisture will enable the rising edges to be gently pushed back down with the help of a heated spatula, since the added moisture will reactivate the glue in the ground and help soften the dry paint layers. The sharp edges of the craquelure make it paramount that the painting is first thoroughly consolidated, and the surface cleaning done only after consolidation.

Sturgeon glue will be the first option for consolidating, since it has good adhesion, film forming and ageing properties which are close to the original materials of the painting and will not impose a new set of material behaviours (Baker 2015, 165). This will also leave open the option of using other consolidation materials, since the sturgeon glue is water soluble and does not form an insoluble and impenetrable film as some other consolidants would.

A 3 % sturgeon glue will be used for consolidation for sufficient adhesion, moisture and flexibility. A stronger solution might cause unwanted tensions, and since the painting has visible signs of being saturated with a glue from the lining or some other previous treatment, the use of a stronger solution seems unnecessary. The moisture from the solution will also reactivate the existing glue in the painting's structure. (Mecklenburg et al. 2012, 7-23.)

To help the sturgeon glue get between the paint layers, ground and the canvas from the small cracks, petroleum benzine (a non-polar solvent with a boiling range of 100-140 °C) will be used to lower the surface tension of the sturgeon glue. Petroleum benzine will also saturate the fibres of the original painting support to some extent which helps in getting the sturgeon glue to better remain between the ground layer and the canvas and not seep through to the canvas immediately after application (Soppa 2016). The consolidated areas will be treated with a heated spatula and left to dry under sandbags at least overnight in order to ensure that the paint layer edges pushed down will not rise back up.

In case the sturgeon glue does not seem to provide the necessary adhesion, there is the possibility of using Lascaux® Medium for Consolidation (MFK). The MFK is an acrylic dispersion designed for consolidating polychrome sculptures. It has a very low surface tension and good ageing and flexibility properties. It is easily available, ready to use and has been studied and tested for conservation use. The downside of MFK is its removability as, it is easily removed with water immediately after application but forms an insoluble film quite quickly after drying and is then soluble in esters, aromatics, acetone and ethyl methyl ketone (Hedlund and Johansson 2005). Other acrylic glues could also be considered, but they have the same downside with removability as MFK. Different molecule weight Aquazol® consolidants have also been used for consolidating paint. Aquazol® is soluble in water and alcohols, but it has weaker adhesion and film forming qualities than sturgeon glue.

5.2 Surface cleaning

Surface cleaning will be done after the consolidation and before varnish removal to remove any residues of the sturgeon glue and to prevent any dirt migrating from the surface to the lower layers of the painting. Because the paint layer has cupping and risen edges, it must be consolidated before cleaning to prevent any paint loss. Cleaning will be tested first with water, warm water, saliva and if these prove to be inadequate, then with a 1-2 % mixture of triammonium citrate in water. It seems that solutions above 2 % of triammonium citrate do not have an added effect to cleaning surface dirt (Morrison et al 2007).

5.3 Varnish removal

Solubility tests with solvents will be made to find the right polarity of the varnish. Different colour areas will be tested carefully to determine their durability to solvents. The yellow varnish layer will be removed or reduced in some areas by a tested and suitable solvent mixture with a cotton swab. A gel compression method might be used to speed up the work. A gel made of ethanol with 3 % Klucel G (w/v) will be applied on to a gauze (such as Hanotex or a similar fabric), put on the varnish surface and left to dissolve the varnish for a short period of time. Then with the capillary effect provided by a Kimberly-Clark professional Kimtech® 7506, dry absorbent towels and light pressure, the gel and the dissolved varnish will be removed from the surface. This gel compression method is described in detail by Gwendoline Fife et al. (2011).

The advantages of the gel compression method compared to the cotton swab with free solvents, is that it is quick and in the gel form the solvent will not easily spread through the paint and ground layers but will remain in the carrier gauze and only have an effect in swelling the targeted varnish layer (Fife et al. 2011). It also minimises further abrasions to the paint surface, since there is no rubbing or rolling involved. The even swelling of the old varnish and the capillary effect of the Kimtech® towel make this a good method for removing varnish from uneven surfaces.

5.4 Removal of old overpainting

Old overpainting and retouching will be removed to a level that is sensible to the visual integrity of the painting and considering each previously restored area individually. In case of the overpainting and retouching of the background, namely in the upper corners, the beard of Holofernes and near Judith's head, there seems to be little sense in removing everything that can be removed, only to find out that these areas need to be painted dark again. In the case of the blue sleeve, the restoration is disturbing and do not match the surrounding colour area. These should be removed, and possibly underlying damaged areas below filled and retouched to match the original colour.

Large areas in the beard of Holofernes's head and on top of Judith's head must be examined carefully and great care should be taken while removing the varnish and retouching. The retouched and overpainted areas are relatively large (figure 31). The x-radiography showed no white areas of lead-white based filling in the areas of paint and ground loss, except in one area left of Judith's head, where a tear to the canvas has been mended and filled.

Figure 31. Detail image of the overpainted or retouched area visible in the UV-fluorescence picture marked with magenta, IR- and X-ray images of the same area.

Most of the overpainting and retouching seem to be directly under the varnish layer and they may be easily removed with the varnish if they are made with paints with a resin as a binding component. If needed, a 10 % dimethyl sulphoxide in ethyl acetate can be used carefully to dissolve the restorations which are done with oil paint. This is a strong solvent that will swell the oil medium and should only be used if absolutely necessary since it may cause damage to the original paint layer.

6 Conservation report

6.1 Consolidation of paint layers and surface cleaning

The paint layer was consolidated with a 3 % sturgeon glue in de-ionized water. Petroleum benzine with a boiling point range of 100-140 °C was used to lower the surface tension of the glue and to locally saturate the fibres of the original painting support. Consolidated areas were treated with a heated spatula to gently push down any edges and to further soften the paint layer and to help evaporate the excess water from the glue. After the treatment, the areas were left to dry under light weight bags for a minimum of overnight to ensure the evaporation of water from the glue and good adhesion (figure 32).

The 3 % sturgeon glue proved to be a good choice for consolidation, since the paint and ground layers were very dry and, in some areas, had become quite brittle. The water in the sturgeon glue gave enough humidity to soften the brittle layers and enabled them to be gently pushed back down. In severe craquelure areas, especially in the top of the painting, the consolidation had to be repeated to gently force down the sharply risen edges of the paint layer. After a second treatment these areas were secure and plane.

Figure 32. Consolidation of paint and ground layers. Petroleum benzine was used to saturate the fibres of the original painting support and to lower the surface tension of the sturgeon glue. Excess glue was rolled off the surface with a cotton swab. A heated spatula was used to gently push down any sharp edges. Sandbags were left on the consolidated areas for the duration of the drying to ensure adhesion.

During and after the consolidation the surface was tested for cleaning. The surface did not seem very dirty to the naked eye and tests proved that there was only superficial dust on the varnish surface, which was easily removed with both saliva and warm water using cotton swabs (figure 33). The surface was cleaned with saliva and warm water during and after the consolidation.

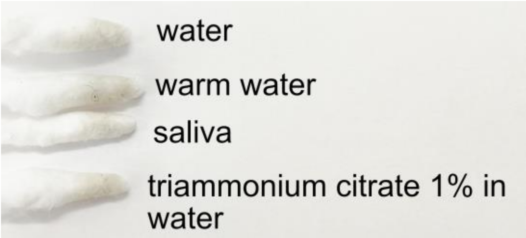

Figure 33. Swabs used in cleaning test. There was only some superficial dust on the varnish surface was removed easily during the cleaning of excess sturgeon glue.

6.2 Varnish removal

The UV-fluorescence image gave indication of the varnish being a natural resin by showing a blue-green fluorescence typical to dammar (Merz-Lê 1998, 70). The FTIR-analysis showed that the varnish was a natural resin without a wax component. Natural resins, such as dammar and mastic, consist of triterpenoid compounds. Dammar varnish begins to deteriorate by autoxidation and the primary initiates for this are photochemical and thermal energies (Merz-Lê 1998, 69). According to Merz-Lê, photochemical oxidation occurs at the double carbon bonds, carbonyl groups and tertiary hydrogen groups. The yellowing of dammar is caused by a secondary reaction with the autoxidation products and it is a thermal nonoxidative process. (ibid..)

With ageing, dammar becomes more polar and less soluble but does not crosslink. By remaining non-crosslinked and low molecular weight, aged dammar is removable with polar solvents, such as ketones and alcohols (ibid., 69-70). According to Merz-Lê changes in colour are noted within 25 to 50 years. The HAM painting's varnish had turned a very dark yellow colour, so it could possibly be assumed to be at least 50 years old.

Solubility tests with the Feller's series of solvents (cyclohexane, toluene and acetone) and mixtures of these solvents increasing in polarity (Horie 1987, 43) should preferably be conducted to determine the precise polarity of a solid material, in this case the varnish. The Feller's series has solvents which were not attainable for these tests, so in order to find a suitable F_d-value for the varnish in the Teas-triangle (figure 34), a set of mixtures of ethanol (Etax Aa) and petroleum benzine were used (table 1). Ethanol was chosen as a solvent since both UV-fluorescence and FTIR-analyses indicated, that the varnish was a natural resin and since aged natural resins such as dammar would be soluble in alcohols. In the test, petroleum benzine is a non-polar solvent and ethanol a polar solvent. With the increased share of ethanol, the polarity of the solvent mixture increases (Cremonesi 2008).

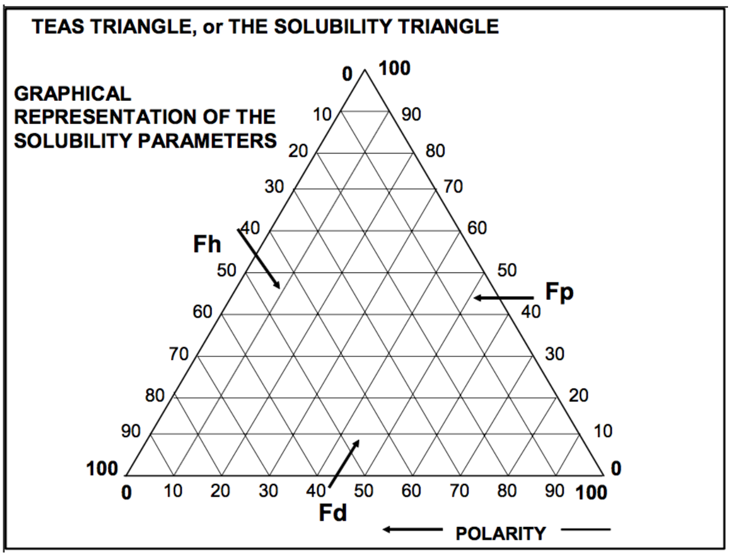

Figure 34. Teas-triangle of solubility parameters (Cremonesi 2008).

Volume				
Ligroin	Ethanol	Fd	Fp	Fh
100		97	2	1
90	10	91	4	5
80	20	85	5	10
70	30	79	7	14
60	40	73	8	19
50	50	67	10	23

Table 1. Solubility parameters for petroleum benzine and ethanol after Paolo Cremonesi (2008). Ligroin – petroleum benzine with a boiling point range of 100-140 °C.

6.2.1 Solubility testing

Solubility testing was done using different mixtures of ethanol as a polar solvent and petroleum benzine as a non-polar solvent (figure 35). Some minor solubility was noticed with a mixture of 15 % ethanol and 85 % petroleum benzine, but the varnish surface remained sticky for up to a mixture of 30 % ethanol and 70 % petroleum benzine when the varnish became soluble in a nice gliding manner but leaving the paint layer still completely intact. This would place the F_d-value of the varnish somewhere between 85-79 F_d. A value this high could mean that the varnish is not very old since it has not oxidised very far (Ruuben 2017).

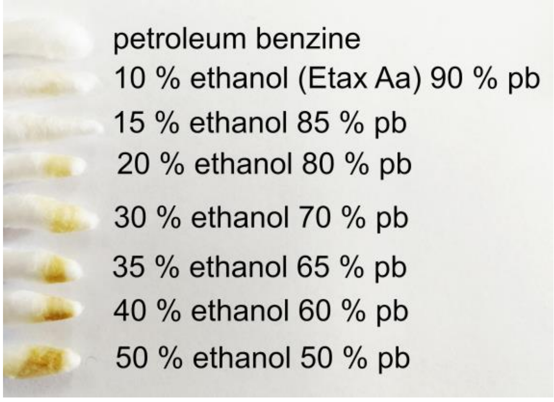

Figure 35. Solubility tests with petroleum benzine and ethanol (Etax Aa). Swabs were gently rolled on the varnished surface for approximately 10 seconds.

6.2.2 Varnish removal

Varnish removal was further tested in an area in the upper corner of the painting normally covered by the frame by using a cotton swab and a solvent mixture of 30 % ethanol and 70 % petroleum benzine. This proved to be too radical for the dark brown background but worked well in the more stable areas, such as the white sleeve of Judith's blouse and skin areas. These areas contain high levels of lead white, a pigment which does not need a high intake of oil and is therefore stable and can endure relatively strong (polar) solvent mixtures due to ageing and formation of cross links in the oil binder medium. With further examination it was noticed that the upper corner tested with the solvents had retouching, which would explain in part its sensitivity to solvents.

The cotton swab method (with a swab that has a controlled amount of solvent so that it does not drip from the swab) is good in small areas that need to be controlled and monitored carefully, such as the previously heavily cleaned areas (blood trails on the basket and Judith's hair locks in the HAM painting). However, it is also a very slow method. Taking into consideration the large size of the painting and the limited time available for this thesis work, it seemed justified to try the gel compression method described earlier (Fife et al. 2011) to speed up the removal process. In most cases gel compression is also a very gentle and easily controllable method for varnish removal.

The gel compression was carried out using a gel of ethanol (Etax Aa) with 3 % Klucel G as a thickening agent. The gel was applied on to a Hanotex gauze which was then placed directly on the varnish surface. The gauze was left on the surface for approximately 5 to10 seconds and then a Kimtech® -towel was pressed on top of the gauze and rubbed with the back of a spoon to induce a capillary suction removing the solvent gel and some of the dissolved varnish from the surface (figure 36).

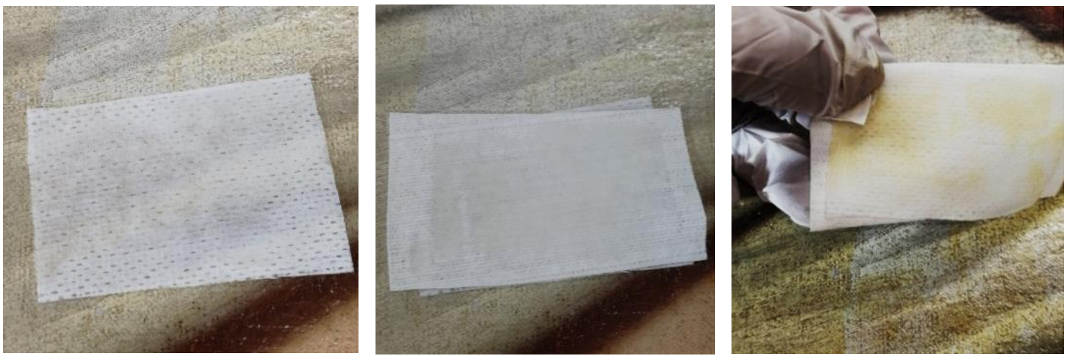

Figure 36. Removing varnish with the gel compression method. In this case the gel could have been left to work for a longer time, since much of the varnish is still left on the painting surface.

A polyethylene foil on top of the Hanotex gauze can be used to slow down the evaporation of the solvent, but in this case, it was not necessary since the working time of the gel was so short. In areas where the paint layer was plain and securely attached, the remaining gel and dissolved varnish were removed by pressing a clean Kimtech® towel on the treated area. In some areas the remaining gel and swollen or dissolved varnish was wiped clean of the remaining dissolved varnish with a cotton swab and a solvent mixture with 15-20 % ethanol in petroleum benzine. This proved to be a gentle and effective way to remove the varnish without damaging the paint layer. The method was also suitable for the sensitive brown background paint. The varnish removal was controlled with a UV-flashlight throughout the process.

6.3 Removal of old overpainting and retouching

Previously overpainted areas were only partially removed from the area near Judith's head. The areas in Holofernes's beard and Judith's dress were left intact for the time being. These areas will be treated later on. The bright blue retouching on Abra's sleeve was removed easily along with the varnish. Dark spots were discovered under the retouching, but the mechanism causing these spots remains unclear. Similar spots were also left on Holofernes's face, so it might be that these are either dirt or old oil resin varnish deposits in the cavities of the paint layer.

6.4 Summary of conservation during the thesis work

From the beginning of this thesis work, it was clear that the conservation and restoration the painting required would not be finished due to the limited time available. The focus of this thesis was on the material analysis and this was completed. The outbreak of the coronavirus and the challenges it created on working with the painting affected the practical conservation work to a point, but overall, most of what was planned was successfully completed. Most of the paint layer of the 17 287 cm^2 painting was consolidated and a good part of the varnish was removed or thinned down (figure 35). The final parts of the conservation and restoration of the painting will be completed at a later date.

The varnish removal or thinning concentrated on the central picture area on the basis of getting a clearer IR-reflectography image as the glossy varnish would cause fewer disturbing reflections.

Figure 37. (A) During varnish removal, symmetrical day light. (B) Areas with varnish intact marked with green colour.

7 Restoration plan

The conservation of the HAM painting as part of this thesis ends in the partial removal or thinning of the old and yellow varnish. The remaining varnish will be removed, and restoration completed at a later date. A plan for restoration and consideration and suggestions for materials used will be offered as a part of this thesis.

After the varnish and overpainting as well as retouching are removed or thinned down, the possible ground and paint loss areas should be filled and isolated, an intermediate varnish should be applied before retouching to saturate the pigments. After retouching a final varnish should be applied for an even finish and to protect the retouching and the paint surface.

7.1 Filling

A suitable filling material for the paint loss areas could be a mixture of sturgeon glue and chalk or gypsum since these are readily available and easy to use, even though animal glue-based fillings tend to shirk when drying. However, the loss areas are quite small in size and situated along the stable, cut edges of the original painting support, so the shrinking does not pose a huge problem. As noted earlier, sturgeon glue has good ageing, adhesion, and flexibility properties. The areas requiring filling are small and in peripheral areas of the painting, mainly in the upper and lower edge. The purpose of the filling is to ensure the stability of the paint layer of the damaged areas in the future as well as to prevent the damage progressing any further. For this reason, the fillings should be made directly on the original painting support before any intermediate varnish or isolating layer is applied as they might compromise the stability of the filling.

If the paint loss areas were larger and situated, for example, in the bent tacking margins, a filling with Beva 371, chalk and microcrystalline wax could be a good option, since it is easy to make, stays removable with non-polar solvents and is easy to apply with a heated spatula (Seymoure 2013). Since the Beva-filing is easily shaped by heat, it would be a good choice for large areas which need a surface imitation. An imitation mould replicating the paint surface could be made with a two-component silicone and pressed on the Beva-filling with a heated spatula. The surface imitation helps to disguise the otherwise plane fillings to match the uneven surface of a canvas painting mimicking the weave of the canvas and possible craquelure patterns.

7.2 Intermediate varnishing

An intermediate isolating varnish layer before the retouching is necessary for the integrity of the original paint layer. It saturates the paint back to how it was meant to be viewed with a glossy varnish and isolates the original paint layer from the retouching. Three options, dammar, Laropal A81 and Regalrez 1094, are considered in the table 2 below, comparing the refractive index, solubility in solvents, molecular weight and ageing properties (Goltz 2012; Proctor and Whitten 2012; Samet 1998; Merz-Lê 1998). The painting will be kept under controlled humidity and lighting conditions and most likely will not be covered with a glass. These factors should be kept in mind when choosing a suitable varnish.

Studies done by René de la Rie in the 1980's of low molecular weight varnishes came to the conclusion, that "as long as a resin was clear and had a refractive index close to 1.5, then the molecular weight was the factor that most influenced the optical properties of the varnish" (Proctor and Whitten 2012, 641).

	Dammar natural triterpenoid resin	**Laropal A81** urea aldehyde resin	**Regalrez 1094** hydrogenated hydrocarbon resin (HHR)
Refractive index	1,53-1,54	(for Laropal K80: 1,53)	1,52
Solubility	xylene, toluene, alcohol, acetone, isopropanol **insoluble** mineral spirits, petroleum benzine	soluble in hydrocarbon mixtures of approximately 30–40 per cent aromatic content most oxygenated solvents such as ketones, alcohols, and ethers **insoluble** in almost all purely aliphatic hydrocarbons	soluble in non-aromatic, non-polar solvents, 100 % aliphatic hydrocarbons, cycloparaffinic, and aromatic solvents **insoluble** in polar solvents, including oxygenated solvents such as **alcohols**, ketones and ethers
Solubility after ageing	polarises with ageing but stays generally soluble	remains soluble in a mixture of aliphatic and aromatic solvents	no increase in polarity, decrease in molecular weight
Molcular weight	(average molecular weight 424-506) low molecular weight, **satin finish**	low molecular weight, **satin gloss,** saturation like dammar does not provide the physical protection of a polymer varnish	(average molecular weight 900) low molecular weight, **saturates well and is glossy** brushing with little friction, "sinks in"

Table 2. Comparing traits for dammar, Laropal A81 and Regalrez 1094.

A Regalrez 1094 synthetic varnish could be a good choice for the intermediate varnish. The solvents used for the Regalrez 1094 varnish enable the use of retouching binding media that is soluble in ethanol, such as Laropal A81 or Mowilith 20 with dry pigments. This way, if the retouching needs to be removed with ethanol, the intermediate varnish will not be affected and will also act as a barrier for the original paint layer. The downside of the Regalrez 1094 is the tendency to "sink in" into the ground layer due to its low molecular weight (Proctor and Whitten 2012). To a certain extent, all of the varnishes considered will most likely sink in at least to some extent and the complete removability of any varnish is mostly hypothetical. Keeping this in mind, it would be sensible to choose a varnish with good ageing properties, that will not accelerate the degradation of the painting's other materials.

Dammar varnish is a natural resin with some impurities, but the ageing properties of it are well known, since it has been used in conservation since the 19th century (Goltz 2012, 639). With dammar or mastic, hindered amine light stabilizers such as Tinuvin 292 are recommended since they improve the ageing characteristics of the natural resin varnishes (ibid.). For natural resins, such as dammar or mastic Tinuvin 292 should be added at 3 % of the weight of the resin and for synthetic varnishes 2 % (Proctor and Whitten 2012, 642).

A spray varnishing seems a sensible method for the application of the varnish, since the painting is so large. Spray varnishing is fast and relatively easy to control for an even finish, but it requires a varnishing room with appropriate ventilation and health and safety measures, such as an appropriate face mask and filter. However, a spray varnish might not level or saturate the painting as effectively as brushed varnish, but coatings can be built up to a saturation level wanted (Goltz 2012, 638).

Large scale paintings have been varnished with a brush, but this requires experience and can result in uneven application and dripping. For brushing, a lower viscosity varnish is advised with solvents or solvent mixtures with high boiling points (Goltz 2012, 636). Brushing a varnish may cause a deeper penetration impregnating the ground and painting support, which could in turn cause degradation or, on the other hand, help to further consolidate the paint and ground layer (ibid.).

For synthetic resins, the following order for varnishing layers has been suggested: Laropal A81 / Regalrez 1094 (Proctor and Whitten 2012, 651). However, if the intermediate varnishing is done using Laropal A81, it makes the retouching more difficult, since the Laropal A81 is so easily soluble in ethanol which is usually used as a solvent in the retouching process. This means that every stroke of retouching dissolves the underlying varnish. Therefore, it would make sense to choose the Regalrez 1094 as the intermediate varnish.

7.3 Retouching

Retouching could be done with either Laropal A81 or dry pigments in Mowilith 20 binding medium. These two can be mixed together since both are soluble in ethanol. The Laropal A81 retouching colours either by Kremer on Gamblin® are quite expensive but also very lasting. They are ready to use, unlike dry pigments with a separate binding media. Since the HAM painting has a restricted colour scheme, dry pigments with Mowilith 20 binder could also be a good option.

7.4 Final varnishing

The final varnishing could be done by spraying, if the solvents used in all the considered options would dissolve the retouching. A brush varnishing would cause the retouching to spread. The final varnish can be the same as used in the intermediate varnish layer. By using different varnishes, advantages of the physical, chemical, and aesthetic properties of each resin can be exploited to reach a desirable outcome, be it the level of gloss, removability or stability. It has been customary to finish the varnishing with a layer that might yellow over time but stays removable (Proctor and Whitten 2012, 650). The final varnishing could be done with either dammar or Regalrez 1094, keeping in mind that dammar will turn slightly yellow and brittle over time, but this will be slowed down with the use of Tinuvin 292 in the mixture.

8 Summary

The main aim of this thesis was to conduct material analysis of an oil painting on canvas in the HAM collections which was dated to the early 17th century and attributed to a French painter Pierre Mignard. The attribution was put in question by a discovery of a similar painting in Oslo recently attributed to Artemisia Gentileschi. Material analyses done confirmed, that the materials and techniques of the HAM painting are those commonly used in the 17th century oil paintings on canvas, and that they in most parts match the ones found in the Oslo painting. The paintings are of different size formats and the Oslo painting has a green curtain in the background that is not present in the HAM painting. The Oslo painting has more detailed jewellery painted on Judith’s dress and head band than the HAM painting. Another composition was found under the visible one in the HAM painting, no such findings have been done on the Oslo painting. Both paintings have similar original canvases that have been lined and the cross-section analysis showed a double ground layer in both paintings. The Oslo painting has grey and white ground or *imprimatura* layers that the HAM painting does not have. The Oslo painting did not have any visible underdrawings where the HAM painting showed some lines, that could possibly be underdrawings, especially near Judith's profile. Pigment analysis of the HAM painting's blue pigment in Abra's sleeve and the bright yellow pigment in Judith's jewellery are still in progress.

As a part of this thesis, consolidation of the paint and ground layers and a partial removal or thinning of the varnish were done as practical conservation measures. The varnish removal was done with a gel compression method using an ethanol gel thickened with Klucel G applied on a Hanotex gauze on top of which a Kimtech® towel was placed for capillary suction. The gel compression method worked well on the varnish. The material analysis and solubility tests done to the varnish supported the use of the ethanol gel. A more optimal gel with a different solvent or solvent mixture could have been used, but due to time restrictions a previously known and tested ethanol gel was chosen.

Overall, the material analysis which was planned at the beginning of this thesis work was finished on time and gave valuable information about the materials and methods used in the painting. The time spent on the testing of the solubility of the varnish and finding suitable solvent mixtures for the removal of the varnish was underestimated, but a good result was reached with the materials and methods chosen. The thesis project provided experience in scheduling, project management, material analysis, practical conservation on a large-scale painting and scientific writing.

Further comparative analysis of painting materials and techniques with the *Judith* in Oslo and other Gentileschi paintings could provide interesting information for the attribution of the HAM painting. An archival research in Russia would be necessary to trace the provenience of the painting before it was purchased by Otto W. Furuhjelm. An overall study of the whole Furuhjelm collection could possibly give more insight to the history of the HAM *Judith's* conservation.

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Appendix 1

Before conservation, symmetrical daylight

Photo by Hanna Kukorelli / HAM.

Appendix 2

Before conservation, sidelight

Photo by Hanna Kukorelli / HAM.

Appendix 3

Reverse side, symmetrical daylight

Photo by Hanna Kukorelli / HAM.

Appendix 4

Ultraviolet fluorescence image, before conservation

Appendix 5

Infrared reflectography during varnish removal

Appendix 6

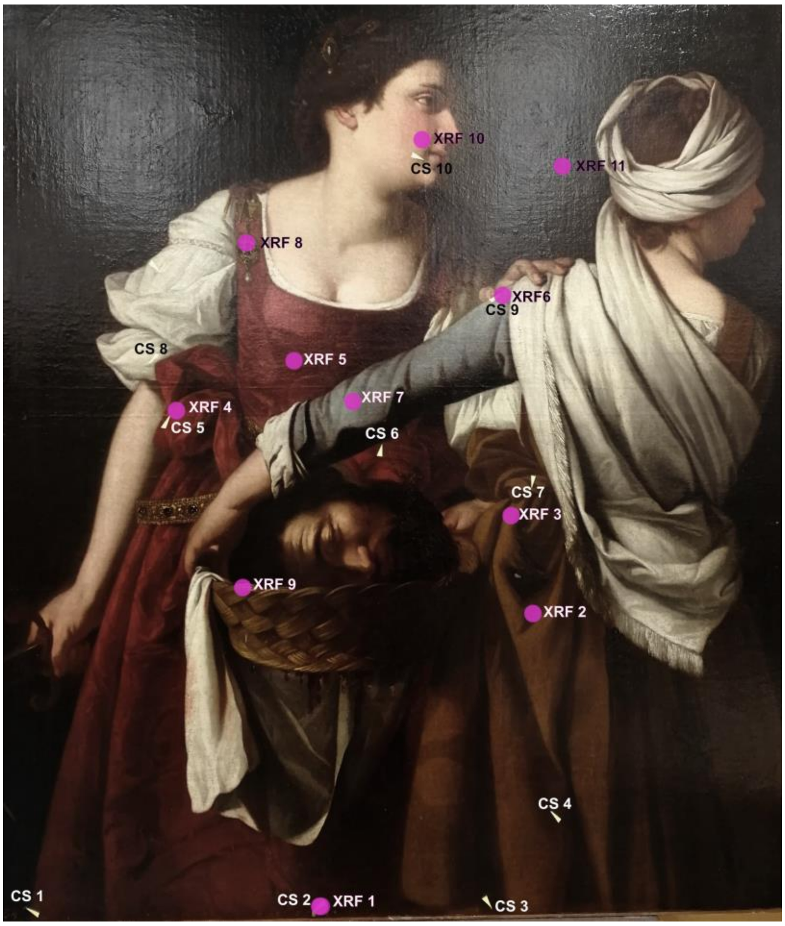
X-radiography compilation image

X-radiography images by Heikki Häyhä. Digitally compiled by Emilia Laaksovirta.

Darker areas are a result of each individual x-radiography image being first adjusted separately and then compiled in to one image. All images were taken with the same pre-settings.

Appendix 7

X-ray fluorescence analysis



XRF-measurement and cross-section sample points marked on the painting.

XRF-measurement results marked as particles per million. Colour coded from high ppm number (red) to medium (orange - yellow) to low (blue).

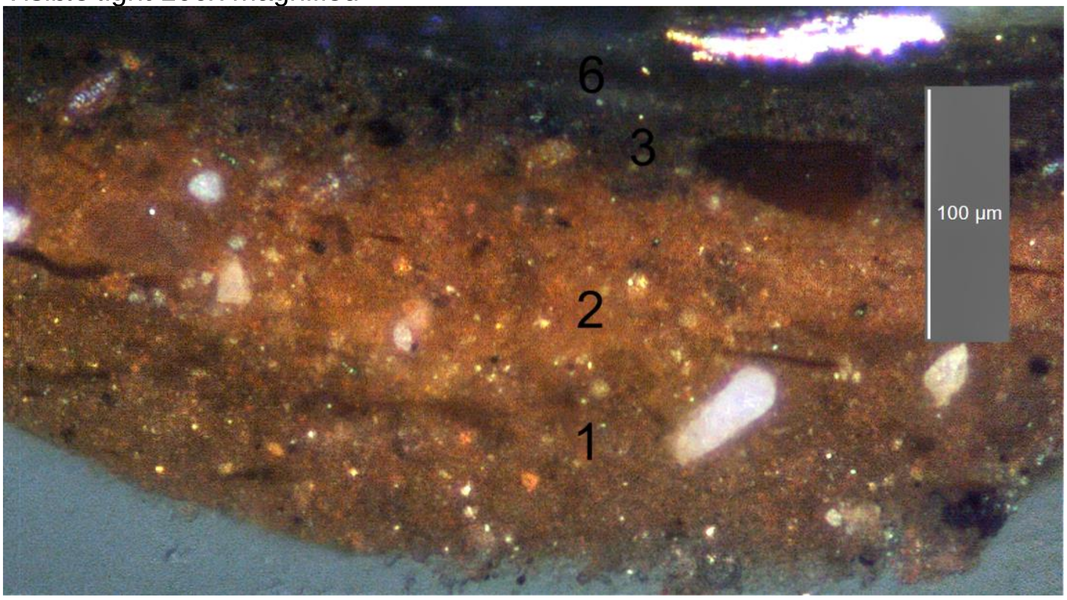
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11
	dark bottom egde	dark yellow dress	light yellow dress	light red dress	dark red dress	blue sleeve	blue retouching	yellow jewellery	light yellow basket	judiths cheek	dark background
P	4444	2017		6201						6170	6378
S	85292	50887	70467	217221	118531	22896	189837	9678	125434	207086	52574
Cl	43069	34029	47565	86300	71845	91828	18411	53057	73081	99964	46114
K	18332	19885	21781	7616	17924			16237	8840		20615
Ca	117597	125768	76320	30849	57235	3827	12147	90913	40089	6572	140313
Ti	2620	3528	7047					3507	2640		5231
Mn		1422									1994
Fe	84022	210816	184999	32457	85145	6185	19457	90673	87303	16383	146059
Zn							35997				
Sn	1955				1943	2526		7598	3456		
Sb			4842	2128						2811	4923
Hg	4475	1814	15162	160680	60661	2721	2395	3741		84252	5760
Pb	339405	219107	255396	276105	369069	484382	455058	343365	439326	404618	299294
Si	12240	37250	41778	12373	8627	12851	8349	20061	13277	9906	

Appendix 8

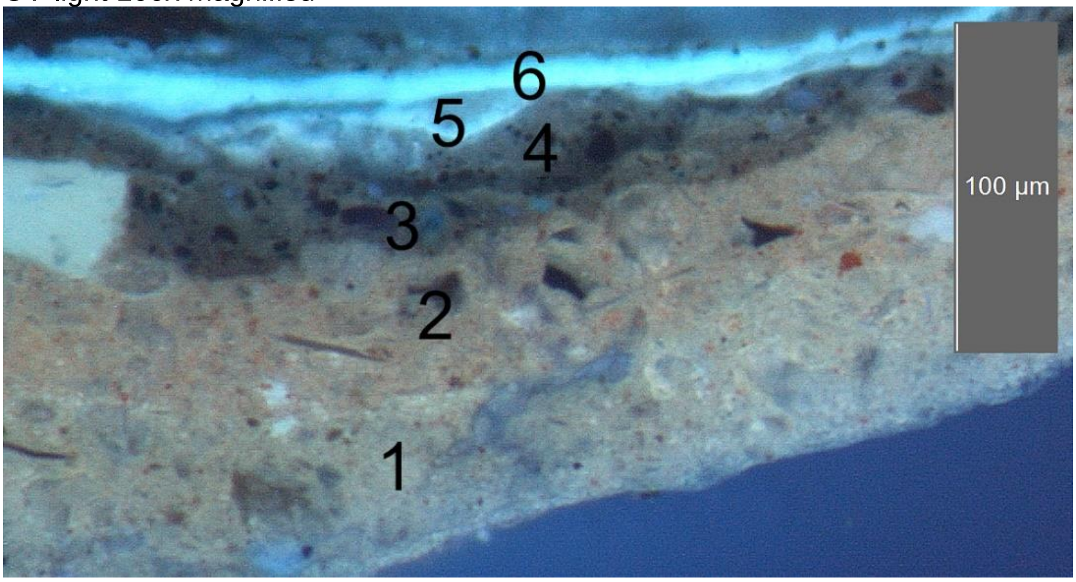
Cross section samples. Samples were photographed using a Leica DMLS light microscope, and Leica DFC 420 microscope camera. All images have been cropped and digitally enhanced for better visibility of layers and particles.

CS 1 Dark brown background bottom right

Visible light 100x magnified



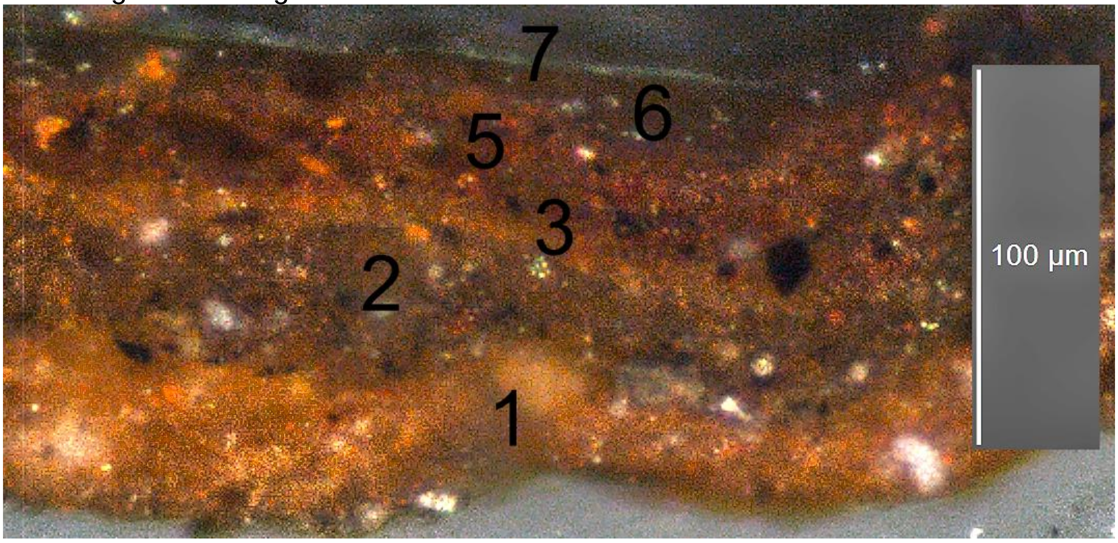
UV-light 100x magnified



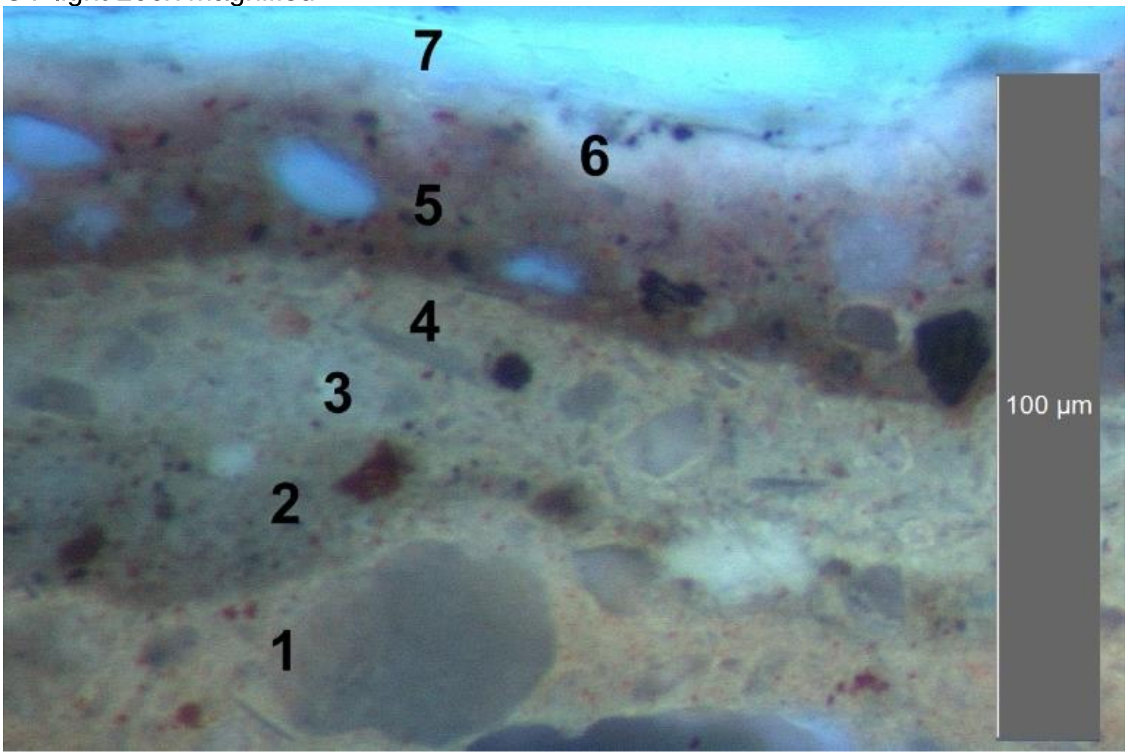
6. Varnish
5. Possibly coloured varnish?
4. Paint layer
3. Paint layer
2. Ground layer
1. Ground layer

CS2 Dark red, Judith's dress, bottom edge

Visible light 100x magnified



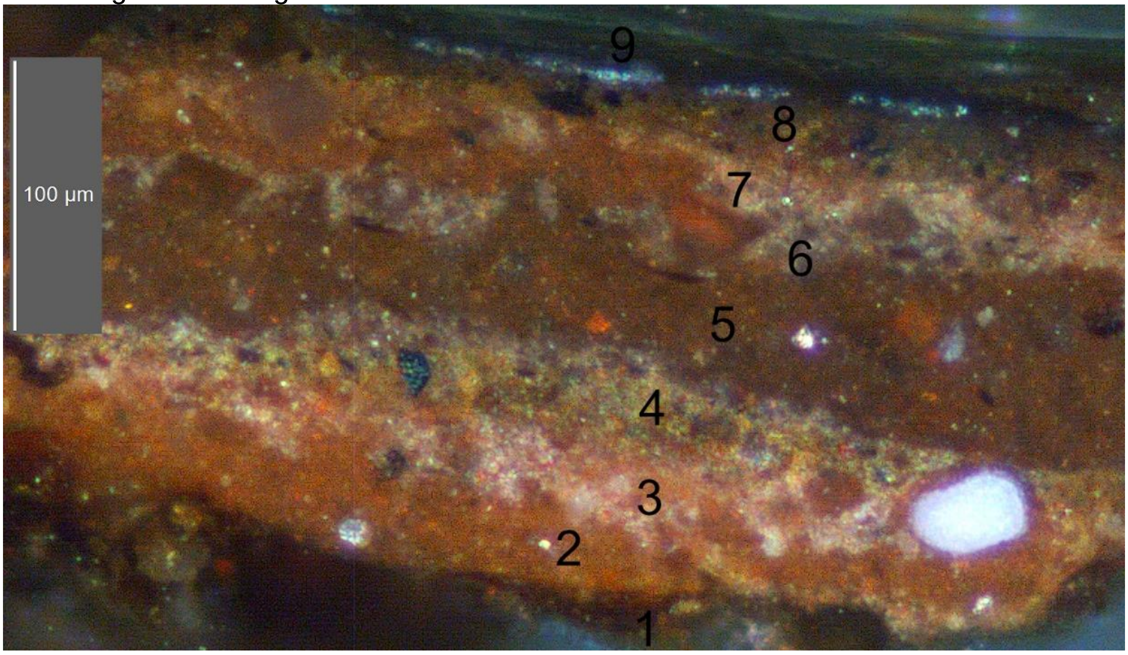
UV-light 200x magnified



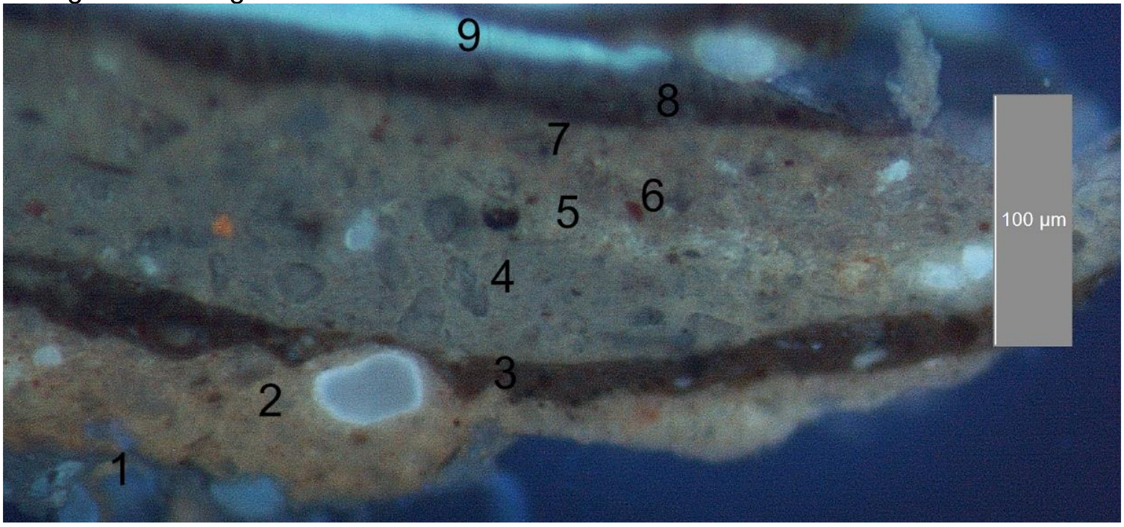
7. Varnish
6. Paint layer, red lake?
5. Paint layer, bright read particles lead red?
4. Paint layer
3. Paint layer
2. Ground layer
1. Ground layer

CS 3 Dark yellow, Abra's dress, bottom edge

Visible light 100x magnified



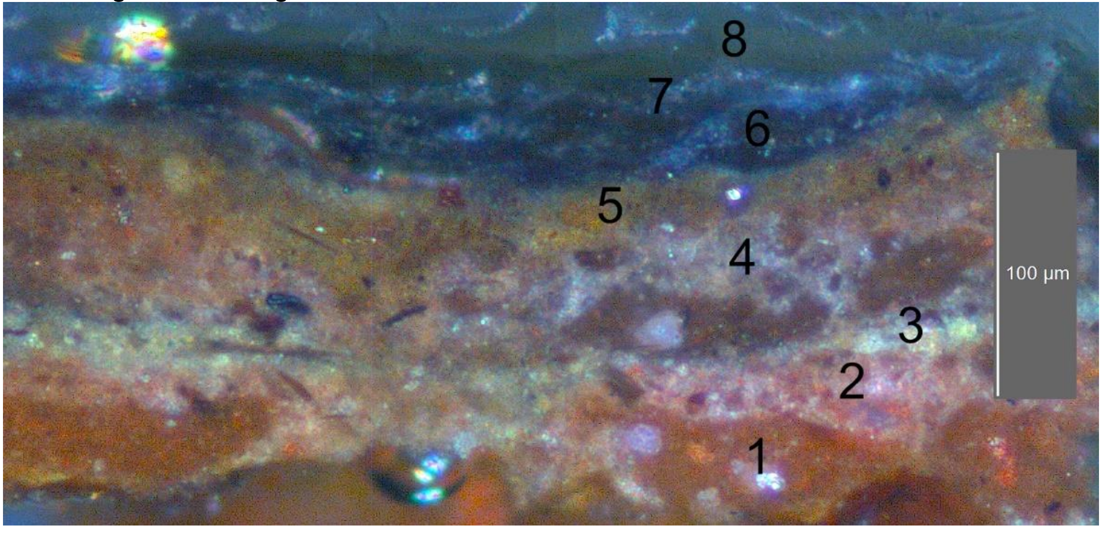
UV-light 100x magnified



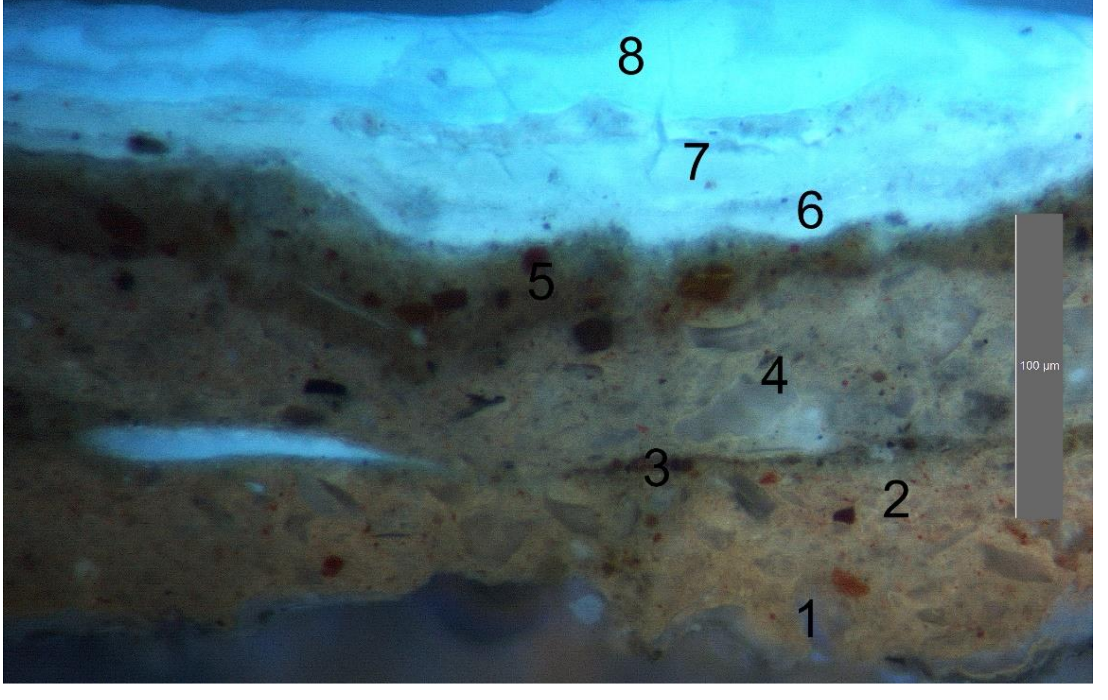
9. Varnish
8. Paint layer, yellow
7. Paint layer, light red
6. Paint layer
5. Paint layer, red brown
4. Paint layer, yellow pigment
3. Ground layer
2. Ground layer
1. Sizing

CS 4 Yellow, Abra's dress

Visible light 100x magnified



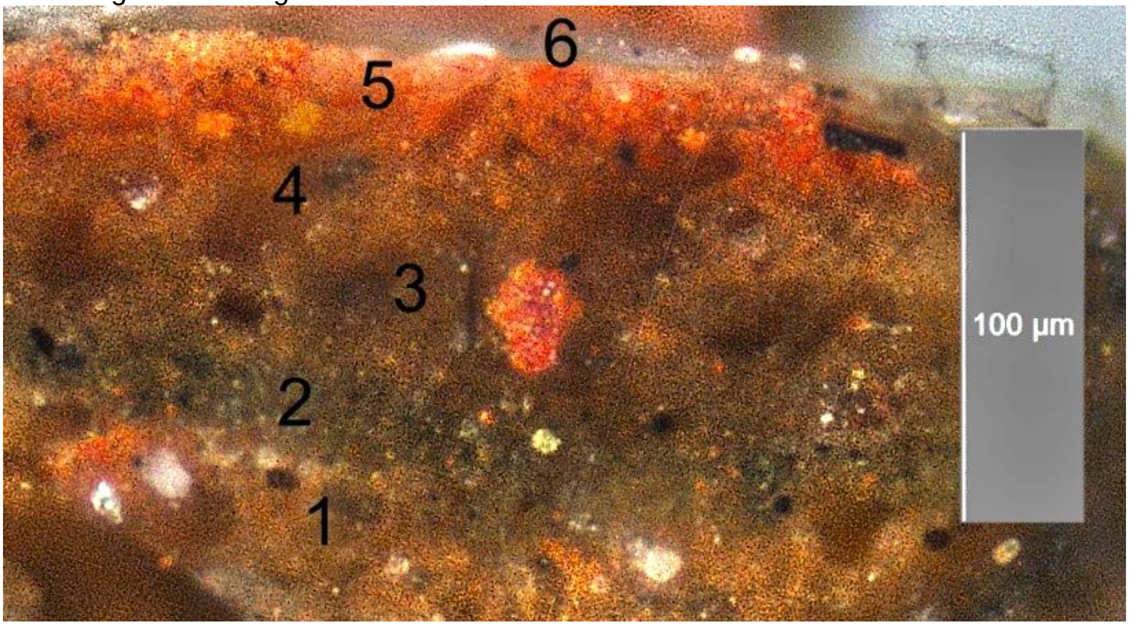
UV-light 200x magnified



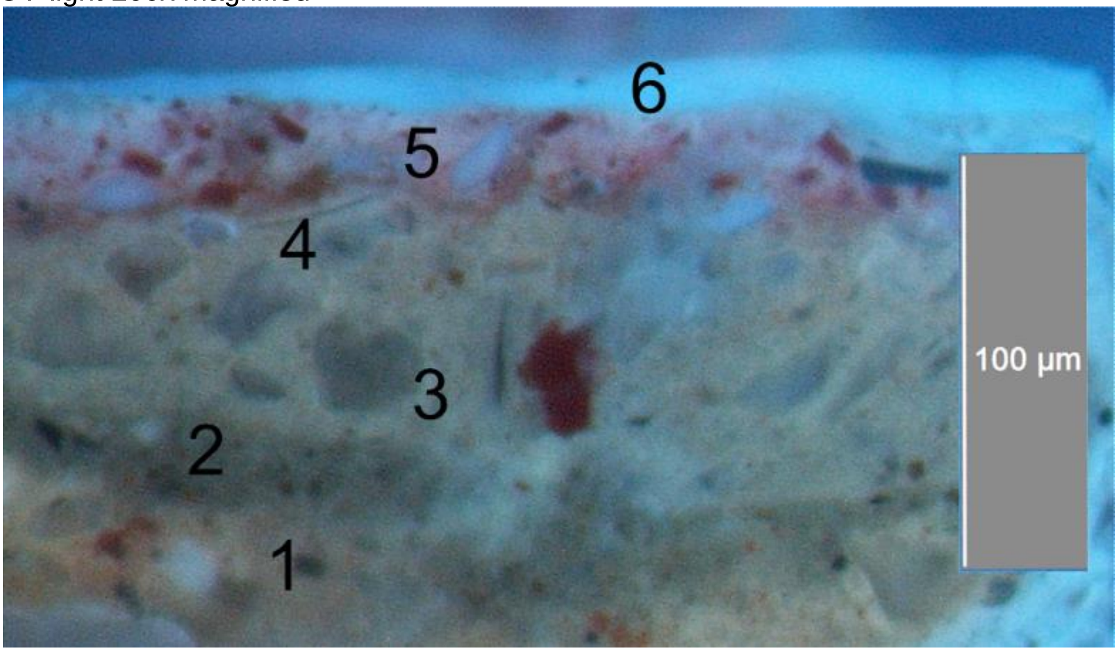
8. Varnish
7. Varnish
6. Varnish
5. Paint layer, yellow
4. Paint or ground?
3. Paint with glue or varnish?
2. Ground
1. Ground

CS 5 Red, Judith's dress

Visible light 100x magnified



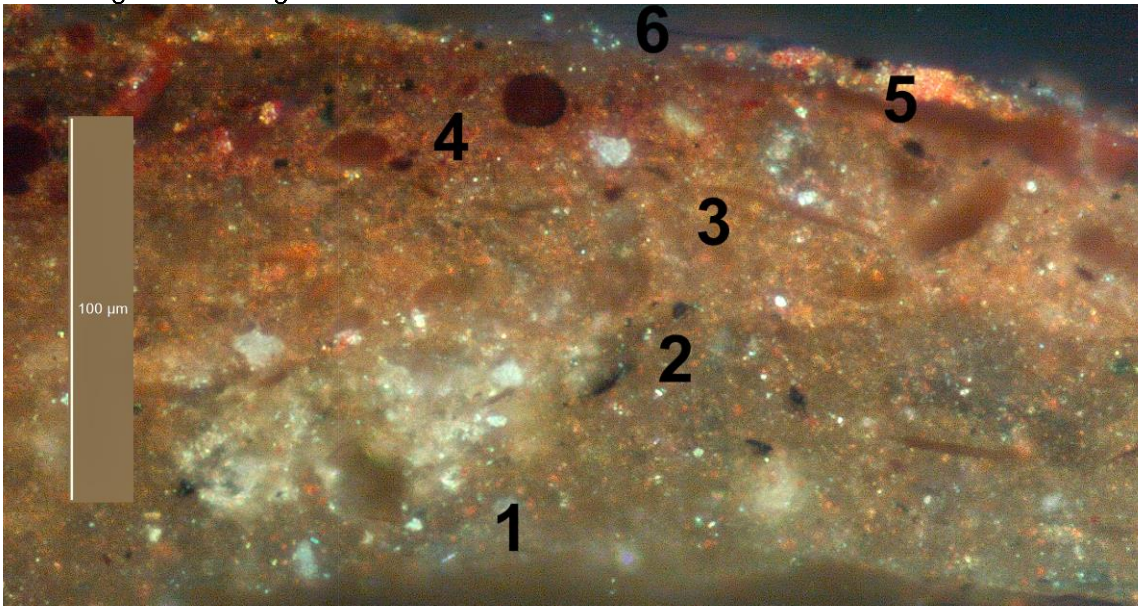
UV-light 200x magnified



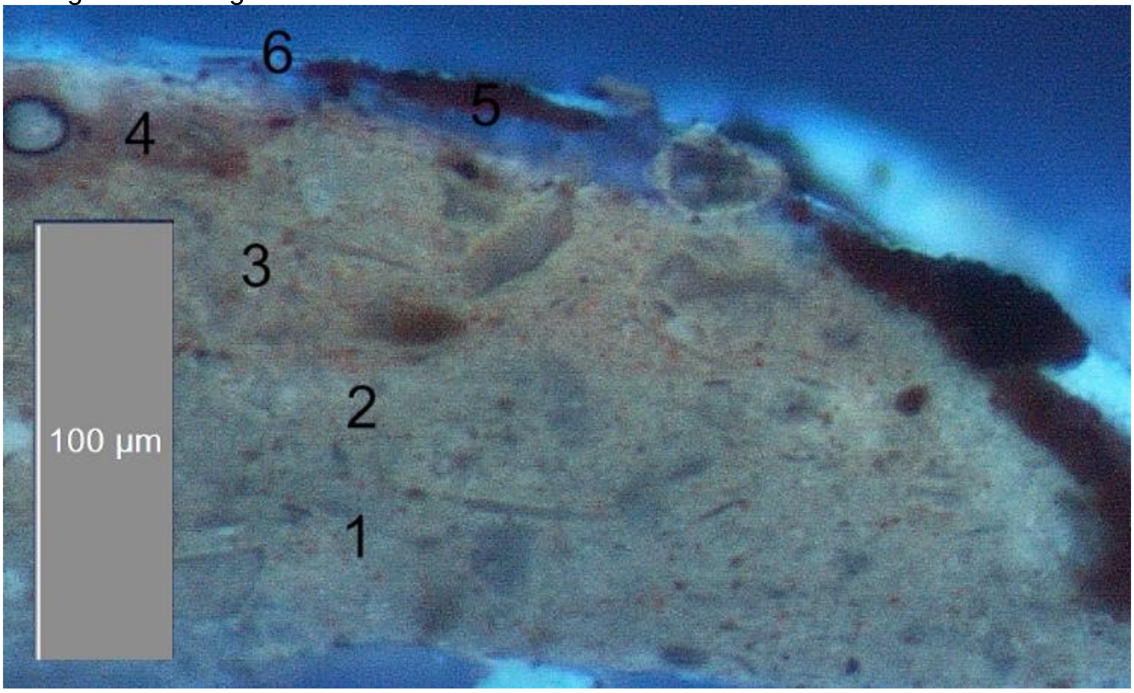
6. Varnish
5. Paint layer bright red, lead read and organic pigments?
4.-3. Paint layers or paint and ground
2. Ground
1. Ground

CS 6 Red, Judith's dress from under Abra's arm

Visible light 200x magnified



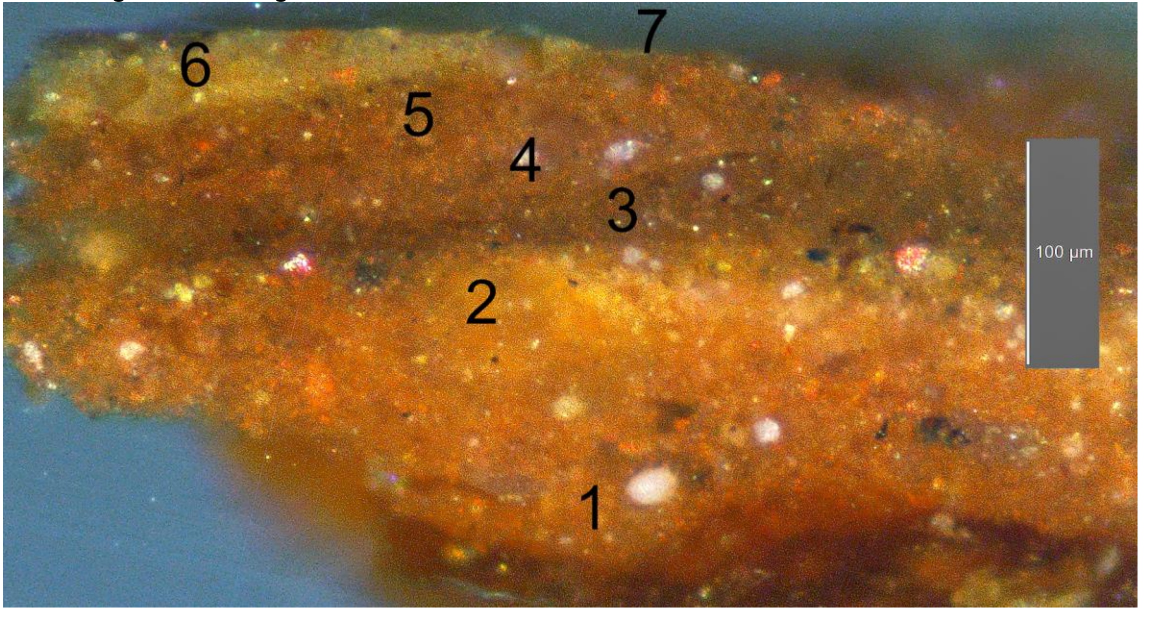
UV-light 100x magnified



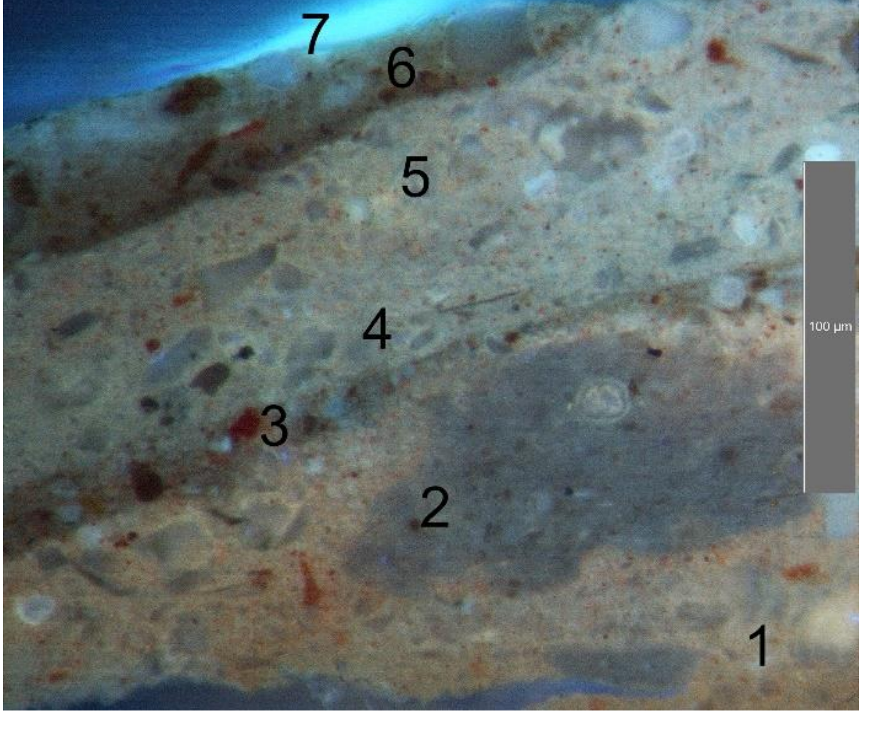
6. Varnish
5. Paint layer, dark red
4. Paint layer, red
3. Paint layer
2. Ground
1. Ground

CS 7 Bright yellow, Abra's dress

Visible light 200x magnified



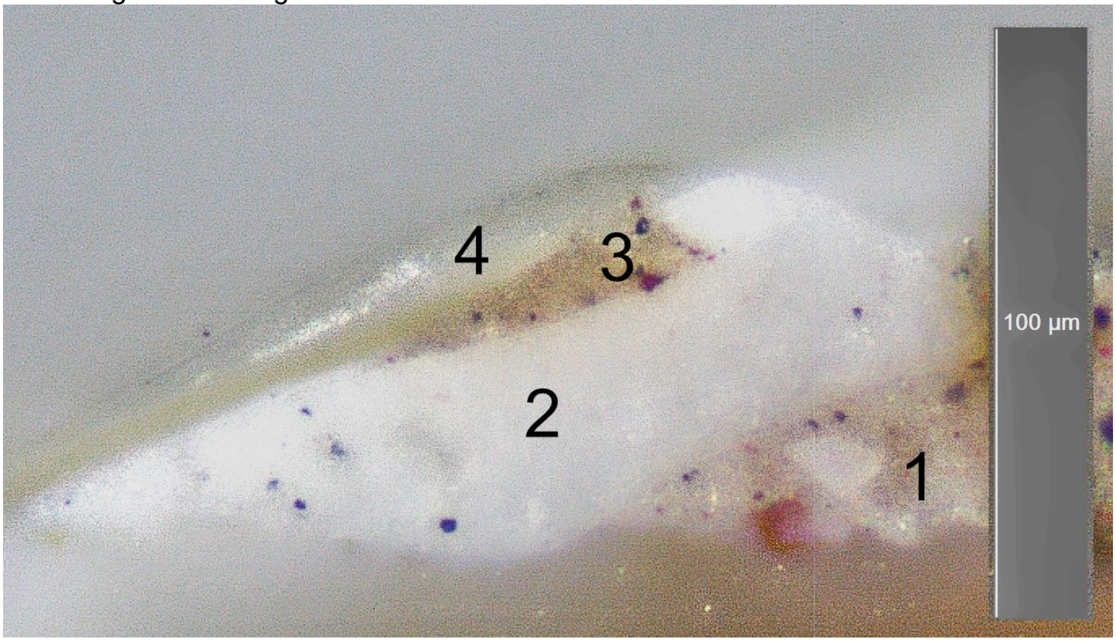
UV-light 200x magnified



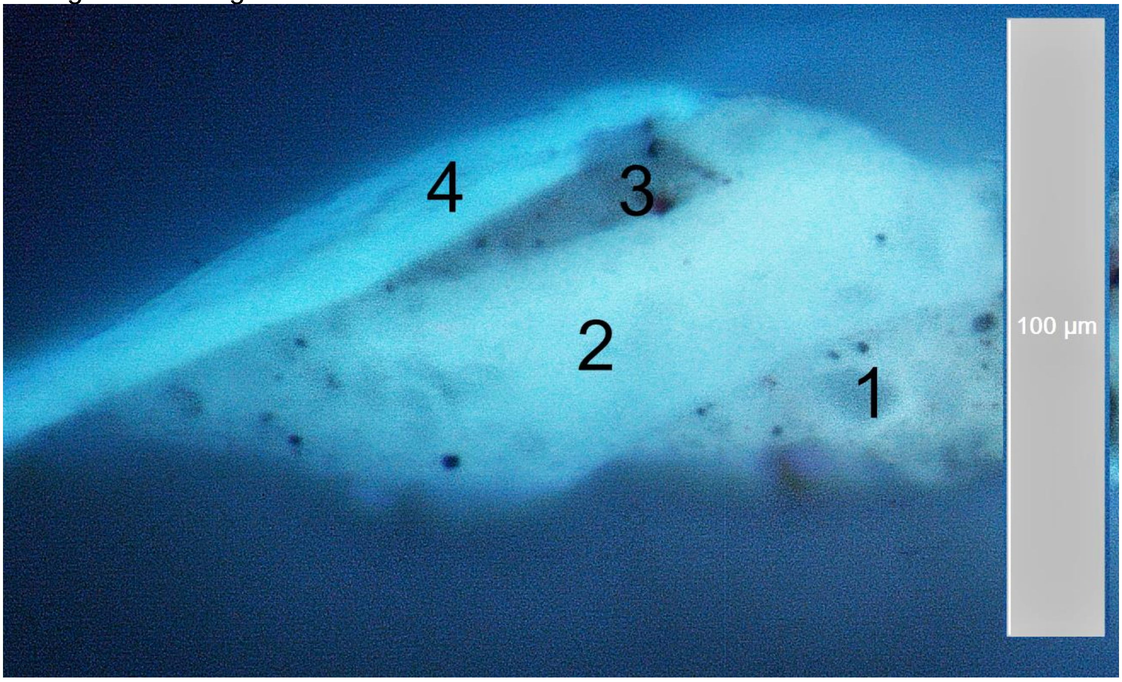
7. Varnish
6. Paint layer, yellow
5. Paint layer, red brown
4. Paint layer, red brown
3. Paint layer, medium brown
2. Ground
1. Ground
Sizing (visible light)

CS 8 White, Judith's shirt sleeve

Visible light 200x magnified



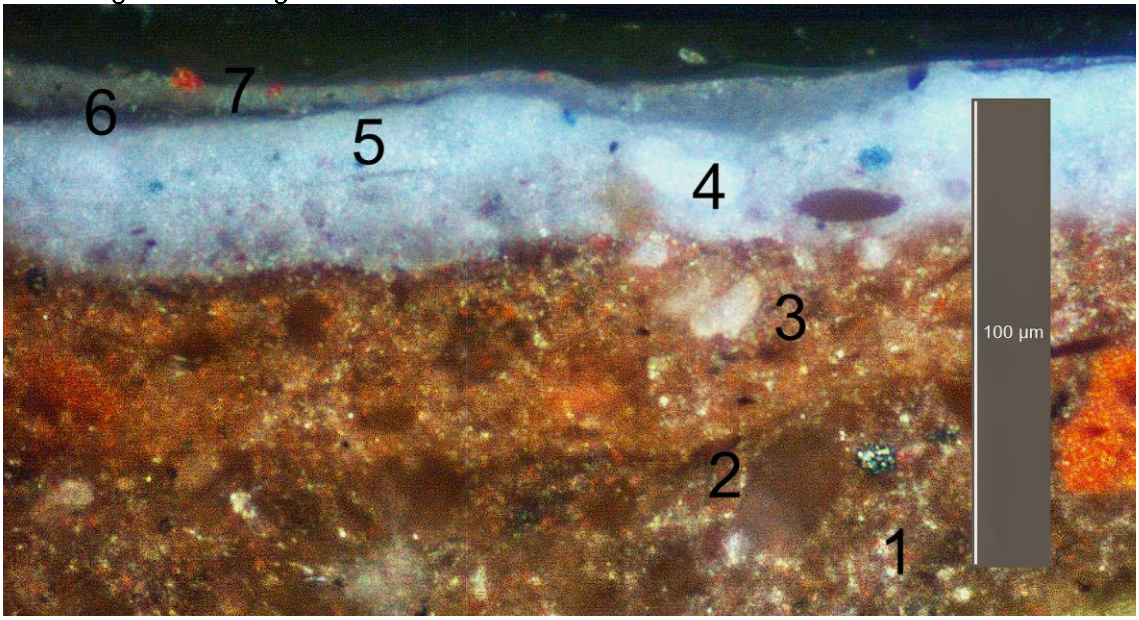
UV-light 200x magnified



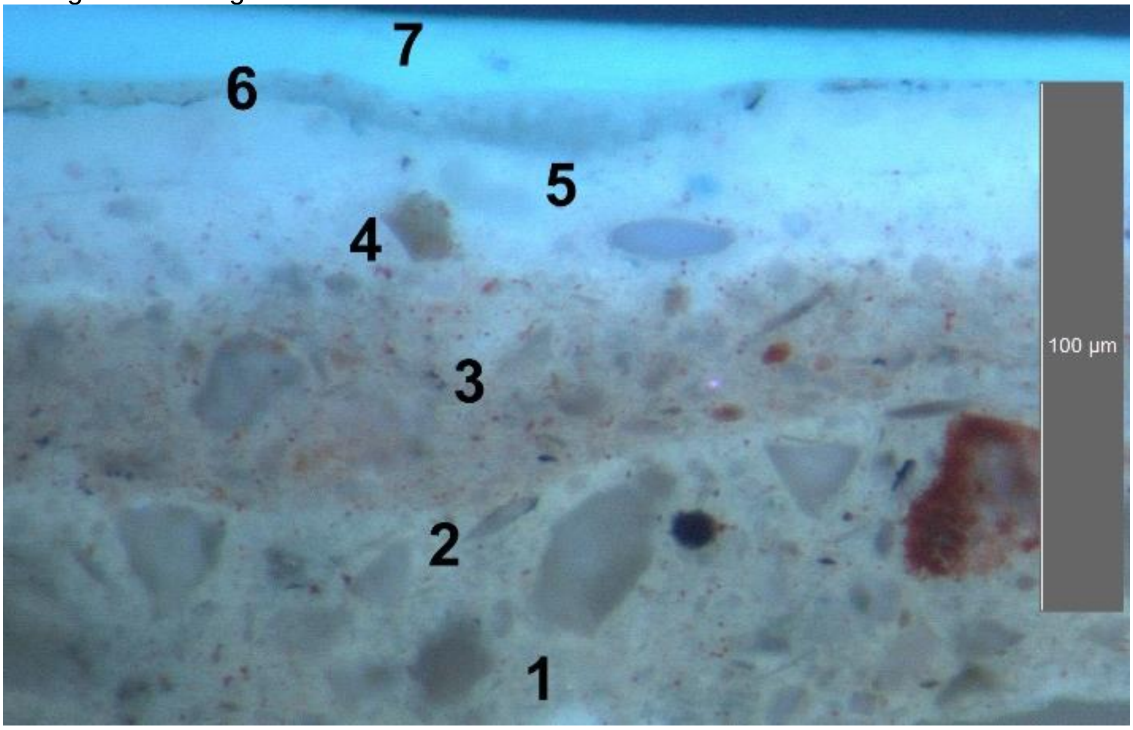
4. Varnish
3. Old oil-resin varnish deposit?
2. Paint layer, white (lead white?)
1. Ground or paint layer

CS 9 Abra's blue sleeve

Visible light 100x magnified



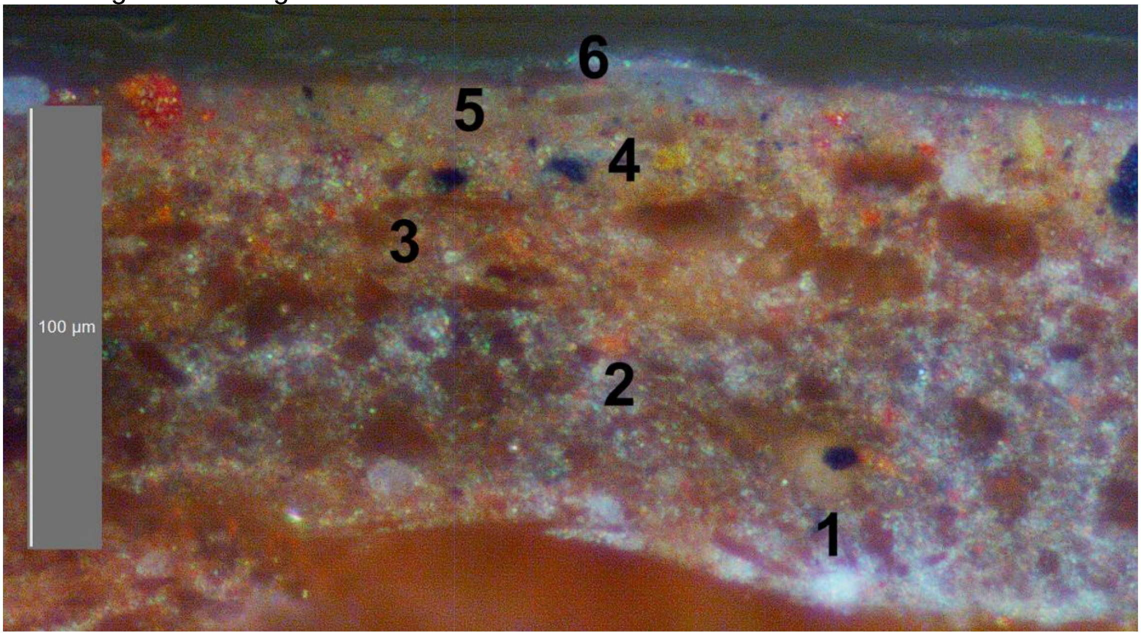
UV-light 200x magnified



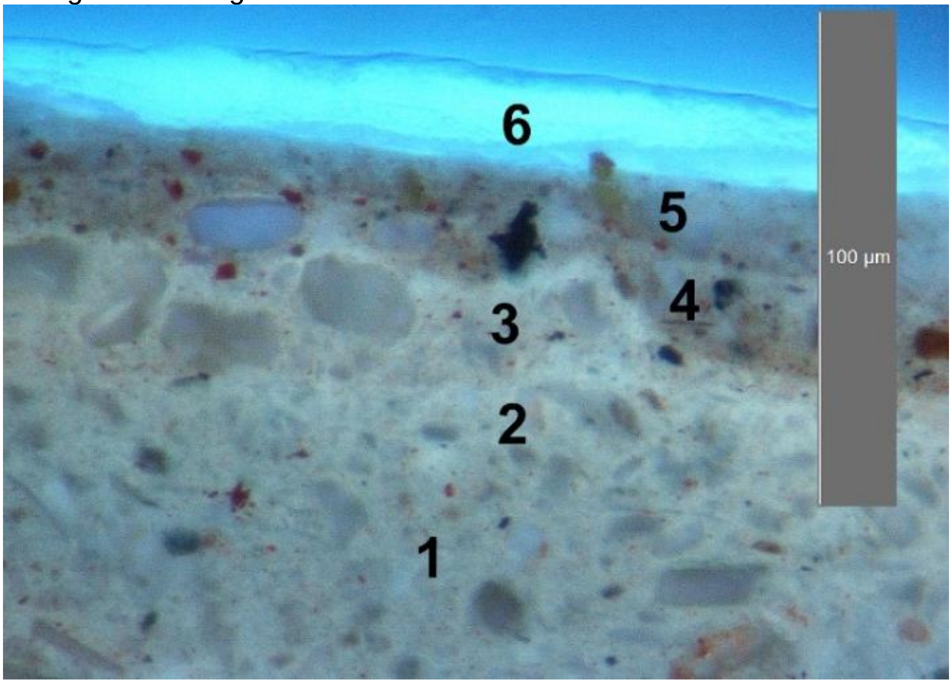
7. Varnish
6. Paint layer, blue
5. Paint layer, white with blue particles
4. Paint layer, light blue, purple particles
3. Paint layer
2. Ground
1. Ground

CS 10 Judith's face

Visible light 200x magnified



UV-light 200x magnified



6. Varnish
5. Paint layer
4. Paint layer
3. Paint layer
2. Ground
1. Ground
Sizing (visible light)