ANALYTICAL REPORT

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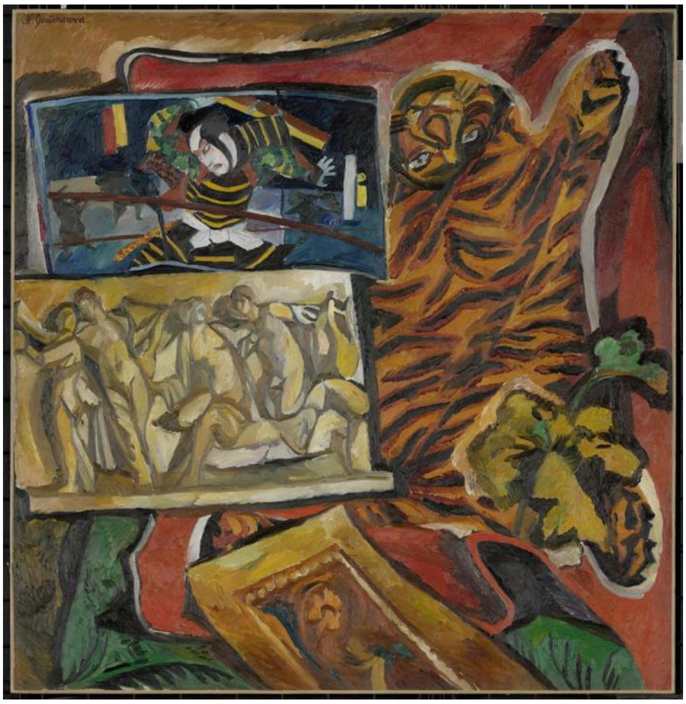

Still Life with Tiger Skin, 1908
Natalia Goncharova
Collection Museum Ludwig, Cologne, Inv. ML 1305

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Summary

A painting on canvas by Natalia Goncharova, *Still Life with Tiger Skin*, with a proposed date of creation of 1908 (it is signed but undated), belonging to the Museum Ludwig (ML 1305) was examined and analysed by Art Analysis & Research, Ltd. in cooperation with the Museum, and funded through a grant from the charity The Russian Avant Garde Research Project (RARP). This artwork was assessed as part of a group of fourteen well-provenanced paintings by the Russian artist couple Goncharova and Mikhail Larionov, held in the collection of the Museum Ludwig. The goal set for this research was to investigate these paintings in order to characterise similarities and differences, with the goals of 1) providing detailed studies of specific paintings, 2) providing wider information on the artists' methods, 3) defining a blueprint for promising methodologies to develop further on other works by these artists and applying such information in support of a *catalogue raisonné*, and 4) creating the foundation for applying similar methodologies and techniques to other artists of the genre. To this end, each of the paintings are described in individual reports (as here) accompanied by a summary report under separate cover. The results of the program of examination, material analysis and technical imaging will be set out herein.

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Contents

Tables, Figures and Plates

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A. Introduction

The painting known as *Still Life with Tiger Skin* (**Plate 1**) by the artist Natalia Goncharova (1881-1962), a work on canvas measuring 1400 mm high by 1365 mm wide, is now part of the collection of the Museum Ludwig, Cologne (Inv. ML 1305). It is signed 'N. Gontcharova' (upper left corner; **Plates 16.a, 16.b**) but is undated; a date of 1908 has been proposed for its creation. It has been examined as part of a larger technical study of fourteen paintings by Goncharova and Mikhail Larionov in the Museum Ludwig, as part of a project funded through a grant from the charity the Russian Avant Garde Research Project (RARP). The project goal has been to generate detailed technical profiles on authentic paintings by Goncharova and Larionov to expand the data available for art historical study and technical characterization of their work[1]; consequently, fourteen well-provenanced paintings by the Russian artist couple held in the collection of the Museum Ludwig were thoroughly examined and analysed[2]. The short-term goal of the project was to define a blueprint for promising routes of research to develop further on other works by these artists and with a long-term goal of contributing such information to support a technical *catalogue raisonné*; these recommendations are laid out in a summary report[3].

The information in this report therefore provides a detailed technical and material account of the painting. In addition, this material is considered in light of the conservation history and provenance information relating to the painting, held by the Museum Ludwig; the supplementary reports produced by Verena Franken in the course of her work on the RARP project summarises this material[4]. Some of the information concerning examination of the paintings has been included here, as relevant, as are a representative selection of the extensive documentation photographs she made.

The structure of this report is as follows. First, the primary findings of the visual examination and technical imaging will be described in **Section B**.

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[1] There is limited specific information available. This includes: Rioux, J.-P.; Aitken, G.; Duval, A. 'Étude en laboratoire des peintures de Gontcharova et Larionov', pp. 220-223. In: *Nathalie Gontcharova, Michel Larionov* [exh. cat.], Éditions du Centre Pompidou: Paris (1995). Rioux, J.-P.; Aitken, G.; Duval, A. 'Matériaux et techniques des peintures de Nathalie S. Gontcharova et Michel F. Larionov du Musée national d'art moderne', *Techne* **8** (1998) 7-32. Gallone, A. 'Œuvres de Michel Larionov et Nathalie Gontcharova: Analyse de la Couleur', *Le dessin sous-jacent la technologie dans la peinture: Colloque XI 14-16 septembre 1995*, R. Van Schoute and H. Verougstraete (eds), Louvain-la-Neuve (1997) pp. 137-141, Pl. 74-76.

[2] These include: Natalia Goncharova: *Paysage de Tiraspol (Tiraspol Landscape)*, 1905, ML 01483; *Rusalka*, 1908, ML 1304; *Still Life with Tiger Skin*, 1908, ML 1305; *The Jewish Family*, 1912, ML 1369; *The Orange Seller*, 1916, ML 1484; *Portrait of Larionov*, 1913, ML 1319.
Mikhail Larionov, *Still Life with Coffee Pot*, c. 1906, ML 01486; *Still Life*, c. 1907/1912, ML 1487; *Still Life with Crayfish (Nature morte à l'écrevisse*), c. 1907, ML 1331; *Portrait of a Man (Anton Beswal)*, c. 1910, ML 1306; *Rayonism, Red and Blue (Beach)*, 1911, ML 1333; *Saucission et maquereau rayonnists (Rayonistic Sausage and Mackerel)*, 1912, ML 1307; *Venus*, 1912, ML 1332; *Rayonistic Composition*, inscribed 1916, ML/Z 211/134.

[3] *Summary Report of the RARP Goncharova/Larionov Project, with the Museum Ludwig,* Art Analysis & Research Inc. (2017).

[4] See reports: *AAR0955.C ML 1305 Conservation*, Franken, V. 'Report on the examination of the painting *Still Life with Tiger Skin* (1908) by Natalia Goncharova' (2017a) and *AAR0955.C ML 1305 Archives*, Franken, V. 'Report on the content of the Museum Ludwig archives, concerning the painting *Still Life with Tiger Skin* (1908) by Natalia Goncharova' (2017b).

Materials analysis on micro-samples taken for pigment and binding medium identification and cross-sections is described in **Section C**.

Inferences drawn regarding the painting on the basis of these investigations will be discussed in **Section D**.

The methodologies and protocols used in each case may be found described in the general **Protocols** supplement, appended to this series of reports.

B. Examination, imaging and analysis of the images

B.1 Methodology

The painting was initially examined visually under normal lighting conditions and with ultraviolet light (UV), then with a stereo binocular microscope.

A range of technical imaging techniques were also employed (**Appendix 3**), generating a variety of images and imaging datasets[5]. These are presented as follows:

- High-resolution visible colour (**Plates 1, 5**);
- UV luminescence (**Plate 2**);
- Oblique illumination (**Plate 3**);
- 3D laser surface scanning (**Plate 4**);
- Short-wave infrared (SWIR), 1600-2500nm (**Plates 6, 7, 8.b**);
- X-radiography (**Plates 9, 10**).

Additionally, weave analysis (including thread counting) was conducted on the basis of the X-radiograph (**Plates 11.a-d**). Some exemplar images recorded as part of the surface microscopy and macrophotography are also reproduced here (**Plates 12-16**).

The imaging revealed a range of aspects regarding the use of materials, structure and technique of production of the painting that are complementary to the visual observations made. Consequently, specific observation will be made to each in this section regarding the interpretation of these specific forms of analysis, while a summary overview in the context of the painting technique is presented in **Section D**, below.

B.2 General observations

The painting is executed on a canvas, which has been lined. Its tacking margins were cut away during this process and the edges finished with paper tape, so that only the recto of the artwork could be studied. Nor is it on its original stretcher, having been re-stretched onto a newer secondary

[5] Additionally, a visible-NIR multispectral dataset was collected to examine its suitability for study of paintings of Goncharova and Larionov. This has not been otherwise reproduced or further analysed here but is available for additional studies in the future.

support, a stretcher with two crossbars and 12 keys (**Plate 5**). The painting is in good condition in so far that much of its original surface is preserved; however, its state is fragile, as the paint layers are prone to brittle cracking and are in part poorly adhered to the ground. There is a good deal of localised retouching and consolidation due to cracking and brittleness in the paint film (**Plates 9.a, 9.b**). It is inscribed 'N. Gontcharova.' along the upper left edge (**Plates 16.a, 16.b**). The painting is not varnished.

B.3 Imaging

Each form of imaging offers different types of insight into the various material aspects of the painting. The most relevant are introduced, in brief, here.

B.3.i Photography with ultraviolet illumination

Excitation by ultraviolet (UV) light can induce luminescence[6] in some materials, commonly seen as a weak re-emission of light in the visible region. Many natural varnishes have this property, emitting a characteristic weak greenish luminescence. While some pigments (notably zinc white and certain 'lake' pigments) are also active in this way, paints otherwise often do not luminesce. Because of the luminescence of varnishes, which are typically applied as a continuous coating across the surface of a painting, this can provide a means of determining if any disturbance has occurred, such as partial cleaning of the surface or addition of later restoration, where the changes show in contrast to the luminescent areas. Consequently, UV light is commonly used to reveal the presence of retouching. When paintings are not varnished, as is the case here, differences between the colour of the luminescence of the different paints and any added retouching paints may also indicate later stages of intervention (as here; **Protocol 3.2** and **Plate 2**).

In the UV image of this work, no evidence for a varnish is visible. Of the pigments present, a red lake is seen to have a very bright, orange luminescence; this is found, for example, along the right side of the nose, and the two bars to the left of the samurai. This is not an original pigment, but a modern retouching paint. The red to the right edge, above the green leaf, is likewise of a more brilliant hue than the surrounding paint. In other instances, the retouching paint tends to image more darkly than the original paint, such as along the edges and in localised areas. Such regions may be detected through their different colour in relation surrounding paint (for example, retouching along the upper edge, to the right, especially in the upper right corner, is quite dark). Some of the material used for consolidation has a whiteish fluorescence.

B.3.ii Surface conformation

[6] Commonly referred to as 'UV fluorescence', the word *luminescence* is used here as a broader term that may encompass not only fluorescence phenomena (prompt re-emission of light), but also phosphorescence (slow re-emission of light due to transition via forbidden quantum states). In both cases emission is typically at longer wavelengths than the excitation; here, the excitation is in the UV to blue part of the spectrum (hence 'UV'; in practice, so-called UV-A) and emission in the visible region.

Two techniques for examination of the surface structure of the painting were used: photography under oblique illumination and 3D laser scanning. While the former may be the more familiar of the two as a physical examination technique, both essentially provide a means of elucidating paint texture and object deformations, either by recording shadowing, or through direct measurement of surface height. Of the two, 3D laser scanning offers important advantages in terms of being more replicable in the future (to support longer-term conservation assessments for example) and as a numerical dataset that can be studied visually and algorithmically for diagnostic features of technique. Imaging of the painting using oblique illumination, as well as 3D laser surface scanning (see **Protocol 3.3**), served to reveal two kinds of textural features that are particularly evident in this painting.

The 3D imaging must be considered in the context of the conservation treatment of the painting, which has been lined. Consequently, original features relating to stresses in the canvas due to stretching on the original secondary support and subtle differences due to the thickness of the paint layers have been flattened and regularised. A number of features may be specifically highlighted (see especially **Plate 4.b**):

- The areas of impasto do not seem to have been significantly affected by the lining; there is excellent surface detail preserved across the painting.
- The texture of the ground is significant enough to be visible in the 3D imaging, when the paint has been applied thinly.
- Equally, the degree of the cracking is significant enough that this also shows clearly in the 3D imaging.
- The painting has been worked with high impasto across the whole of the canvas, providing a very graphic 3D rendition of Goncharova's brushwork.

B.3.iii Short-wave infrared (SWIR)

The interest in technologies capable of imaging artworks past the red end of the visible spectrum, in the 'near' ('NIR') or short-wave ('SWIR') infrared regions, has primarily developed out of the long-standing application to reflectography, exploiting the phenomenon of variable transparency of paint films at different wavelengths to enable visualisation of features lying beneath the surface. Imaging of underdrawing has been a major contribution to the study of authorship in paintings, permitting a fuller comprehension of artists' working practices and extending the evidence used in attribution questions. Practical experience (as well as theoretical consideration) has shown that deeper IR cameras can confer additional benefits in terms of penetration to underlying layers; consequently, a system capable of operating in the SWIR region was used here (see **Protocol 3.4**).

Due to the fragmentary aspect of the underdrawing, in charcoal, only small glimpses of this preparatory stage could be resolved in the SWIR (**Plates 6, 7, 8**) though a general presence of charcoal fragments was observed over the painting when examined with magnification (**Plates 13.a-c, 14.a**). In the comparative images shown in **Plate 8**, it is clear that the IR does not penetrate the thick paint layers, but does resolve between the different layers of black material present on the exposed ground. The reason for the lack of penetration of the IR lies in a number of factors, probably a combination of the thin and diffuse distribution of the material and the IR blocking properties of the thick overlying layers of paint

B.3.iv X-radiography and weave analysis

X-radiography shows internal structures in paintings because the transmitted X-rays are blocked to different degrees by virtue of the inherent absorption and thickness variations of the constituent materials. For example, pigments based on lead (such as 'lead white') stop the passage of X-rays more effectively than materials based on organic compounds (such as carbon blacks or the binding medium of the paint), while a thicker application of a material will block more than a thinner one. This allows visualisation of sub-surface features, such as abandoned or altered earlier phases (*pentimenti*), use of techniques such as superimposed forms as opposed to forms left in reserve, characteristic brushwork and so forth.

Here, the prepared surface of the canvas is largely covered by the application of paint, which extends to the tacking margins, although small areas of ground are visible throughout the painting where forms abut. Consequently, the X-ray (**Protocol 3.6**; **Plates 9, 10**) reveals a very direct rendition of form, with areas painted in reserve imaging brightly (where they block the passage of X-ray energy), and areas immediately around many of these forms appearing dark. The dark areas in the X-ray corresponding to the thinly primed areas of canvas that were left visible (i.e. unpainted; these are more X-ray transparent than heavily worked regions). As a very thick application of paint is used in many areas, this painting provides a particularly vivid example of Goncharova's energetic and spontaneous brushwork. As in many of her canvases, there is no evidence of pentimenti; rather, the underdrawing lays in the forms, which are then rendered in paint, without further adjustment.

Infilling of the interstices of the threads comprising the canvas support with the priming (ground) and paint also allows the canvas weave to be visualised in the X-ray. Even if a painting is lined, making direct access to the original canvas difficult or impossible, X-ray images can permit the primary weave structure to be examined in detail. A common characterisation of canvases (apart from weave type) is the 'thread count', or number of threads per unit in warp and weft directions. Conventionally determined by hand-measuring a number of representative areas, this is now done by applying an image processing algorithm to the entire X-ray image, which has the benefit of providing both greatly enhanced determination of thread counts as well as density and thread orientation information across the whole painting (see **Protocol 3.7**; **Plates 11.a-c**). In this case, due to a combination of the thickness of the paint layers in which the composition is worked and the limitations of the resolution of the X-ray system used, the imaging was not sufficient to allow for resolution of the weave type or the thread count with high certainty.

The canvas appears to be a plain weave with a thread count determined at 9.3 threads per centimetre in the vertical direction and 8.9 in the horizontal although again, given the poor resolution of the weave in the X-ray, these findings are tentatively stated. The well-distributed and even cusping distortion at the left edge of the canvas only suggests that the format of the work has likely been trimmed or cut down somewhat along the other three sides (**Plate 9.a**).

C. Sampling and analysis

C.1 Introduction

Samples were taken of the support, ground preparation, paint and varnish layers of the work for analysis by different means in order to determine the range of materials (canvas, pigments, binders and coatings) used in the painting, the nature of the preparation layer and the sequence of layering employed in building up the painting.

To this end, a series of 16 locations selected over a representative range of the painting were micro-sampled for identification of the pigments (**Table App.2.i, Plate 17**), with six micro-samples of paint taken for analysis of the binding media (**Tables App.2.ii-2.iii**). Two further samples were taken for preparation as cross-sections to study the layering in the selected areas, with the aim of elucidating the development of the painting (**Plates 18, 19**). As the painting is lined and the tacking edges removed and taped over, canvas threads could not be taken for fibre identification and radiocarbon dating.

Micro-samples for analysis were taken from locations that were adjudged to be original (that is, were clearly contiguous with those below and adjacent to them, and not retouching or repair). Locations were also further selected to represent as wide a range of the colours – and therefore probably pigments and media – as possible. Thus, the materials identified and discussed below therefore represent, as far as can be determined, the full extent of the original palette used by the artist.

The micro-samples taken for pigment characterisation were subjected to systematic analysis by polarised light microscopy (PLM) combined with UV-visible-near infrared micro-spectrophotometry, scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDX), Raman microscopy (**Table App.2.i, Protocols 2.1, 2.2, 2.3**) and some Fourier Transform Infrared Spectroscopy-Attenuated Total Reflectance (FTIR; **Table App.2.ii, Protocol 2.4.1**).

Organic components were identified by FTIR (**Table App.2.ii**; **Protocol 2.4.1**) and subsequently by Gas Chromatography-Mass Spectrometry (GCMS; **Table App.2.iii**; **Protocol 2.5**).

All of the analytical techniques applied are standard methods within the field, capable of allowing the kinds of differentiation required for this type of work. Comparison was also made between samples from the painting and examples of similar pigments from a large collection of reference standards previously analysed by multiple means[7]. Certain differentiations cannot necessarily be made from this range of techniques, although for present purposes the level of discrimination is thought to be largely or wholly sufficient. All materials were generally identified through a

[7] The pigment reference collection belongs to the Pigmentum Project (see: http://pigmentum.org) and runs to around 3500 samples of both historical and modern origin. Analysis of this collection includes PLM and SEM-EDX as well as other techniques such as X-ray diffraction and Raman microscopy. Access to this research collection is gratefully acknowledged. Reference to specific specimens in the text of this report is to the Pigmentum collection number [Pxxxx]. An organic binding media reference collection is also held by AA&R; samples in this set are cited as [AARxxx].

combination of the techniques applied; however, certain key diagnostic features were specifically determined through one or other method.

C.2 Support

Because the canvas could not be sampled, the fibre type could not be identified.

C.3 Radiocarbon dating

Because the canvas could not be sampled, radiocarbon dating could not be conducted.

C.4 Ground

The **ground** (Sample [1]) was found to be composed of lead carbonate hydroxide and lead(II) carbonate (**Table App.2.i**). A linseed oil binder was identified with FTIR and GCMS (**Table Apps.2.ii-iii**). The extremely lumpy appearance of the ground may be due in part to the formation of lead-based soaps, but such formation is not consistent throughout the layer (as seen in the cross-sections, which reveal the presence of somewhat coarse lead white, but no obvious soap formation **Plates 18, 19**).

C.5 Underdrawing

The composition was apparently sketched in with charcoal (as seen in cross-section of Sample [10], **Plate 20**; also **Plate 14.a**). Further details appear to have been laid in with a dilute paint comprised of bone black (Sample [14], **Table App.2.i**, **Plate 8**).

C.6 Paint layers: Pigments

The following **pigments** (**Tables App.2.i, App.2.ii**) were identified in the paint:

- Zinc oxide (‘zinc white’)
- Barium sulfate (as a minor phase in the zinc white)
- Lead chromate (‘chrome yellow’)
- Cadmium sulfide (‘cadmium yellow’)
- A yellow earth containing goethite (‘yellow ochre’)
- Mercury(II) sulfide (‘vermilion’ red)
- A red earth containing hematite
- A red lake pigment (dyestuff and substrate not further characterised, possibly a natural dyestuff)
- Chromium oxide green with chromium borate (‘viridian’)
- Iron hexacyanoferrate(II) (‘Prussian blue’)
- Ultramarine, synthetic, blue
- Iron-containing brown earth
- A carbon-based black, probably a bone coke (‘bone’ or ‘ivory’ black)

C.7 Paint layers: Binding media

All samples, including both ground and paint layers, indicated the presence of a drying oil (**Tables App.2.ii, 2.iii**).

Sample [2], a white paint, and sample [3], a yellow paint, contain walnut oil or a mixture of linseed and poppy oil; other possibilities for identification would be non-traditional oils such as safflower or soybean oil, although this is not likely to be the case in an early 20th century paint. Sample [10], a bright blue paint, contained linseed oil.

Additionally, FTIR of sample [3] also indicated the apparent presence of shellac (resin produced by the insect *Kerria lacca*). There are several possible reasons for its presence, including that it represents traces of an earlier varnish not otherwise now extant on the painting, or was an accidental or deliberate admixture to the paint. However, shellac has not been identified in any other sample either on this painting, or those forming the larger study of Goncharova and Larionov's works of which this forms a part.

FTIR also indicated the presence of metal soaps, probably of lead and zinc, assumed to be reaction products between pigments and binding medium.

C.8 Stratigraphy

The preparation of cross-sections allowed for examination of the overall stratigraphy and composition of the priming and paint layers.

Sample [1] has a white ground layer covered with a red-orange paint in which some larger red particles are visible, with an occasional black particle. Sample [10], a bright blue, also contains the white ground layer, over which are numerous black splinter-shaped particles, indicating charcoal underdrawing; some of these particles can also be seen at the top of the blue paint layer, where they have been caught up in the paint, and moved from their original location on the prepared canvas. The stratigraphy is otherwise uncomplicated.

D. Discussion of the findings

D.1 Support, ground and preparatory work

D.1.i The support

The painting has been executed on a what appears to be a plain-weave canvas (**App.2.v, Plate 10**; no fibre sample was available for analysis) with thread counts tentatively measured (due to insufficient resolution in the X-ray taken from the painting) at 9.3 per cm in the vertical direction and 8.9 per cm in the horizontal direction, although this would indicate an exceptionally coarse or open weave (see **Plate 9** and discussion **Section B.3.iv**, above).

The canvas is fully lined (**Plate 5**). It is affixed to a later (non-original) stretcher with both horizontal and vertical cross bars and 12 keys. As noted, tacking margins have been removed in the lining process, and the edges of the painting finished with brown paper tape (**Plates 5, 16**). As a result of the lining, the base of the painting is quite flat and planar, despite the very thick application of paint it bears. Given the heavy application of paint, the opaque white ground and the presence of paper tape around all of the turnover edges, it was not possible to find an area of exposed canvas to examine.

The incidence of cusping (deformations in the canvas created when it is stretched) is usually captured in the digital images created by measuring the variation in canvas thread angle (**Plate 11.a**). However, due to the poor resolution of the X-ray, the thread counts could not be resolved with certainty, nor could the thread angles. As the painting has been fully lined and placed on a new stretcher, no evidence for any original inscriptions or labels present on the verso of the canvas survive; those which are present are of a later date[8].

D.1.ii Priming

The canvas has been primed with a white ground layer, presumably applied to the stretched canvas by hand as industrially prepared canvases as a rule have much smoother, more even primings (**Plates 12, 13**). Equally, given the proposed date of 1908, this is consistent with what is known of Goncharova's technical practice, it would be expected that the canvas was prepared by the artist, not bought ready primed[9]. Its application is rather thin but it presents an opaque layer and fills the interstices, apparently covering the canvas fully. This is evidenced in the cross-sections prepared from samples of the painting; in Sample [1] especially, the uneven nature of this layer is clearly seen (**Plates 18, 19**). The thickness of the white ground is proportionally much thinner than that of the overlying paint layers, even where it is at its thickest.

The ground is composed of a very pure lead white (with only trace amounts of clay minerals noted) bound in linseed oil (**Tables App.2.i, App.2.ii, App.2.iii**). No evidence for an isolation layer (a glue or oil sealant applied to the canvas before the priming) was noted in the cross-section, though this does not mean that one was not applied. The use of a textured, self-prepared lead white ground has not often been noted in Goncharova's oeuvre; she and Larionov generally used zinc white[10]. However, other examples do exist, such as *Landscape at Tiraspol*, also in the Museum Ludwig collection, likewise with an early supposed date (1905) prior to 1910. Although the grounds of *Still Life with Tiger Skin* and *Tiraspol* present a similar surface texture, the nature of the lead white used in these two paintings is of a very different nature when examined in cross-section. Thus, we may conclude that at more than one occasion, Goncharova used a coarse, low grade lead white bound in oil to prime her canvases.

[8] These are described in more detail in Franken (2017a) *op. cit.*
[9] See Rioux, Aitken and Duval (1998) *op. cit.* p. 18.
[10] *Ibid.*

D.1.iii Underdrawing

Examination of the painting under magnification revealed the presence of powdery black material along the outlines of the forms of the composition (**Plates 13, 14.a**). This material was judged likely to represent remains of the artist's preparatory drawing and a sample was taken for analysis - Sample [14] (**Table App.2.i**) – which was found to be charcoal. As charcoal is a friable, dry material, unlike paint, it does not have the advantage of a liquid medium to assist in adhering it to the surface. Consequently, the particles are held in place only tenuously; often it may be seen that they have been dragged into the paint as it was applied: see cross section Sample [10] (**Plate 19;** also **Plate 14.a**), in which large black particles are visible both at the interface with the white ground, and at the top of the paint layer where they have been dragged along with the paint. As this material is so friable, it is difficult to interpret the visible remains of underdrawing found on the painting. Examination of the painting with magnification suggests that perhaps a second stage in the laying in process involved the use of a dilute, finely particulate black paint; marks that may be thin, diffuse brush strokes may also be observed in the gaps in the paint where the preparation is exposed (**Plate 13.a**). Analysis of a sample taken from such material (Sample [14], **Table App.2.i**) identified the use of a dilute paint consisting of finely particulate bone black.
Despite the known presence of an underdrawing and the use of high intensity short-wave IR imaging (SWIR) the underdrawing was not resolved in the IR image (**Plates 6, 7**). This phenomenon has been observed with increasing frequency in recent years as more and more late 19th and early 20th century paintings are studied with imaging techniques previously applied primarily to Old Masters. Careful study of such paintings, combined with IR imaging, has documented the common use of underdrawings in the works of many painters where they had not formerly been recognised; equally, these underdrawings, due to their friable nature (thus, easily disrupted and dragged by the paint when applied) and the nature of early 20th century paint (often based on heavy metals and applied very thickly), have been shown not to resolve in most infrared images[11]. The use of underdrawing in *Still Life with Tiger Skin*, likewise, does not resolve clearly in infrared imaging; only small passages may be seen (**Plate 8**).

D.2 Paint, pigments and binding media

D.2.i General observations

The preservation of the original surface of the painting is generally quite good, although there is minor loss and flaking, (some retouching visible in the UV image: **Plate 2**; loss visible as darker areas in the X-ray, **Plate 9.a**, supported by the mapping of retouching, **Plate 9.b**) and the paint film is quite fragile (**Plates 4.b, 14.c**). As noted above, the paint is poorly adhered to the ground and the painting has been lined and mounted on a new stretcher; due to the difficulty in assessing the thread density and due to the lack of access to the tacking margins, it is not possible to assess to what degree the work retains its original format. On the right and left sides, the brush strokes are cut off by the paper tape, whereas along a large portion of the

[11] This fact was first widely noted in the literature during the investigation of Impressionist paintings in the Wallraf Richartz Museum, Cologne, in 2010, during the course of the investigations for the exhibition *Impressionism: Painting in Light*. The phenomenon of friable underdrawing that does not resolve in IR images was observed in Monet's works.

upper edge, especially to the right, the paint surface has been lost and to a somewhat lesser degree, along the bottom edge to the right side.

The painting is signed in a deep purple brown tone, on the upper left corner (**Plates 16.a, 16.b**). The signature was applied after the underlying yellow brown paint of the background was substantially dried, as the inscription does not disrupt the underlying structure of the brush strokes.

The use of an underdrawing allowed the artist to focus on the varied application of colour and texture; the painting is executed in a very sure and spontaneous manner, only occasionally leaving areas of primed canvas exposed between the adjacent forms (see **Plates 13.c, 14.b**)[12]. Setting in the composition before beginning to paint would have facilitated this manner of working, with very few overlaps of colour or form. No evidence for complex layering was seen; areas are worked quite directly, with mixing both on the palette, and wet-in-wet directly on the canvas. The colours are bright and intense, the paint strongly opaque and used quite thickly (**Plates 3, 4, 13.c, 14, 15**) as well as spread thinly in other passages (**Plate 16.a**). The lining of the painting has evened off the local stresses that would have otherwise been present between paint and canvas, leaving a very flat, uniform surface, punctuated by the loaded impasto brushstrokes, only slightly flattened by the process. It is likewise unclear to what degree the fibrous aspect of the surface has been regularised through the application of the lining. No use of transparent glazes was observed; the colours remain intense, though the surface aspect is quite matte. The painting does not show evidence of having been varnished, in keeping with the artist's preference for a brightly coloured, rough, matte finish. Due to the state of the painting (with edges covered by brown paper tape) it is not possible to observe to what extent the paint continued up to, or over, the turnover edges[13].

D.2.ii Paint: pigment and binding medium

While zinc white (with a trace of barium sulfate) bound with walnut oil or a mixture of linseed oil and walnut oil, was used for the painting proper, lead white bound in linseed oil was chosen for the preparation of the canvas. A range of other pigments were used in the palette of the painting, consisting of two types of yellow (chrome yellow, cadmium yellow, yellow earth), four types of red (vermilion, red lake with a natural dyestuff, red earth), two blues (Prussian blue, synthetic ultramarine blue), one green tone (chromium oxide hydrate, or 'viridian' green), brown (earth pigment) and black (a bone or ivory black) (**Table App.2.i**).

The medium for the lead chromate paint Sample [3] was found to be walnut oil, or a mixture of linseed oil and walnut oil, while analysis of the bright blue ultramarine based paint, Sample [10], was shown to be linseed oil (**Tables App.2.ii, App.2.iii**).

---

[12] The use of reserves is very common in Goncharova's work. See Rioux, Aitken and Duval (1998) *op. cit.* pp. 19, 25, 26.

[13] Attempts to remove the paper tape in some areas so as to allow better study of the edges of the painting were abandoned, as the paint has poor adhesion to the ground, but strong adhesion to the tape, making it difficult to safely remove the tape form the paint surface.

The cross-sections prepared confirm the observations made on the surface, and with the various forms of imaging: the paint was worked freely and directly in thick layers (**Plates 18, 19**). The painting shows a consistent use of thick, impasto applications over the whole of the surface. There is more concentration on strong brushwork and fluidity here, than in other paintings, and no thinly painted but highly textured (with overlapping short strokes) areas. Mixing has taken place both on the palette, and on the brush, sometimes wet-in-wet directly on the canvas (**Plates 14, 15**). This direct application has led to quite thin passages where the canvas weave and fibrous texture of the ground remain slightly visible (**Plate 16.b**), and others where it is fully obliterated by a heavy build-up of impasto (**Plates 15.a, 15.b, 15.c**).

D.2.iii Materials analysis and implications for dating

The painting has been dated to 1908 on stylistic grounds. It is also listed in an exhibition catalogue of 1913[14].

As the painting could not be appropriately sampled, there is no radiocarbon date for the canvas.

The materials identified in the painting are compatible with the supposed date, although they also continued in use after that time and would not preclude a revision of date if deemed necessary. The findings generally agree well with the data collected in the study of 45 paintings by Goncharova and Larionov in the collection of the Musée national d'art modern, Paris[15].

Other technical characteristics arising from the larger review of the works of Goncharova and Larionov may also contribute to a fuller understanding of the relative dating of this painting in the future.

E. Conclusions

The examination of the painting revealed a work that was created with dynamic brushwork using a bright palette of paints applied over an initial setting in of the composition with a charcoal underdrawing, subsequently refined with a dilute black paint. The evident textured aspect of the priming, which is clearly visible in the paint layer as well, is particularly characteristic, although the use of lead white, not zinc white, in the priming of a painting of this early period of Goncharova's *oeuvre* is unusual, though not at all implausible (and finds correspondence in *Landscape at Tiraspol* of 1905, in the Museum Ludwig collection). The granular nature of the ground, while resulting in a similar surface effect as the *Tiraspol* ground, is of a different aspect when examined in cross-section. Thus, at more than one occasion, Goncharova was using a coarse, low grade lead white to prime her canvases. The original format of the painting was probably adjusted from the original,

[14] Ėganbjuri, Ėli [pseudonym of Il'ja Zdanevič]: *Natalija Gončarova. Michail Larionov* [exhibition catalogue, Moscow 1913], editor not identified, Moscow: publisher not identified (1913) p. 8.

[15] The combination of zinc white ground with lead white paint presents the single exception, in that the authors claim that only zinc white was used throughout the paintings by the two artists. Rioux, Aitken and Duval (1998) *op. cit*. p. 18.

although due to the absence of tacking edges and the presence of tape around the borders of the work, the degree to which this is the case could not be accurately assessed. The results of the examination have not found any evidence that would speak against the proposed date of the work, 1908.

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Bhavini Vaghji	Senior Scientist	Materials analysis
Francis Eastaugh	Senior Imaging Engineer	Scientific imaging processing
Dr Joanna Russell	Scientist	Materials analysis

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G. Appendices

Standard protocols used by AA&R in the preparation of this report for sampling, materials analysis and imaging are listed in each subsection below and detailed in the appendices to the global summary report.

App.1 Sampling and sample preparation

Protocols:

[P.1.1] Sampling
[P.1.2] Cross-sectional analysis

App.1.i Sampling

Table App.1.i Samples taken for analysis

#	*Colour*	*Description*	*Location[16]*	*Analysis*
1		Ground	2/1245	PLM, SEM-EDX, Raman, FTIR, GC-MS, CSA
2		White	391/311	PLM, SEM-EDX, Raman, FTIR, GC-MS
3		Yellow	505/235	PLM, SEM-EDX, Raman, FTIR, GC-MS
4		Orange	471/192	PLM, SEM-EDX, Raman
5		Red Orange	1016/139	PLM, SEM-EDX, Raman
6		Crimson Red	64/925	PLM, SEM-EDX, Raman
7		Green Dark	286/1155	PLM, SEM-EDX, Raman, FTIR
8		Green, Bright	305/84	PLM, SEM-EDX, Raman, FTIR
9		Blue Dark	239/11114	PLM, SEM-EDX, Raman
10		Blue Bright	38/1198	PLM, SEM-EDX, Raman, FTIR, GC-MS, CSA

[16] The coordinates in this column are given in millimetres, the measurements taken from the left edge of the picture, and from the lower edge of the picture.

Table App.1.i Samples taken for analysis				
#	*Colour*	*Description*	*Location*[16]	*Analysis*
11		Brown orange	10/1272	PLM, SEM-EDX, Raman
12		Bright Red	219/1020	PLM, SEM-EDX, Raman
13		Black	8/1243	PLM, SEM-EDX, Raman
14		Underdrawing	39/1203	PLM, SEM-EDX, Raman
15		Dark Brown	28/1252	PLM, SEM-EDX, Raman
16		Green Blue	583/919	PLM, SEM-EDX, Raman
17		Fibre Vertical	n/a	PLM, FTIR, C14

App.1.ii Cross-sectional analysis

Results are shown in **App.5**, **Plates 18, 19.**

App.2 Materials analysis summary results

Protocols:

[P.2.1] Polarised light microscopy (PLM)
[P.2.2] Scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDX)
[P.2.3] Raman microscopy
[P.2.4.1] Fourier Transform Infrared Spectroscopy-Attenuated Total Reflectance (FTIR-ATR)
[P.2.5] Gas Chromatography-Mass Spectrometry (GCMS)

App.2.i SEM-EDX, Raman microscopy and PLM analysis

Table App.2.i Analytical results SEM-EDX, Raman Microscopy and PLM

#	Colour	SEM-EDX (elements)			Raman Microscopy (peaks, cm^{-1})	Identification
		Major	Minor	Trace		
1	Ground	**Pb**	-	*Al, Si*	1466 (vw), 1440 (vw), 1417 (vw), 1296 (vw), 1128 (vw), 1062 (vw), **1053 (vw), 1049 (vw), 110 (w)**	**Lead carbonate type white** Organic pigment[17]
2	White	**Zn**	-	*Al, Si, S, Cl, Ca, Sr, Ba, Pb*	**988 (vw), 438 (vw)**	**Zinc oxide (main)** **Barium sulfate (trace)**
3	Yellow	**Al**	Cr, Pb	*Si, S, Cl, K, Ca, Zn*	**840 (vs),** 420 (vw), **401 (vw), 378 (vw), 359 (m), 338 (vw), 327 (vw), 136 (vw)**	**Lead chromate yellow [P2239]**
4	Orange	**S, Cd**	-	*Al, Si, Ca, Fe, Zn*	**254 (vw)**	**Mercury sulfide (trace)**[18] Cadmium sulfide
5	Red-orange	**S, Hg**	-	*Al*	**344 (w), 285 (vw), 254 (vs), 142 (vw), 108 (vw)**	**Mercury sulfide [P0010]**
6	Crimson red	**Al, P**	S	*Si, Cl, K, Ca, Fe, Zn, Hg*	1293 (vw), **343 (vw), 253 (w)**	**Mercury sulfide (trace)** Organic red on Al/P/S substrate (main)
7	Dark green	**Cr, Zn**	-	*Al, Si, P, S, Cl, K, Ca, Fe*	-	Chromium oxide hydrate Zinc oxide
8	Bright green	**Cr**	S, Ba	*Al, Si, P, K, Ca, Zn, Sr*	-	Chromium oxide hydrate Barium sulfate (minor) Zinc oxide (trace)
9	Dark blue	**Zn**	Mg, Fe	*Al, Si, P, S, Cl, K, Ca, Co*	**2154 (w), 2093 (vw), 946 (vw), 597 (vw), 535 (w),** 436 (vw), 381 (vw), **328 (vw), 277 (m), 218 (vw)**	**Prussian blue** **Zinc oxide**
10	Bright blue	**Al, Si**	Na, S	*Mg, K, Ca, Zn*	**585 (vw), 549 (w)**	**Ultramarine**
11	Brown-orange	**Si**	Al, Fe	*Mg, P, Cl, K, Ca, Ti, Zn, Pb*	144 (vw)	**Titanium dioxide, anatase type?**
					402 (vw)	**Goethite** Aluminosilicate clay minerals

[17] Yellowish-orange pigment particles were observed.
[18] Mercury was not identified in the SEM-EDX analysis.

Table App.2.i Analytical results SEM-EDX, Raman Microscopy and PLM						
#	**Colour**	**SEM-EDX (elements)**			**Raman Microscopy (peaks, cm^{-1})**	**Identification**
		Major	**Minor**	**Trace**		
12	Bright red	**Fe**	Si, Zn	*Mg, Al, P, S, K, Ca*	**2155 (vw), 1592 (w, br), 1307 (w, br), 608 (vw), 537 (vw), 503 (vw), 411 (vw), 291 (w), 224 (vw)**	**Hematite (main)** **Carbon-based black** **Prussian blue** Zinc oxide (minor) Silica (minor)
13	Black	-	Al, Si, P, Ca, Fe	*S, Cl, K, Zn, Pb*	**1594 (w, br), 1316 (w, br)**	**Carbon-based black (bone or ivory black)** Iron containing earth pigments Aluminosilicate clay minerals
14	Underdraw-ing	-	S, Cl, Ca, Pb	*Al, Si, P, K, Zn*	**1054 (vw)**	**Lead carbonate type white** Bone black[19]
15	Dark brown	-	Al, Si, Fe, Zn	*P, S, Cl, K, Ca*	**1594 (w, br), 1305 (w, br),** 144 (vw)	**Carbon-based black** Iron containing earth pigments Aluminosilicate clay minerals Zinc oxide Bone black
16	Green-blue	**Zn**	Mg	*Al, Si, P, Cl, K, Ca, Fe, Pb*	**2154 (vw), 2091 (vw), 536 (vw), 276 (vw)**	**Prussian blue** Zinc oxide

[19] EDX analysis indicated the presence of calcium and phosphorus, indicative of bone (hydroxylapatite). Particle morphology was consistent with a coarse bone black pigment.

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App.2.ii Fourier Transform Infrared Spectroscopy-Attenuated Total Reflectance (FTIR-ATR)

Table App.2.ii Summary results from FTIR

#	Colour	FTIR (peaks, cm^{-1})	Identification
1	Ground	3524 (vw), 3320 (vw, br), 2956 (vw, sh), 2919 (m), 2850 (w), 1732 (m), 1715 (w), 1634 (vw), 1615 (vw), 1556 (vw, sh), 1539 (vw), 1532 (vw), 1519 (w), 1506 (w), 1393 (vs), 1298 (vw), 1242 (w, sh), 1171 (vw), 1089 (vw), 1044 (vw), 1020 (w, sh), 941 (vw), 874 (vw), 855 (vw), 837 (vw), 769 (vw), 720 (vw), 679 (s)	Lead carbonate hydroxide [P0864] Lead(II) carbonate [P0896][20] Oil Metal soap formation, presumably lead-based
2	White	3376 (w, br), 2953 (vw, sh), 2918 (s), 2850 (m), 1738 (m), 1716 (w), 1581 (vw, sh), 1574 (vw), 1567 (vw), 1556 (vw), 1539 (vs), 1454 (s), 1435 (vw, sh), 1410 (m), 1317 (vw), 1164 (m), 1075 (s), 982 (vw), 721 (vw), 635 (vw), 609 (vw)	Barium sulfate Carbonate[21] Oil[22] Metal soap formation, zinc-based[23] Metal soap formation
3	Yellow	3405 (w, br), 2922 (m), 2853 (w), 1731 (vw, sh), 1713 (s), 1634 (vw), 1557 (vw), 1454 (w), 1416 (vw), 1374 (vw), 1291 (vw, sh), 1247 (w), 1235 (vw), 1143 (w), 1110 (vw, sh), 1038 (w), 847 (w), 814 (vw), 783 (vw, sh), 718 (vw), 657 (vw, sh)	Lead chromate [P2239] Natural resin[24]
7	Dark green	3338 (w, br), 2917 (s), 2850 (s), 1738 (s), 1715 (w), 1587 (vw, sh), 1574 (vw), 1564 (vw), 1547 (m), 1539 (vw), 1532 (s), 1454 (s), 1410 (vw), 1398 (w), 1362 (vw), 1317 (vw, sh), 1284 (w), 1250 (w), 1169 (w), 1096 (vw), 1058 (w), 951 (vw), 899 (vw), 880 (vw), 801 (vw), 745 (vw), 721 (vw), 694 (vw), 679 (vw), 669 (vw)	Chromium borate[25] Oil Metal soap formation, zinc-based[26] Metal soap formation
8	Bright green	3443 (vw, sh), 3218 (vw, br), 2954 (vw, sh), 2916 (m), 2849 (w), 1733 (w), 1713 (vw), 1614 (vw), 1592 (vw), 1538 (s), 1455 (m), 1398 (vw), 1362 (vw), 1285 (m), 1252 (vw), 1168 (m), 1111 (vw, sh), 1068 (s), 982 (vw), 947 (m), 877 (s), 800 (m), 745 (vw), 720 (vw), 696 (vw), 681 (vw), 631 (s), 604 (m)	Chromium borate[27] Zinc chromate Barium sulfate Oil[28] Metal soap formation, zinc-based[29]

[20] The sample contains both lead carbonate hydroxide and lead(II) carbonate based on the additional peak at 837 cm^{-1}. This additional peak present at 837 cm^{-1} is absent in lead carbonate hydroxide but is present in lead II carbonate. Some of the peaks that are assigned to lead carbonate hydroxide are also present in lead II carbonate.
[21] It is not possible to say in which form the carbonate is since both lead carbonate type white and calcium carbonate show this peak. Other peaks which can be used to differentiate one from the other are absent.
[22] The characteristic peak of oil occurring at around 1160 cm^{-1} was not observed in the spectrum due to the presence of barium sulfate whose peaks were masking this characteristic peak of oil however it is assumed that oil is present due to the formation of metal soaps.
[23] The peaks present in the sample spectrum matched the reference spectrum of zinc stearate, reference number AAR308. Zinc was identified in the SEM-EDX analysis.
[24] The peaks present in the sample spectrum matched the reference spectrum of shellac, reference number AAR023.
[25] The peaks assigned to chromium borate are present in the reference spectrum of chromium oxide hydrate, reference number P0092.
[26] As noted 23, above.
[27] As noted 25, above.
[28] As noted 22, above.
[29] As noted 23, above.

Table App.2.ii Summary results from FTIR			
#	**Colour**	**FTIR (peaks, cm^{-1})**	**Identification**
10	Bright blue	**3412 (w, br), 2956 (vw, sh), 2918 (m), 2850 (w), 1736 (w), 1717 (vw),** 1614 (vw, sh), **1589 (w), 1549 (w), 1532 (vw, sh), 1463 (w), 1410 (vw),** 1398 (vw), **1379 (vw, sh),** 1318 (vw), **1243 (vw, sh), 1166 (vw, sh), 1078 (vw), 977 (vs), 719 (w), 694 (vw), 652 (vw)**	**Ultramarine** **Oil** **Metal soap formation**

App.2.iii Gas Chromatography Mass Spectrometry (GC-MS) Analysis

Table App.2.iii Summary results from GCMS					
Sample #	**Hexadecanoic acid, methyl ester ($C_{17}H_{34}O_2$)**		**Octadecanoic acid, methyl ester ($C_{19}H_{38}O_2$)**		**Ratio**
	Retention time, mins	**Peak area**	**Retention time, mins**	**Peak area**	
1	25.654	2.156×10^9	29.589	1.599×10^9	P/S = 1.35
2	25.654	2.480×10^9	29.597	1.067×10^9	P/S = 2.32
3	25.662	3.380×10^9	29.597	1.452×10^9	P/S = 2.33
10	25.678	5.661×10^8	29.590	2.723×10^8	P/S = 2.08

The P/S value of **Sample [1]**, lead white ground, was 1.35, consistent with **linseed oil**.

The P/S value of **Sample [2]**, white paint, was 2.32, consistent with **walnut oil or a mixture of linseed and poppy oil**[30].

The P/S value of **Sample [3]**, yellow paint, was 2.33, most consistent with **walnut oil or a mixture of linseed and poppy oil**[31].

The P/S value of **Sample [10]**, bright blue paint, was 2.08, consistent with **linseed oil**.

[30] It would be possible to associate this spectra with other, non-traditional types of oils, such as safflower or soybean oil, but given the early context of this painting, such an identification does not seem plausible.
[31] As note 30.

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App.3 Imaging methods

Protocols:

[P.3.1] Photography with visible light
[P.3.2] Photography with ultraviolet illumination
[P.3.3] 3D laser surface mapping
[P.3.4] SWIR infrared imaging (IR)
[P.3.6] X-radiography
[P.3.7] Thread counting and weave analysis

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App.4 Plates

Plate 1. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Recto, visible light**.

Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050884_07, www.kulturelles-erbe-koeln.de/documents/obj/05020005

Plate 2. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Recto, UV light**.

Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050884_06, www.kulturelles-erbe-koeln.de/documents/obj/05020005
Some of the red lake shows a strong orange luminescence.

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Plate 3. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. Recto, raking light.

Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050884_04, www.kulturelles-erbe-koeln.de/documents/obj/05020005

Plate 4.a Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Recto, 3D laser scan**.

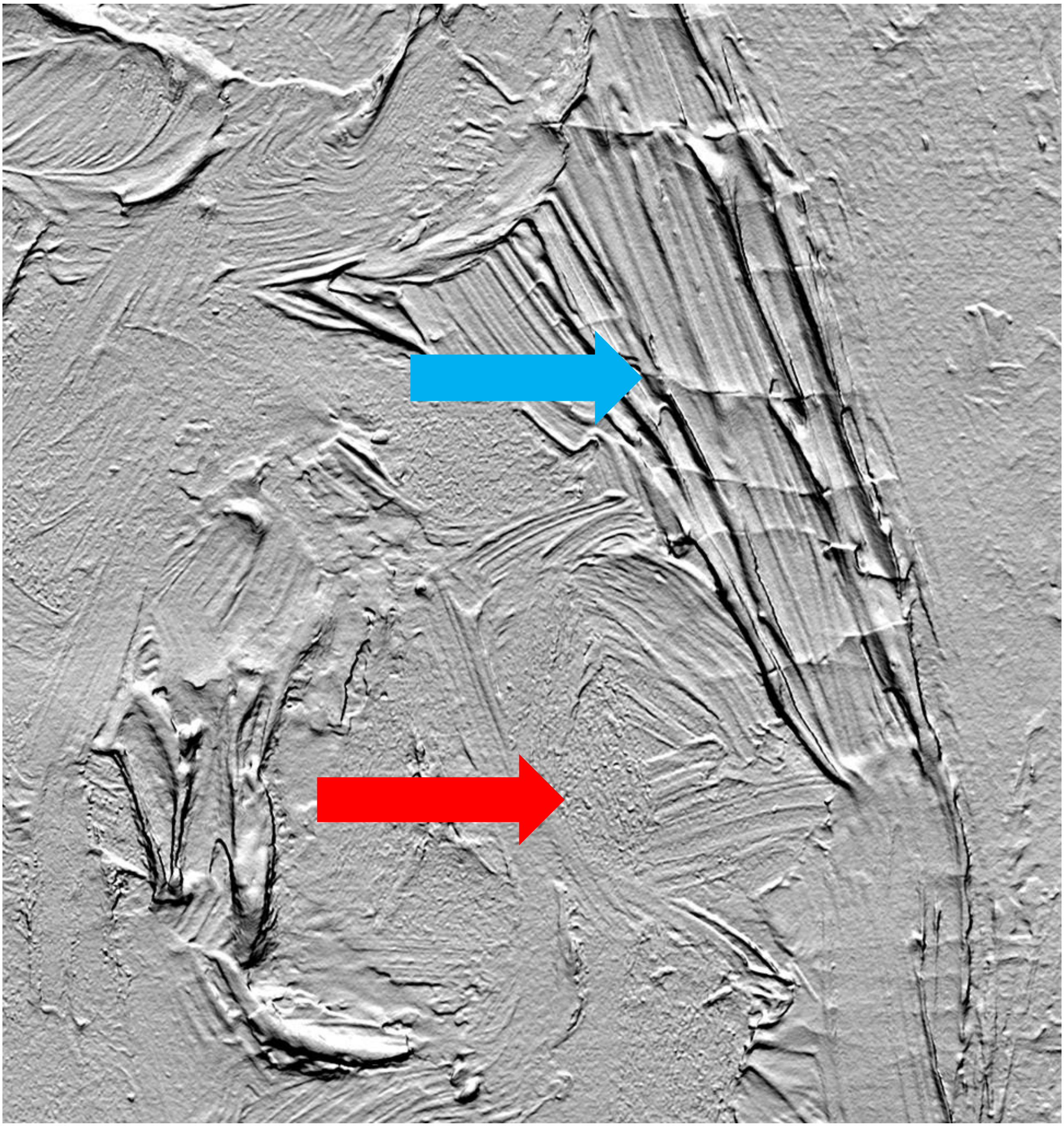


Plate 4.b Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Recto, 3D laser scan**, detail.

The texture of the ground is visible in the thin areas (for example, as indicated by the red arrow), as is the brittle cracking of the thickest strokes (blue arrow).

Plate 5. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Verso, visible light**.

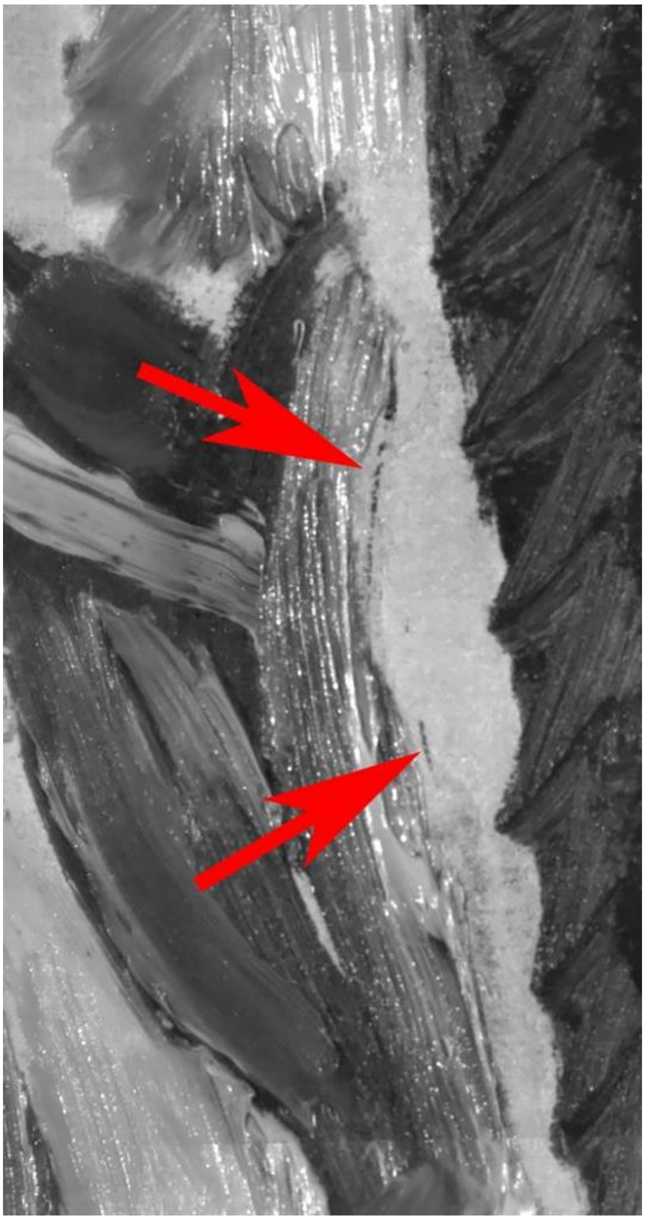
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050884_02, www.kulturelles-erbe-koeln.de/documents/obj/05020005

Plate 6. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Recto, SWIR image**.

There are a number of small areas of missing data (black areas); the stripes along the top and bottom edges are the result of stitching anomalies in assembling the IR image.

Plate 7. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **Detail, SWIR image**.

Despite the known presence of underdrawing, it is not readily visible with long wave IR imaging, due to the heavy use of black line and the general IR opacity of the paint.


a.

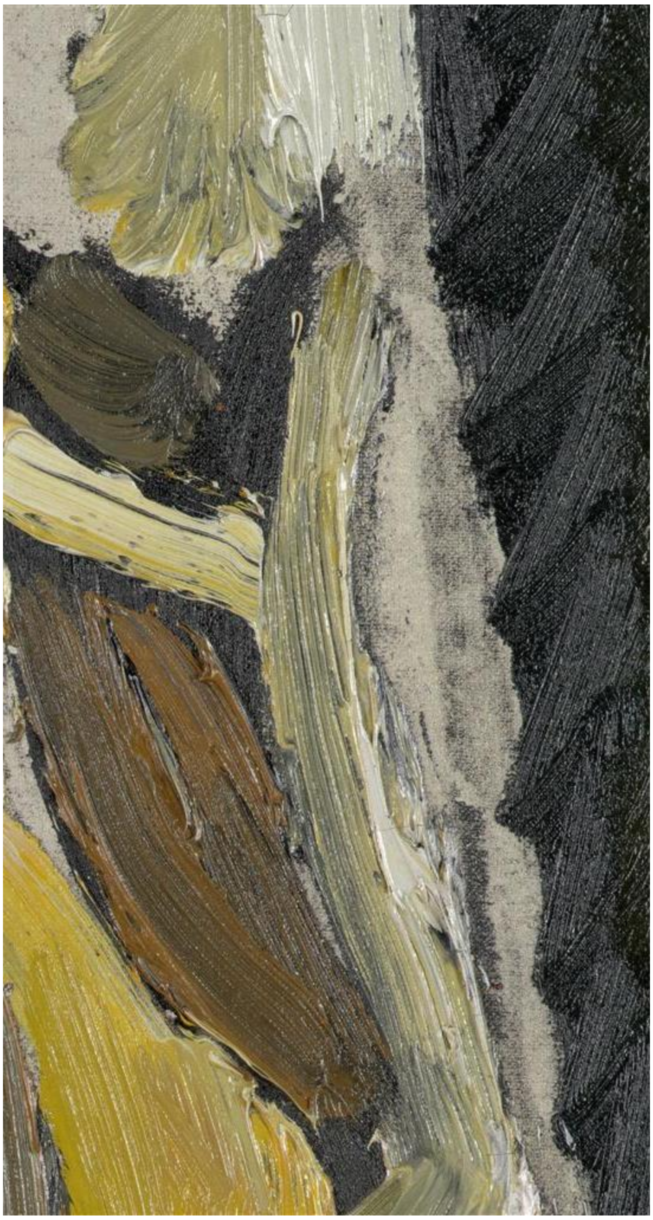

b.

Plate 8. Details: left, **a.** SWIR image, red arrows showing fine drawn lines that resolve in black, while right, **b.**, shows the same detail in visible light.

These lines may represent the drawing in charcoal, which was either developed with black brush work, or, somewhat brushed away and rendered more diffuse, as visible in b., under normal lighting.

a.

b.

c.

Plate 9. Natalia Goncharova, Still Life with Tiger Skin, 1908, collection Museum Ludwig: Inv. Nr. ML 1305. **X-ray image**.

Near right, **b.)** map showing location of retouching in green, far right, **c.)** the X-ray image before digital compensation for the stretcher bars.

Plate 10. X-ray image, detail (picture frame, lower centre), showing canvas structure and brushwork.

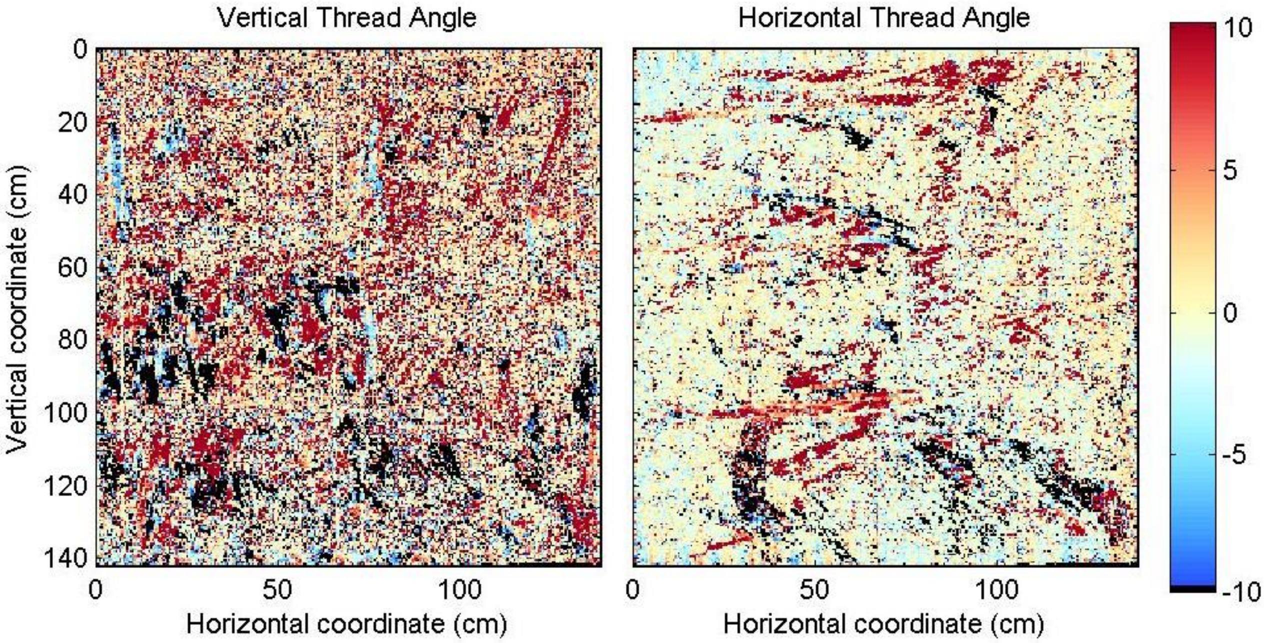


Plate 11.a Maps showing variation in canvas thread angle.

Due to the poor resolution of the X-ray, the results must be regarded as inconclusive.

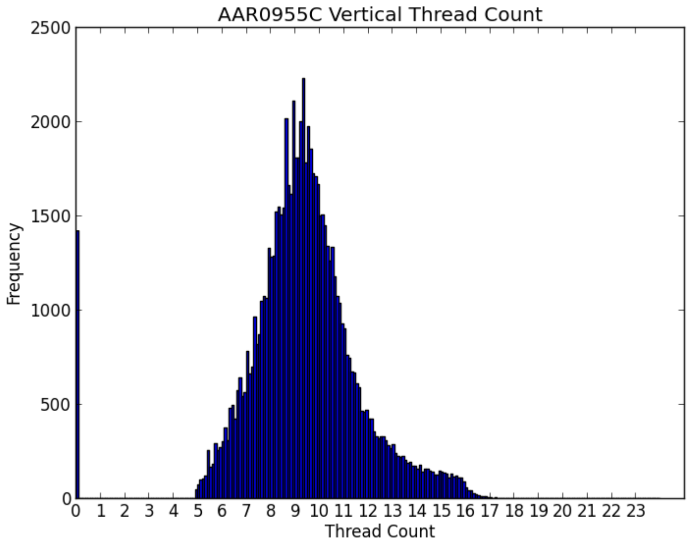


Plate 11.b Histogram of vertical thread count readings.

Showing variation in thread count per centimetre.

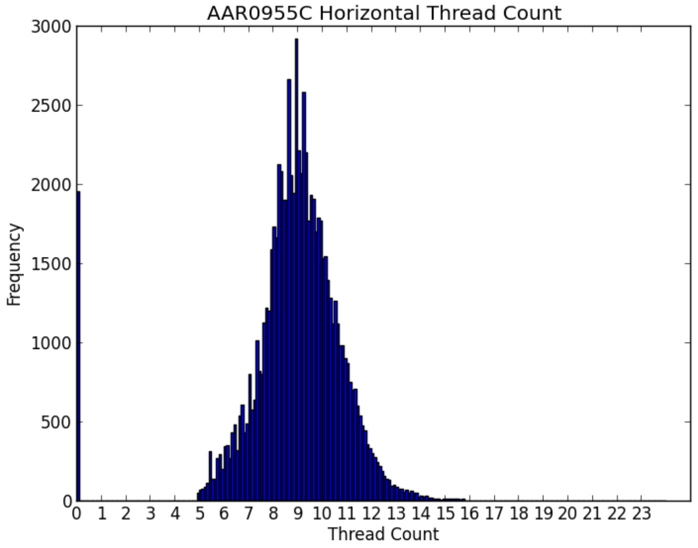


Plate 11.c Histogram of horizontal thread count readings.

Showing variation in thread count per centimetre.

Plate 11.d Table of thread count data (threads per centimetre)

	Mean	Estimated thread count (mode)
Vertical	9.54	9.3
Horizontal	9.14	8.9

Note: results of the analysis are stated only tentatively, as poor resolution in the fine detail of the X-ray has impeded proper reading of the data.

Plate 12.a Microscope detail of the lead white-based priming.

The granular nature of ground may be noted, as well as the presence of powdery and friable underdrawing.

Plate 12.b Macro detail of the lead white-based priming.

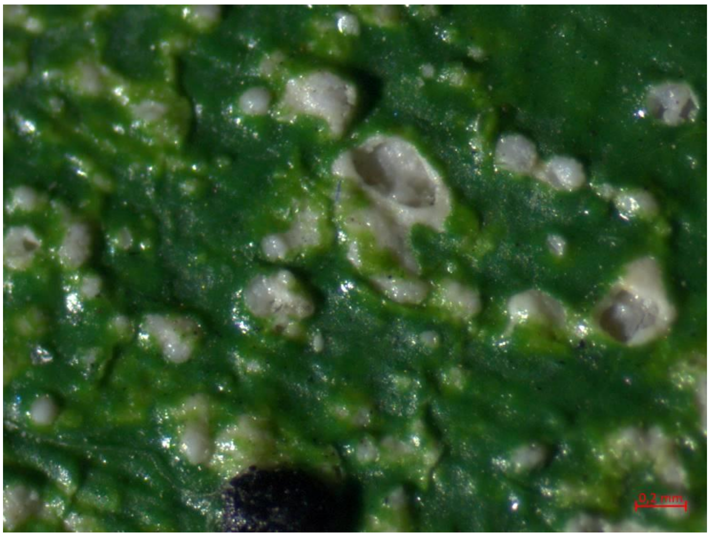


Plate 12.c Detail of what appear to be protrusions.

The white lumps in the paint layer may be protrusions caused by lead soap formation, but no direct evidence for this was found in the samples taken.

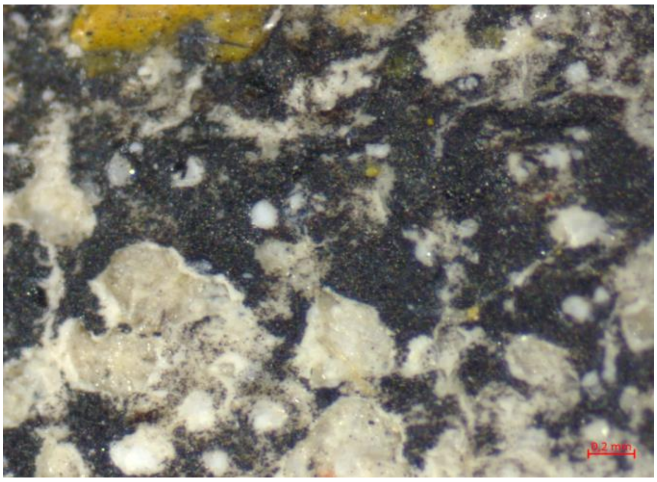


Plate 13.a Left: microscope detail, showing the underdrawing medium.

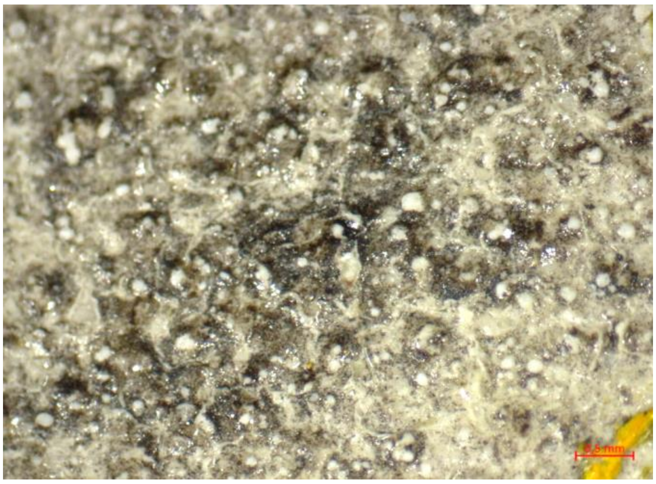


Plate 13.b Left: macro detail, showing the diffuse aspect of the underdrawing medium.

Plate 13.c Below: detail of the exposed ground, and of the underdrawing.

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Plate 14.a Detail of the exposed ground, and of the friable underdrawing medium.

The black fragments are drawn up in the yellow paint, middle right.

Plate 14.b Detail showing the free, wet-in-wet working of the paint.

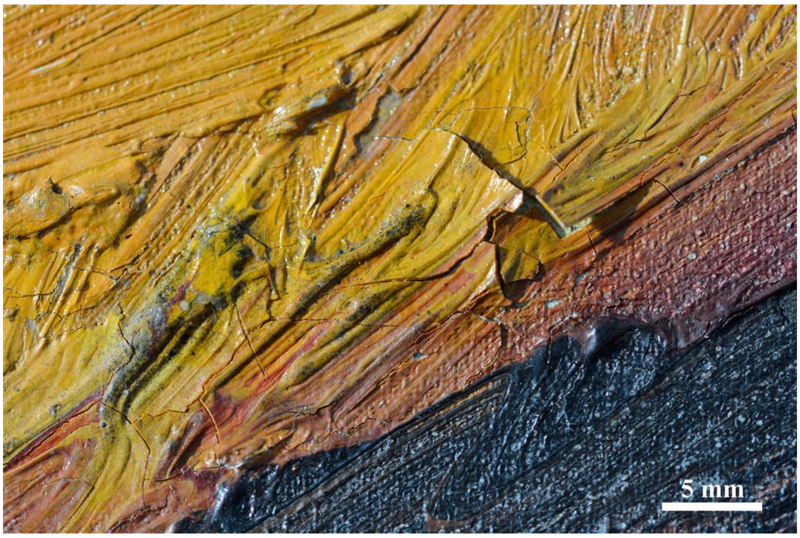


Plate 14.c Detail of delamination of brittle areas of crack.

The texture of the granular ground is visible through the thin passages of the red and blue paint, lower right.

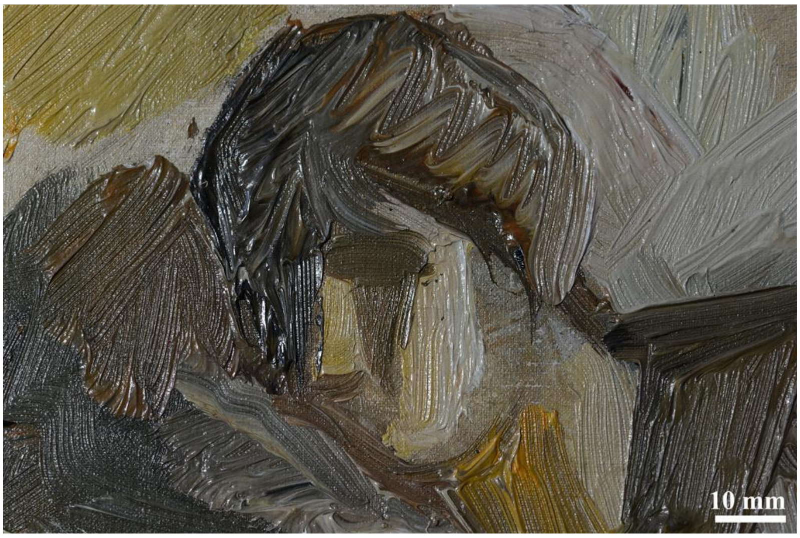


Plate 15.a Detail showing the free, wet-in-wet working of the paint.

The paint has a substantial three-dimensionality.

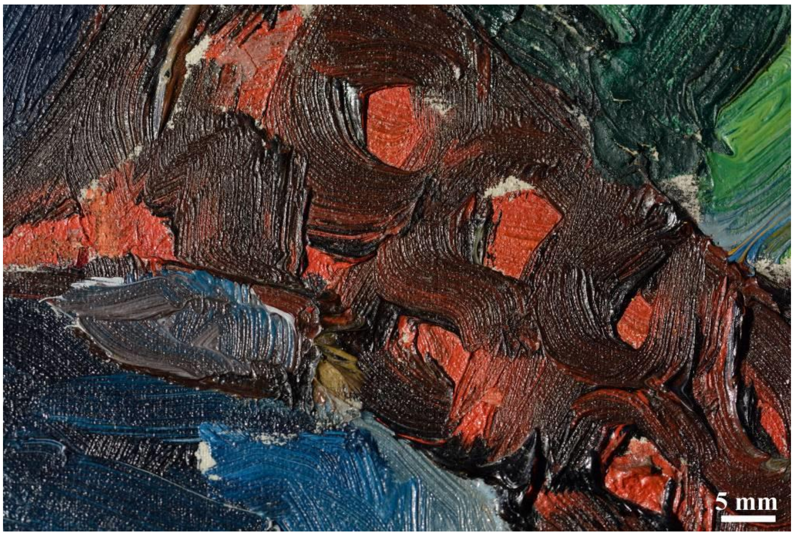


Plate 15.b Detail showing the free, wet-in-wet working of the paint.

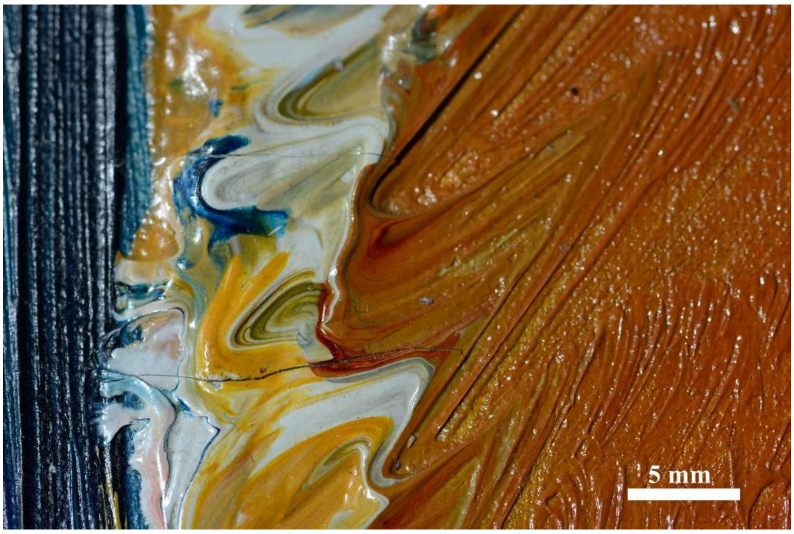


Plate 15.c Detail showing mixing within the brushstrokes.

Plate 16.a Detail of the inscription, upper left corner.

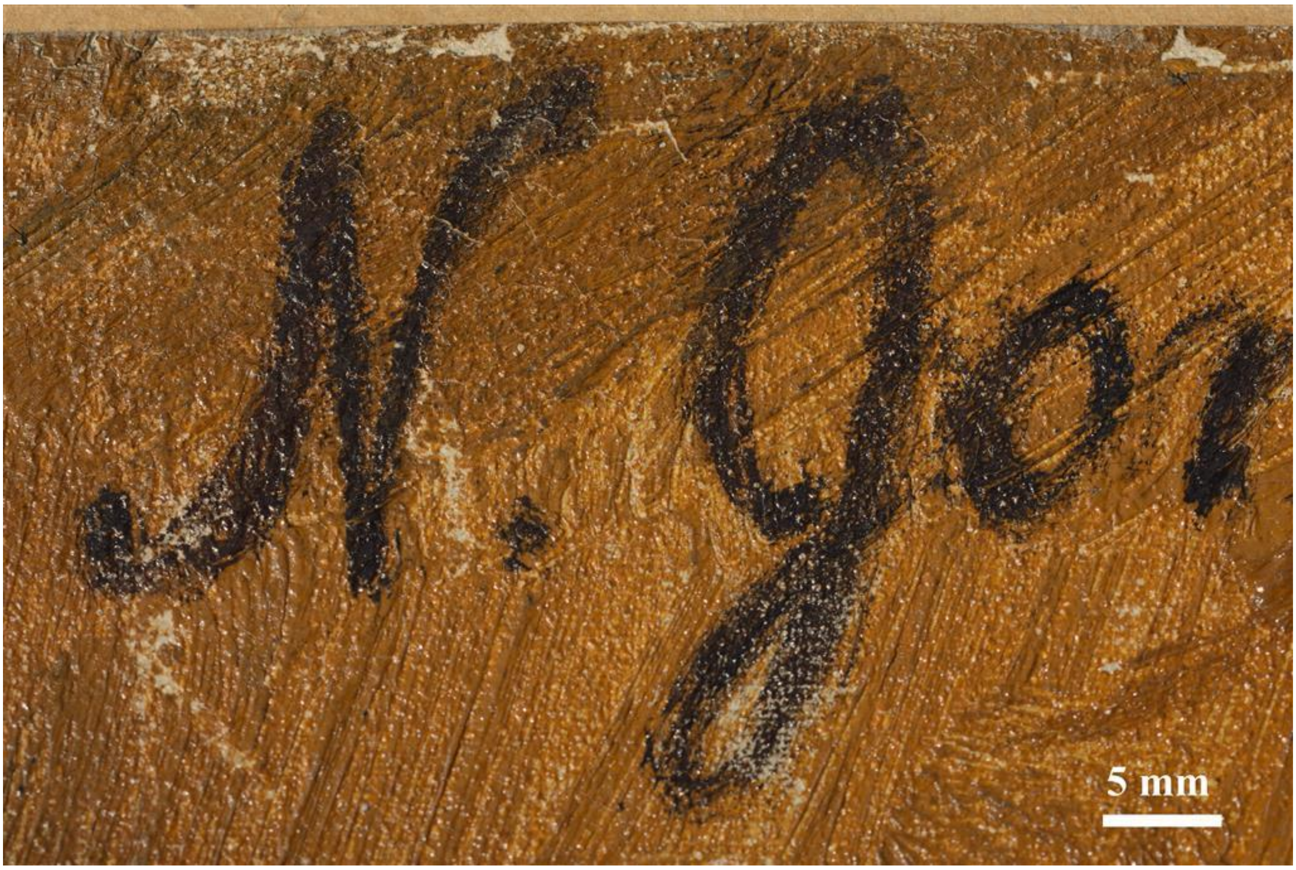
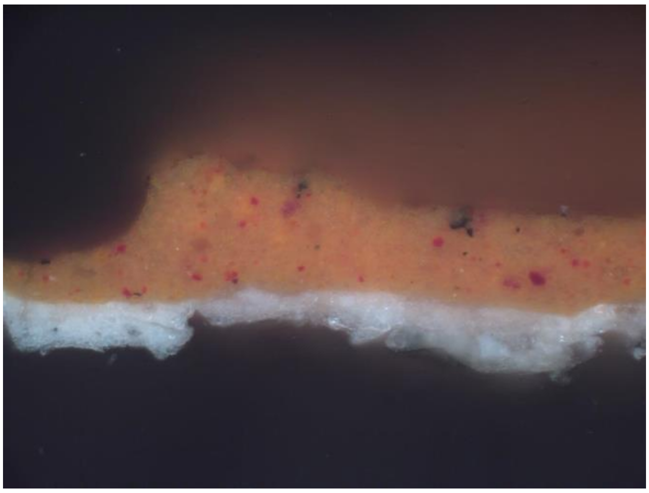
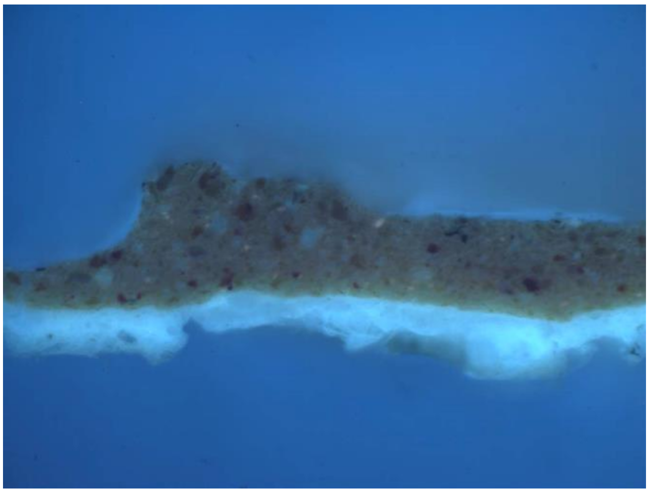


Plate 16.b Detail of the inscription, upper left corner, macro.

Plate 17. Image showing approximate location of samples taken for materials analysis.

App.5 Cross-sections[32]

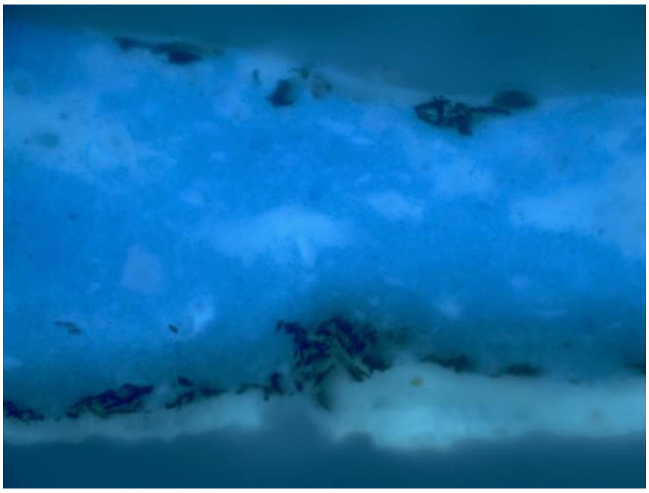




a. **b.**

Plate 18. Cross section, Sample [1].

Image ~260µm high. The sample has a white ground layer covered with a red-orange paint layer, in which some larger red particles are visible, with an occasional black particle.



a. **b.**

Plate 19. Cross section, Sample [10].

Image ~260µm high. Bright blue. Over the white ground layer are numerous black splinter-shaped particles, indicating charcoal underdrawing. Some of these particles can also be seen at the top of the blue paint layer, where they have been caught up in the paint, and moved from their original location on the prepared canvas.

[32] Photographed under visible light, left (**a.**), and with ultraviolet illumination, right (**b.**).