Art Analysis & Research

ANALYTICAL REPORT

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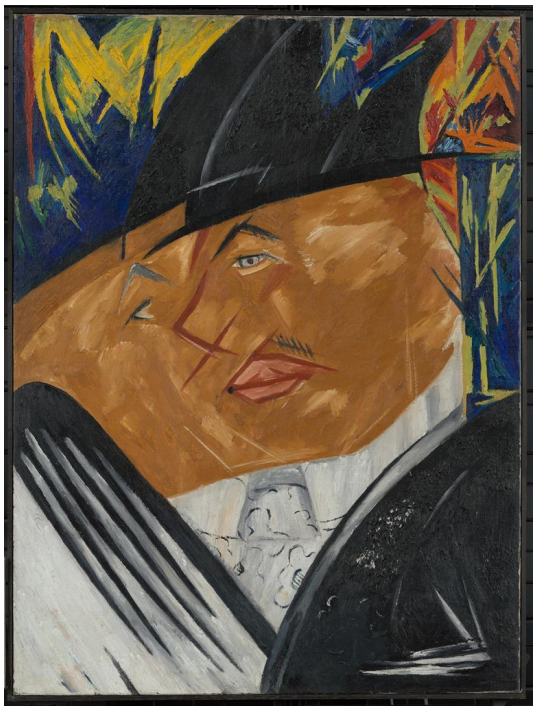

Portrait of Larionov, 1913
Natalia Goncharova
Collection Museum Ludwig, Cologne, Inv. ML 1319

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Summary

A painting on canvas by Natalia Goncharova, *Portrait of Larionov*, with a proposed date of creation of 1913 (it is unsigned and undated), belonging to the Museum Ludwig (ML 1319) 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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Tables, Figures and Plates

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A. Introduction

The painting known as *Portrait of Larionov* (**Plate 1**) by the artist Natalia Goncharova (1881-1962), a work on canvas measuring 1090 mm high by 800 mm wide, is now part of the collection of the Museum Ludwig, Cologne (Inv. ML 1319). It is unsigned and undated; a date of 1913 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**.

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

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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.], 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 a 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; *Saucissions 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.F ML 1319 Conservation*, Franken, V. 'Report on the examination of the painting *Portrait of Larionov* (1913) by Natalia Goncharova' (2017a) and *AAR0955.F ML 1319 Archives*, Franken, V. 'Report on the content of the Museum Ludwig archives, concerning the painting *Portrait of Larionov* (1913) by Natalia Goncharova' (2017b).

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 (**Plates 2, 6**);
- Oblique illumination (**Plate 3**);
- 3D laser surface scanning (**Plate 4**);
- Short-wave infrared (SWIR), 1600-2500nm (**Plate 7**);
- X-radiography (**Plate 9**).

Additionally, weave analysis (including thread counting) was conducted on the basis of the X-radiograph (**Plates 10.a-c**). Some exemplar images recorded as part of the surface microscopy and macrophotography are also reproduced here (**Plates 11-14**).

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 in fair condition; it is executed on a medium weight canvas, which has been lined as well as loose lined, causing some flattening of the surface texture of the impasto[6]. The reasons that lining was considered necessary are not known, though there is a good deal of cracking, flaking and

[5] Additionally, a visible-NIR multispectral dataset was collected to examine its suitability for study of paintings of Goncharova and Larionov. As it did not offer information significantly different or superior to that derived by the SWIR imaging, this has not been otherwise reproduced or further analysed here but is available for extramural studies in the future.

[6] The conservation report suggests that the painting was wax lined, then subsequently loose lined. Given the surface deformations visible in the 3D imaging and oblique lit imaging, the lining is now failing in some areas as the painting exhibits a number of deformations of the canvas.

loss of the paint, which has resulted in a number of restorations, including both retouching and a degree of overpainting of some areas. While access to the verso was not possible, the tacking edges have been preserved. It is currently mounted on a new stretcher, with a single, horizontal crossbar and 10 keys (**Plate 5**). 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[7] 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. Retouching in many small areas over the painting's surface is clearly visible especially in the flesh coloured areas and in the upper third of the composition. No strong luminescence was noted from any of the original paints in the UV image, though the zinc white paint displays a relatively neutral white tone (not strongly yellow or green, as in some instances) while the blue used in the background in the upper regions is shown to exhibit a distinctive purplish hue.

B.3.ii Surface conformation

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

[7] 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.

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 is best understood in the context of the conservation treatment of the painting, which has been lined. Consequently, some 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. However, here a number of surface deformations along the upper edge and right edge in particular suggest that the adhesion of the lining and the canvas has failed, as the canvas is no longer being held flat. A number of features may be specifically highlighted:

- Areas of impasto have been lightly flattened, most likely as a result of prior lining treatment of the painting.
- An area of 'rippling' (canvas distortions, cause unknown) along the upper edge, right corner and right-hand side.
- An intentional use of stippled brushwork in the black regions of the hat and the jacket, differentiating surface by use of texture in these monochromatic regions.

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**).

In the IR image (**Plate 7**), no discrete underdrawing can be seen. However, this does not necessarily mean that no underdrawing is present; as imaging of other paintings examined in this project revealed, underdrawings in friable charcoal or dilute carbon black paint were not usually resolved, although examination at magnification showed its presence. The reason for the lack of resolution in 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. Thus, in this particular case, the presence or absence of an underdrawing cannot be ascertained with certainty; the canvas was densely covered with paint, allowing for very limited opportunity to find underdrawing in the gaps between adjacent areas of colour.

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 very small areas of ground are occasionally visible throughout the painting where forms abut. Consequently, the X-ray (**Protocol 3.6**; **Plate 9**) 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).

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 10.a-.c**).

Here, the canvas was found to be a plain weave. The thread count on this work was determined as 14.4 threads per centimetre in the vertical direction and around 14 in the horizontal, although the analysis indicated a bimodal distribution with a second value at 18.5, possibly suggesting use of distinctly different thread weights in the weave. There is no significant cusping visible, which is unusual in the works analysed. However, this is consistent with the evidence provided by different forms of investigation, such as the 3D image and examination of the tacking margins.

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 13 locations selected over a representative range of the painting (**Table App.1.i, Plate 15**) were micro-sampled for identification of the pigments (**Table App.2.i**), with five micro-samples of paint taken for analysis of the binding media (**Tables App.2.ii-2.iv**). One further sample was taken for preparation as a cross-section to study the layering in the selected areas, with the aim of elucidating the development of the painting (**Plates 16, 17**). Finally, canvas threads were taken for fibre identification and radiocarbon dating (**App.2.iv**).

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 (**Table App.2.i**) by polarised light microscopy (PLM) combined with UV-visible-near infrared micro-spectrophotometry (**Protocol 2.1**), scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDX) (**Protocol 2.2**), Raman microscopy (**Protocol 2.3**) and some Fourier Transform Infrared Spectroscopy-Attenuated Total Reflectance (FTIR; **Protocol 2.4, Table App.2.ii**).

Organic components were identified by FTIR (**App.2.ii**; **Protocol 2.4**) and subsequently by Gas Chromatography-Mass Spectrometry (GCMS; **App.2.iii**; **Protocol 2.5**). Protein staining of cross-sections using SYPRO® Ruby was also conducted (**App.2.iv; Protocol 2.6**).

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

C.2 Support

The canvas was identified as being based on linen (*Linum usitatissimum* L.) in both weave directions (**App.2.v**; **Protocol 2.7**).

[8] 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].

C.3 Radiocarbon dating

Radiocarbon dating was applied to linen fibres from the canvas support (**App.2.vi; Protocol 2.7**).

The radiocarbon date was determined as 97±23 years before present. After calibration, this yielded a date distribution that included a number of ranges within the 19th century at the 95.4% probability level but for which the most relevant period for the origin of the canvas is probably that which lies across 1904-1917, pre-dating the so-called 'bomb-pulse' period that begins in the mid-1950s.

C.4 Ground

The ground (Sample [13]) was found to be composed primarily of zinc oxide with traces of anhydrite-type and gypsum-type calcium sulfate (present in the form of large, irregular, translucent, colourless particles) and an aluminosilicate clay; calcium carbonate may also be present (**Table App.2.i**).

The ground is primarily bound in a drying oil and has apparently formed metal soaps with the zinc oxide pigment phase (**Table App.2.ii**). However, irregular staining of the ground with SYPRO® Ruby indicates that protein may also be present as a minor component in the ground. (**Table App.2.iv, Plate 17**). Traces of phosphorus were also detected in the ground, suggesting the possibility that casein may be present along with the oil.

C.5 Underdrawing

No underdrawing could be identified on the painting.

C.6 Paint layers: Pigments

The following pigments (**Tables App.2.1, App.2.2**) were identified:

- Zinc oxide ('zinc white') (with a small component of gypsum)
- Cadmium sulfide, possibly with cadmium carbonate ('cadmium yellow')
- Lead chromate ('chrome yellow')
- Zinc potassium chromate hydrate (yellow)
- Mercury sulfide ('vermilion')
- An organic red lake on an aluminium phosphate sulfate substrate
- Earth pigments in red and yellow tones, containing hematite and goethite
- Ultramarine, synthetic, blue
- A bone coke ('bone' or 'ivory' black)

In addition, as additives to various paints as extenders and/or fillers, the following were found:

- Barium sulfate
- Magnesium carbonate
- Calcium sulfate, gypsum type

- An aluminosilicate clay mineral, possibly kaolinite type

The extender barium sulfate was identified as a minor component in the vermilion and ultramarine paints. Calcium sulfate, gypsum type was found with zinc oxide in the white paint sample, and also in the chrome yellow paint (along with a magnesium carbonate extender).

Cadmium carbonate (tentatively identified here) is not infrequently found in association with cadmium sulfide. It is believed to occur either as a phase used during production to form paler shades of cadmium yellow, or as an alteration product. While these can in principle be distinguished on the basis of distribution, further characterisation has not been pursued at this time.

C.7 Paint layers: Binding media

All samples, including both ground and paint layers, indicated the presence of a drying oil in examination with both FTIR and GCMS (**Tables App.2.ii and 2.iii**). GCMS of samples of yellow and white paint further confirmed the presence of linseed oil in both.

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

SYPRO® Ruby staining of a cross-section of sample [13], a white, indicated the presence of protein in both the paint and the ground (**Table App.2.iv**), though it should be noted that protein was not detected by FTIR[9]. The presence of phosphorus in the EDX spectra of the ground could be consistent with use of casein, though given the FTIR and GCMS results this would have to be present as an emulsion with oil.

C.8 Stratigraphy

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

A specimen of white (sample [13]) was examined. This showed a white ground layer followed by a thin layer containing some red particles, a very pale grey layer and a thicker white layer, although the layers are not distinct. Particles displaying a green luminescence in UV indicates the presence of zinc oxide throughout, but are more concentrated in the lowest layer, the ground. As noted above in the discussion of binding media, patchy pink staining of the ground, mainly towards outer edges of sample, indicates that protein is present in the ground, as well as probably in a distinct size layer beneath. Clear pink staining of the upper pale grey and white layers further suggests that a protein is present in the primary paint strata.

The presence of large, irregular, translucent, colourless particles in the ground layer and what appear to be similar, though probably oriented in a laminar position, particles in the upper paint layers was confirmed with Raman microscopy to be calcium sulfate, gypsum type.

[9] SYPRO® Ruby is in principle more sensitive than FTIR, however.

D. Discussion of the findings

D.1 Support, ground and preparatory work

D.1.i The support

The painting has been executed on a medium weight, plain-weave, linen canvas (**App.2.v, Plate 10**) with thread counts of 14.4 per cm in the vertical direction and 18.5 per cm in the horizontal direction (see **Plate 10.d**). The threads seem to preserve a z-twist. The weave is neither particularly open nor particularly tight, with occasional, small interstices observed between the threads.

Some earlier records suggest that the dimensions of the painting were changed: in the acquisition records and in an earlier catalogue entry, its size is given as 1050 x 780 mm[10]. It currently measures 1090 x 800 mm, which would imply a rather considerable extension of 40 mm in height and 20 mm in width. In the investigation of the painting, no evidence was found to support a significant change of dimensions. There is no clear evidence of extension of the paint film along the edges; equally, the tacking margins are preserved and quite broad. If the painting had been enlarged, one would expect rather smaller tacking margins than those currently preserved. These cover the sides of the stretcher bars, as is typical in other works by Goncharaova that have been examined, and the paint film stops primarily at the turnover edge. Consequently, the earlier stated dimensions are more likely to represent a 'sight size' (that is, to the inner dimensions of a frame) than the true size, although the difference of 40mm in one direction could be considered rather large for such an explanation.

The canvas is of a somewhat rough character, with a number of irregular thread inclusions, suggesting it is not of very high quality (**Plate 11.1**), though it is not as coarse as some of the canvases examined in the course of this study. The type of material is more consistent with those produced for domestic or industrial use, rather than canvas produced specifically for fine art painting.

The canvas is fully lined and has also been loose lined, and is affixed to a later (non-original) stretcher (**Plate 5**).

The lack of cusping (variable tension in the support caused by the pulling during stretching) (**Plate 10.a**) is somewhat unusual but could be the result of many different factors. As the painting has been fully lined and remounted on a new stretcher, no evidence for any original inscriptions or labels present on the verso survive; those which are present on the stretcher are of a later date[11].

[10] See Franken (2017a). The size 105 x 78 cm is listed in the invoice (no. 289/ 80, date: 1st April 1980) related to the acquisition of the painting which was bought from the Galerie Gmurzynska. It is also mentioned in the following exhibition catalogue: *Larionov and Goncharova: a retrospective exhibition of paintings and designs for the theatre*, exh. cat. Eds. M. Chamot and C. Gray, Arts Council: London (1961), unpaginated, cat. no. 117 L.
[11] These are described in more detail in V. Franken, *AAR0955.F ML 1319 Conservation Report* (2017).

D.1.ii Priming

The canvas has been primed with a thin white ground, applied to the stretched canvas by hand (i.e. it is not an industrially prepared canvas) (**Plates 11.a, 11.c, 12.a**). It seems to have filled the canvas interstices rather well (**Plate 12.a**). This is evidenced in a cross-section prepared from a sample taken from the painting; in Sample [13], (**Plate 16**) the thickness of the white ground is seen to be proportionally thinner than that of the overlying paint layers, even where it is at its thickest. It is composed of zinc oxide ('zinc white') mixed with what may be an oil and casein emulsion. The ground tests positively for oil (FTIR) and stains positively for protein (**App.2.iv, Plate 17**). No evidence for an isolation layer (a glue or oil sealant applied to the canvas before the priming) was noted and, as stated earlier, it was not possible to examine the verso of the canvas due to the presence of a lining.

D.1.iii Underdrawing

Examination of the painting under magnification did not reveal any evidence of the use of underdrawing (such as diffuse material remaining on exposed white ground). Nor was evidence of such a working stage found in the high intensity short-wave IR image (SWIR) (**Plate 7**). However, as the surface is very solidly painted, with only a few small areas of ground exposed, this fact does not rule out the possible use of some form of preparatory work.

D.2 Paint, pigments and binding media

D.2.i General observations

The condition of the painting is fair – it has been lined, resulting in some flattening of impasto, and exhibits brittle crack that has led to loss and subsequently restoration in the form of retouching/overpainting[12]. There is a good deal of retouching in the area of the face, but it is generally distributed in all areas of the painting (**Plates 13.a, 13.b, 14.a**). This is perhaps best seen in the UV image (**Plate 2**) and by comparing the various forms of imaging (**Plate 8**). The majority of the retouching and overpainting present on the work were present when the painting was acquired by the Museum. Differences related to paint application and the painting's condition may be found when comparing early photographs of the *Portrait* and its present condition, which suggest that these regarding who undertook the interventions took place before 1973 (and possibly after 1961)[13].

[12] These are described in more detail in V. Franken, *AAR0955.F ML 1319 Conservation Report* (2017).

[13] In an exhibition catalogue published in 1973 there is a photograph of the painting in which the alterations are visible. *Selected European Masters of the 19th and 20th Centuries* [exh. cat. 16 June to 7 September 1973, Marlborough Fine Art Limited, London] Marlborough Fine Art Ltd.: London (1973) pp. 52 and 53 (photo), cat. no. 26.

[13] The exhibition catalogue '*Larionov – Gontcharova'* with the photograph was published in 1961, which means at a time the artist was still alive. No changes are seen here; however, this does not necessarily imply that a current photograph was used. The retouching is apparently solvent soluble, unlike the paint: Franken (2017a) *op. cit*. Therefore, it is highly unlikely that the retouching might have been undertaken by Goncharova (who would have most likely simply used oils), rather than a restorer (who would have been more likely to employ a more soluble medium).

The painting is executed in a very sure and spontaneous manner, juxtaposing Goncharova's characteristic jagged brushwork (as in the upper background, where passages of zig-zagging strokes may be seen) with other passages comprised of overlapping, shorter strokes, and others that employ surface texturing as a means of creating visual variety (in the blacks of the hat and jacket). This use of varied brushwork effects is clearly resolved in the X-ray image, which reveals the incredible variety of handling of the different surfaces (**Plate 9**)[14].

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**) as well as spread thinly in other passages. The lining of the painting may have evened off the local stresses that might have otherwise been present between paint and canvas, especially in the lower half of the painting, creating a very flat, uniform surface in that region, which is punctuated by the texture of the loaded impasto brushstrokes (**Plates 13.b, 14.b**). However, along the upper and right edges of the painting, deformations have formed in the canvas that suggest that the lining may be failing locally (**Plate 4**).

No use of transparent glazes was observed; the colours remain intense. While the surface aspect is largely quite matte (**Plates 13, 14.a**), some paints seem more medium rich and have a slightly glossier surface (**Plates 12.b, 14.b, 14.c**). The painting does not show evidence of having been varnished, in keeping with the artist's preference for a brightly coloured, rough, matte finish. As noted above, the paint continues to the turnover edge, and shows no sign of discontinuity, suggesting that it retains its original dimensions (**Plate 11.c**).

D.2.ii Paint: pigment and binding medium

The painting displays a brittle crack pattern in the thicker regions of paint consistent with an oil painting of some significant age. These cracks appear to be localised and associated with the application and type of paint, rather than of a more consistent nature that refers to stresses in the canvas. Another feature observed here is the presence of two fingerprints in the paint film (**Plates 12.b, 12.c**). One of these (**Plate 12.c**) appears to be associated with original paint, not with retouching, though this could be confirmed through sampling if this were desired. The other, in the blue paint (**Plate 12.b**) does not appear to be part of the original structure.

In this painting, both the artist-applied ground as well as the white paint are based on the pigment zinc white. Four tones of yellow (yellow earth, cadmium sulfide, lead chromate and zinc potassium chromate hydrate) have been used, three red tones (vermilion, red earth and red lake), one blue (ultramarine) and one black pigment (an ivory or bone black) were identified. No green pigments were noted.

The cross-section prepared (Sample [13]) confirms the observations made on the surface, and with the various forms of imaging: the ground is solid and reasonably smooth, the paint worked freely and directly over it (**Plates 16, 17**). Mixing has taken place both on the palette,

[14] The use of reserves is very common in Goncharova's work; though used here, the effect is less pronounced than in other paintings, due to the extensive passages of varied brushwork and large forms of the composition. See Rioux, Aitken and Duval (1998) *op. cit.* pp. 19, 25, 26.

and on the brush, sometimes wet-in-wet directly on the canvas. This direct application has led to quite thin passages where the canvas weave and fibrous texture of the ground remain fully visible (**Plates 14.b, 14.c**), and others where it is fully obliterated by a heavy build-up of impasto (**Plates 12.b, 12.c, 13.a**).

D.2.iii Materials analysis and implications for dating

The painting has been dated to 1913 on the basis of an exhibition catalogue of the same year where it is so described[15].

The radiocarbon measurement of the canvas gave an origin for it between 1810-1926 at the 95.4% probability level, though pre-dating the so-called 'bomb-pulse' period that begins in the mid-1950s. In addition to this a period of 3-5 years typically needs to be allowed for processing into canvas and use by the artist. This would be compatible with the art historical date given to it.

The materials identified in the painting (pigments and binding media) are likewise compatible with the supposed date (although they also continued in use after that time). 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[16]. 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 great spontaneity, with a wide range of paint handling used to enliven the different forms. The textured, varied surface of the paint, not the support, is dominant. The presence of several fingerprints in the paint film raises an interesting question as to whether these might be documented and compared with other prints in works by Goncharova, should they be identified. The results of the examination have not found any evidence that would speak against the proposed date of the work, 1913. Materials and techniques noted are consistent with other works of the same period by the artist.

[15] Apparently, it was first exhibited in Moscow in 1913: *Vystavka kartin Natalii Sergeevny Goncharovoi. 1900-1913* [exhibition catalogue, Khudozhestvenny Salon, Moscow, 1913], Moscow: publisher not identified (1913), cat. no. 572. See also Franken (2017b) as cited in note 5.
[16] Rioux, Aitken and Duval (1998) *op. cit.*

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Bhavini Vaghji	Senior Scientist	Materials analysis
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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*[17]	*Analysis*
1		Red	682/913	PLM, SEM-EDX, Raman
2		Dark Transparent Red	680/908	PLM, SEM-EDX, Raman
3		Darker Yellow	684/984	PLM, SEM-EDX, Raman, FTIR, GCMS
4		Bright Yellow	695/983	PLM, SEM-EDX, Raman, FTIR
5		Dark Blue	558/986	PLM, SEM-EDX, Raman
6		Light Blue	567/1014	PLM, SEM-EDX, Raman
7		Light Yellow Green	145/999	PLM, SEM-EDX, Raman
8		Dark Green	50/900	PLM, SEM-EDX, Raman
9		Light Yellow Brown	245/313	PLM, SEM-EDX, Raman, FTIR
10		Brown	343/473	PLM, SEM-EDX, Raman

[17] 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*[17]	*Analysis*
11		White	350/278	PLM, SEM-EDX, Raman, FTIR, GCMS
12		Black	681/253	PLM, SEM-EDX, Raman, CSA
13		White/Ground	0/325	PLM, SEM-EDX, Raman, FTIR, CSA, SYPRO® Ruby Staining
14		Canvas fibre	0/0	FTIR
15		Darker yellow (as 3)	684/984	GCMS
16		White (as 11)	350/278	GCMS

App.1.ii Cross-sectional analysis

Results are shown in **App.5**, **Plates 16, 17.**

App.2 Materials analysis summary results

Protocols:

[P.2.1] Polarised light microscopy (PLM)
[P.2.2] Scanning electron microscopy and 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)
[P.2.6] Cross-sectional protein staining with SYPRO® Ruby
[P.2.7] Fibre Identification
[P.2.8] Radiocarbon dating

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	Red	**S, Hg**	Ba	*Al, Si*	**987 (vw), 343 (w), 285 (vw), 253 (vs), 143 (vw), 107 (vw)**	**Mercury sulfide [P0010] (main)** **Barium sulfate (minor)**
2	Dark transparent red	**Al**	P, S	*Na, Si, Cl, Ca, Ba*	-	Organic red on Al/P/S substrate
3	Darker yellow	**S, Cd**	Mg	*Al, Si, Cl, Ca*	-	Cadmium sulfide
4	Bright yellow	**Mg**	Al, S, Ca	*Si, K, Cr, Pb*	**1008 (vw), 970 (vw), 841 (s), 403 (vw), 377 (vw), 360 (w), 338 (vw), 328 (vw), 183 (vw), 138 (vw)**	**Lead chromate [P2238]** **Calcium sulfate, gypsum type**
5	Darker blue	**Si**	Na, Al, S	*K, Ca, Ba*	**583 (vw), 547 (m), 377 (vw, br), 258 (vw)**	**Ultramarine**
6	Lighter blue	-	Na, Al, Si, S	*Cl, K, Ca, Fe, Ba*	**987 (vw), 551 (w)**	**Ultramarine** **Barium sulfate (trace)**
7	Light yellow-green	**Cr**	Mg, K, Zn	*Al, Si, S, Ca*	1439 (vw), 1295 (vw), **941 (w), 893 (w), 872 (vs), 773 (vw), 410 (vw), 376 (vw, sh), 358 (vw), 344 (w), 142 (vw), 113 (vw)**	**Zinc potassium chromate hydrate [P0085]**
8	Darker green	-	Na, Mg, Al, Si, S, Cr	*K, Ca, Zn, Ba, Pb*	**939 (vw), 872 (vw), 840 (vw),** 590 (vw), **552 (w),** 371 (vw), **359 (vw),** 338 (w)	**Ultramarine** **Zinc potassium chromate hydrate** **Lead chromate**
					872 (vw), 840 (vw), 591 (vw), **552 (w), 359 (vw)**	**Ultramarine** **Zinc potassium chromate hydrate** **Lead chromate**
9	Light yellow-brown	**Si**	Al, Fe	*P, S, Cl, K, Ca, Ti, Zn*	**547 (vw), 463 (vw), 402 (w), 301 (vw), 248 (vw), 145 (vw)**	**Goethite (as an earth)**
10	Red-brown	**S, Ca**	Fe	*Mg, Al, Si, Zn, Ba*	**1311 (vw, br),** 1226 (vw), **1007 (vw), 609 (vw), 499 (vw), 409 (w), 292 (w), 225 (w)**	**Hematite** **Calcium sulfate, gypsum type**
11	White	**Zn**	S, Ca	*Al, Si, K, Ba*	1440 (vw), **1007 (w), 494 (vw), 437 (vw), 415 (vw), 379 (vw), 329 (vw), 220 (vw)**	**Zinc oxide (main)** **Calcium sulfate, gypsum type (minor)**
12	Black	**P, Ca**	-	*Mg, Al, Si, S, Fe, Zn*	**1587 (w, br), 1305 (w, br)**	**Carbon-based black (bone or ivory black)**

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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		
13	White ground	**Zn**	-	*Al, Si, P, S, K, Ca*	**1017 (vw), 438 (w)**	**Zinc oxide (main)** **Calcium sulfate, anhydrite type (trace)** Clay minerals (trace)

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
3	Darker yellow	**2919 (w), 2852 (w), 1735 (w), 1543 (w), 1458 (w), 1403 (w), 1166 (vw),** 1099 (w), **1029 (w), 1005 (w), 907 (vw), 798 (w), 752 (vw), 676 (vw),** 612 (vw)	**Aluminosilicate clay mineral, possibly kaolinite type** **Oil** **Metal soap formation** **Possibly cadmium carbonate**
4	Bright yellow	**3378 (vw, br), 2922 (vw), 2852 (vw), 1738 (vw), 1476 (vw), 1418 (vw), 1102 (w)**	**Magnesium carbonate** **Calcium sulfate type white** **Binding media component (type unidentified)**[18]
9	Light yellow-brown	**2916 (vw), 2852 (vw), 1741 (vw), 1701 (vw), 1546 (vw), 1531 (vw), 1455 (vw), 1151 (vw),** 1099 (w), **1029 (w), 1008 (w), 910 (vw), 798 (w), 694 (vw),** 633 (w)	**Goethite** **Aluminosilicate clay mineral, possibly kaolinite type** **Oil** **Metal soap formation**
11	White	**3523 (w), 3398 (w), 2950 (vw, sh), 2918 (m), 2850 (w), 1735 (w), 1714 (vw), 1705 (vw), 1684 (vw), 1618 (w),** 1574 (vw), 1558 (vw), **1541 (w), 1456 (w), 1446 (vw), 1416 (vw), 1400 (vw, sh), 1379 (vw), 1319 (vw), 1110 (vs), 1003 (vw),** 731 (vw), **719 (vw), 669 (w)**	**Calcium sulfate, gypsum type** **Oil**[19] **Metal soap formation, zinc-based**[20]
13	White ground	**3514 (m), 3398 (w), 3243 (vw), 2952 (vw, sh), 2918 (m), 2850 (w), 1738 (w), 1684 (vw), 1618 (m), 1574 (vw, sh), 1541 (s), 1454 (w), 1410 (w), 1401 (vw, sh), 1320 (vw), 1110 (vs), 1005 (vw), 881 (vw, sh), 722 (vw), 668 (m)**	**Calcium sulfate, gypsum type** **Calcium carbonate**[21] **Oil**[22] **Metal soap formation, zinc-based**[23] **Metal soap formation**

[18] The four peaks present are related to the presence of binding medium; however, it is not possible to identify a particular type of substance as a fuller spectrum would be needed to distinguish between the various possibilities (such as oils, alkyds, natural resins etc.).

[19] The characteristic peak of oils occurring at around 1160 cm^{-1} was not observed in the spectrum due to the presence of calcium sulfate, gypsum type whose peaks were masking this characteristic peak of oil however it is assumed that oil is present due to the formation of metal soaps.

[20] 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.

[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. However, the SEM-EDX

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	
15	25.667	5.044×10^8	29.587	2.429×10^8	P/S = 2.08
16	25.666	6.904×10^8	29.586	3.351×10^8	P/S = 2.06

The P/S value of Sample [15], darker yellow paint, was 2.08, consistent with **linseed oil**.

The P/S value of Sample [16], white paint, was 2.06, consistent with **linseed oil**.

App.2.iv SYPRO® Ruby protein staining

Table App.2.iv SYPRO® Ruby stain results for Sample [13]

Layer	*EDX*	*FTIR*	*SYPRO® Ruby stain*	*Interpretation*
Ground	**Zn** *Al, Si, P, S, K, Ca*	Oil	Patchy pink staining, stronger towards outer edges of sample.[24]	Protein in ground layer
Paint	-	Oil in dark yellow, light yellow-brown, white. Binder unidentified in bright yellow	Clear pink staining of pale grey and white paint layers.	Protein in paint layers

data did not identify any lead but did identify calcium and therefore it is assumed that the carbonate is in the form of calcium carbonate.

[22] As note 19, above.

[23] As note 20, above.

[24] The darker staining at the edges of the ground layer appears to correspond to areas at the periphery of the sample, rather than to a distinct layer at the base of the cross section. There is not sufficient evidence to identify this as a size layer.

App.2.v Fibre Identification of the Canvas

Table App.2.v Canvas fibre identification, Sample [14]

Sample	***Observations under PLM***	***Interpretation***
Vertical	Nodes across fibres, parallel extinction, s-twist A few narrow fibres with lower birefringence, also with nodes across, some with slight twist (extinction more sweeping, difficult to judge twist direction)	Bast fibre, probably linen (*Linum usitatissimum L.*)
Horizontal	Nodes across fibres, parallel extinction, s-twist A few narrow fibres with lower birefringence, also with nodes across, some with slight s-twist	Bast fibre, probably linen (*Linum usitatissimum L.*)

App.2.vi Radiocarbon measurement

Radiocarbon dating is a method for determining age estimates of formerly living organic materials[25]. Carbon has three naturally occurring isotopes, ^{12}C, ^{13}C and ^{14}C. Both ^{12}C and ^{13}C are stable, but ^{14}C decays by very weak beta decay to nitrogen (^{14}N) with a half-life of approximately 5,730 years. While alive, organic materials continue to exchange carbon with the environment, such that they are in equilibrium. On death, the ^{14}C component begins to decay, such that over time the relative amount decreases. Measuring the level of ^{14}C remaining in the material then allows for a date to be estimated. This must be additionally calibrated against natural historical variation in relative ^{14}C levels in the environment, for which there are accepted standard curves expressing the changes over time[26].

Prior to radiocarbon measurement, fibre identification was undertaken, and the canvas sample was pre-tested using FTIR to ascertain the presence of any contaminating material that could influence the outcome. As noted elsewhere, the fibre was identified as a bast type, probably linen (*Linum usitatissimum* L.). FTIR indicated the presence of possibly an oil in addition to the cellulose of the fibre[27].

The canvas sample was then submitted to the Laboratory of Ion Beam Physics, ETHZ at the Swiss Federal Institute of Technology (*Eidgenössische Technische Hochschule Zürich*) for radiocarbon dating (see **Protocol 2.7**).

[25] Based on from the websites of the NDT Resource Center, http://www.ndt-ed.org/EducationResources/CommunityCollege/Radiography/Physics/carbondating.htm and the website of the Oxford Radiocarbon webinfo site: http://c14.arch.ox.ac.uk/embed.php?File=webinfo.html, both consulted on 3 February 2013.

[26] For example, that used here is one known as IntCal13.

[27] Non-cellulosic materials are aimed to be removed by the sample pre-treatment process prior to the radiocarbon measurement.

Table App.2.vi.i Radiocarbon measurement										
Sample-	**Sample**	**Material**	**C14 age**	**±1σ**	**F14C**	**±1σ**	**δC13**	**±1σ**	**mg C**	**C/N**
Nr.	**Code**		**BP**				**‰**			
ETH-77071	AAR0955.F.14	textile	97	23	0.988	0.0028	-24.3	1	1	311.16

The radiocarbon date was determined as 97 years b.p. ±23 years. After calibration, this yielded a date distribution for which the most relevant period for the origin of the canvas lies 1810-1926 at the 95.4% probability level, pre-dating the so-called 'bomb-pulse' period that begins in the mid-1950s.

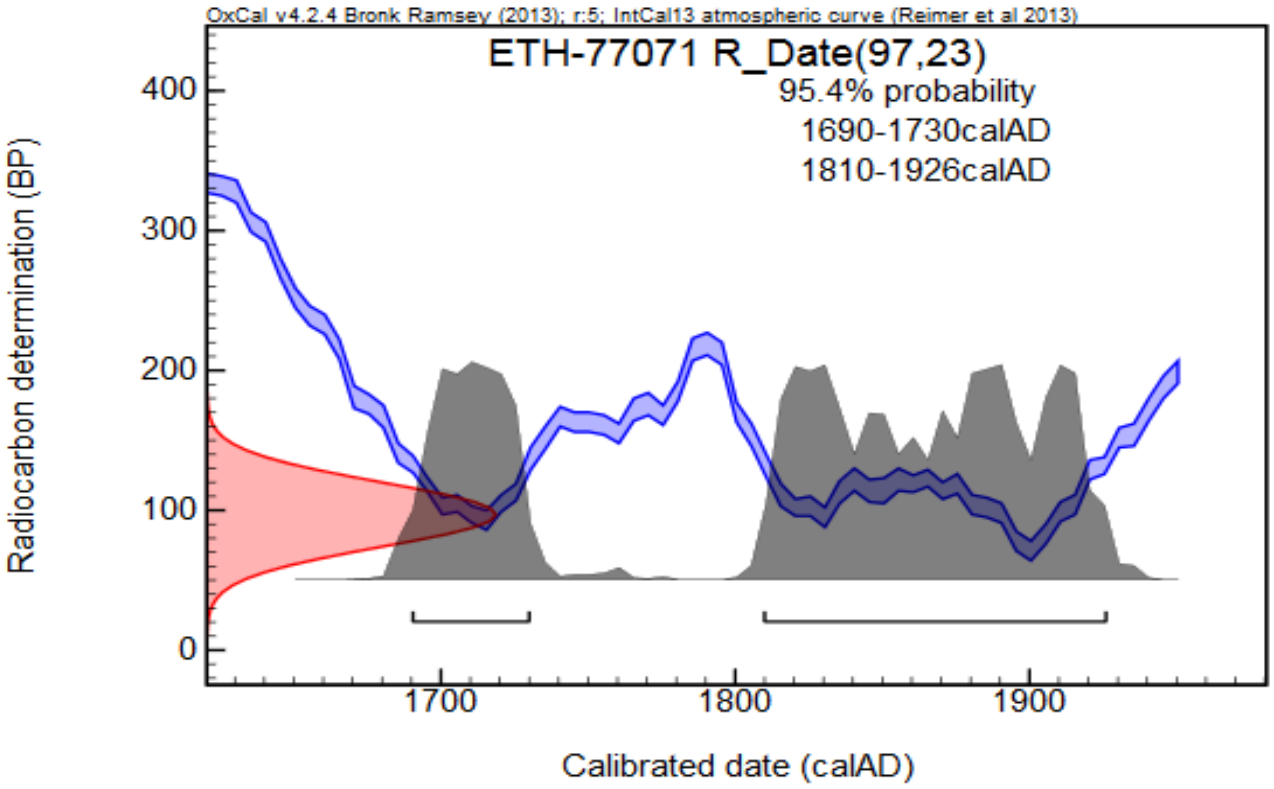

Figure App.2.vi.ii Radiocarbon determination.

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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 (X-ray)
[P.3.7] Thread counting and weave analysis

App.4 Plates

Plate 1. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Recto, visible light.**
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050879_08, www.kulturelles-erbe-koeln.de/documents/obj/05020008

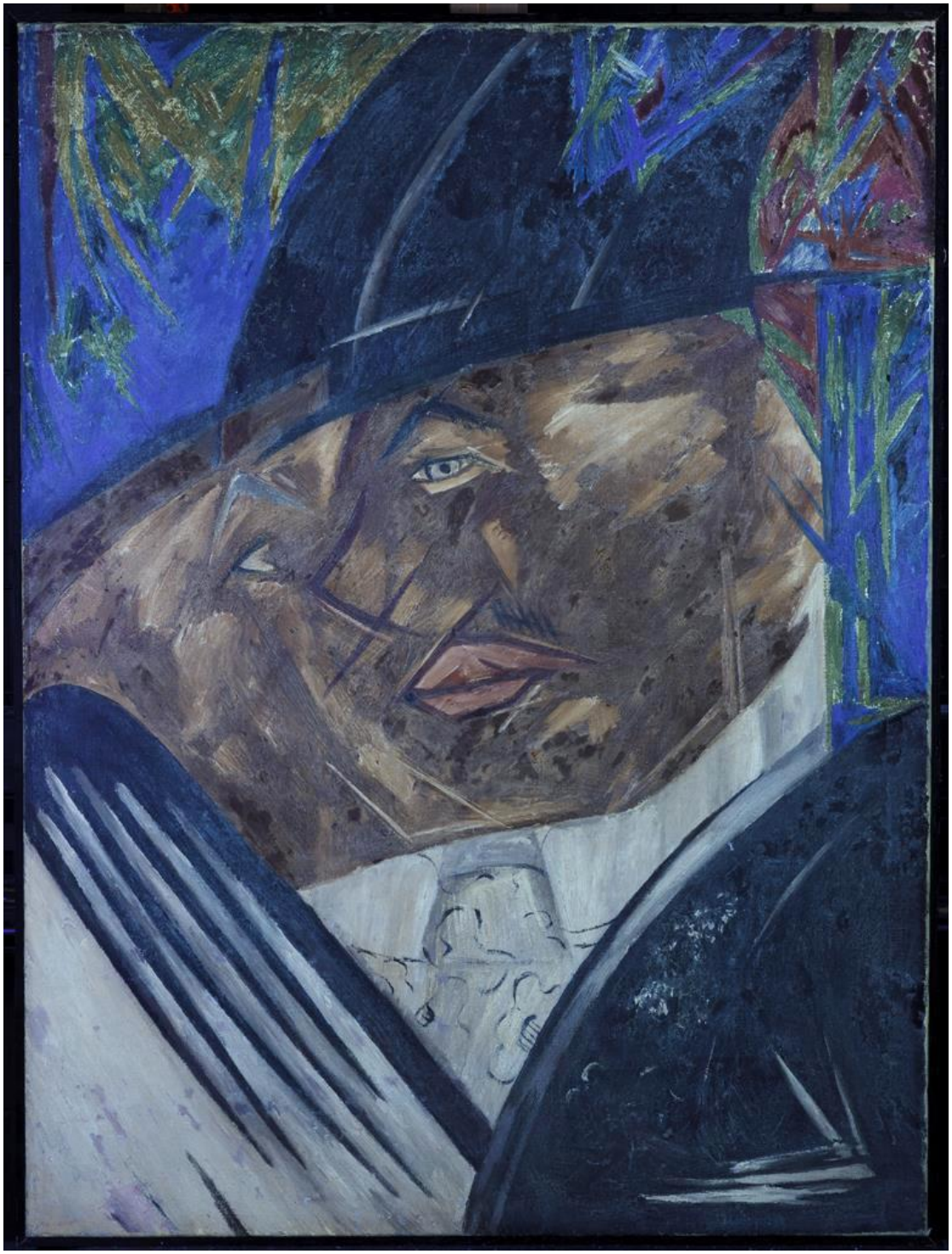


Plate 2. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Recto, UV light.**
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050879_06, www.kulturelles-erbe-koeln.de/documents/obj/05020008

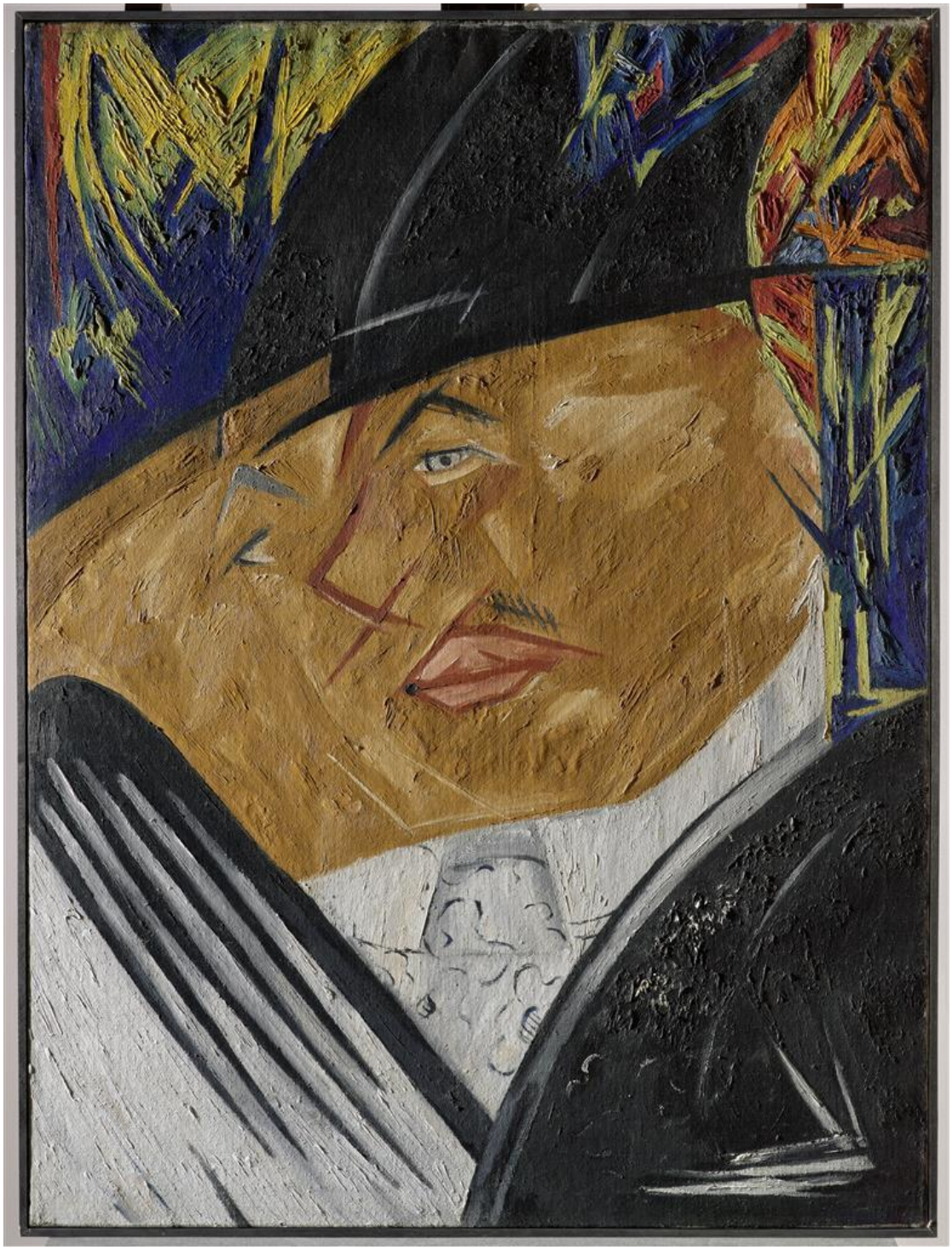


Plate 3. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Recto, raking light.**
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050879_04, www.kulturelles-erbe-koeln.de/documents/obj/05020008

Plate 4. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Recto, 3D laser scan.**

Plate 5. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Verso, visible light.**
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050879_02, www.kulturelles-erbe-koeln.de/documents/obj/05020008

Plate 6. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Verso, UV light.**
Rheinisches Bildarchiv Köln, Patrick Schwarz, rba_d050879_07, www.kulturelles-erbe-koeln.de/documents/obj/05020008

Plate 7. Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **Recto, SWIR image.**

a.

b.

c.

Plate 8. Details: a.) raking light, b.) UV illumination, c.) SWIR image.

Plate 9.a Natalia Goncharova, *Portrait of Larionov*, 1913, collection Museum Ludwig: Inv. Nr. ML 1319. **X-ray image.**

Plate 9.b X-ray image before digital compensation for the stretcher bars.

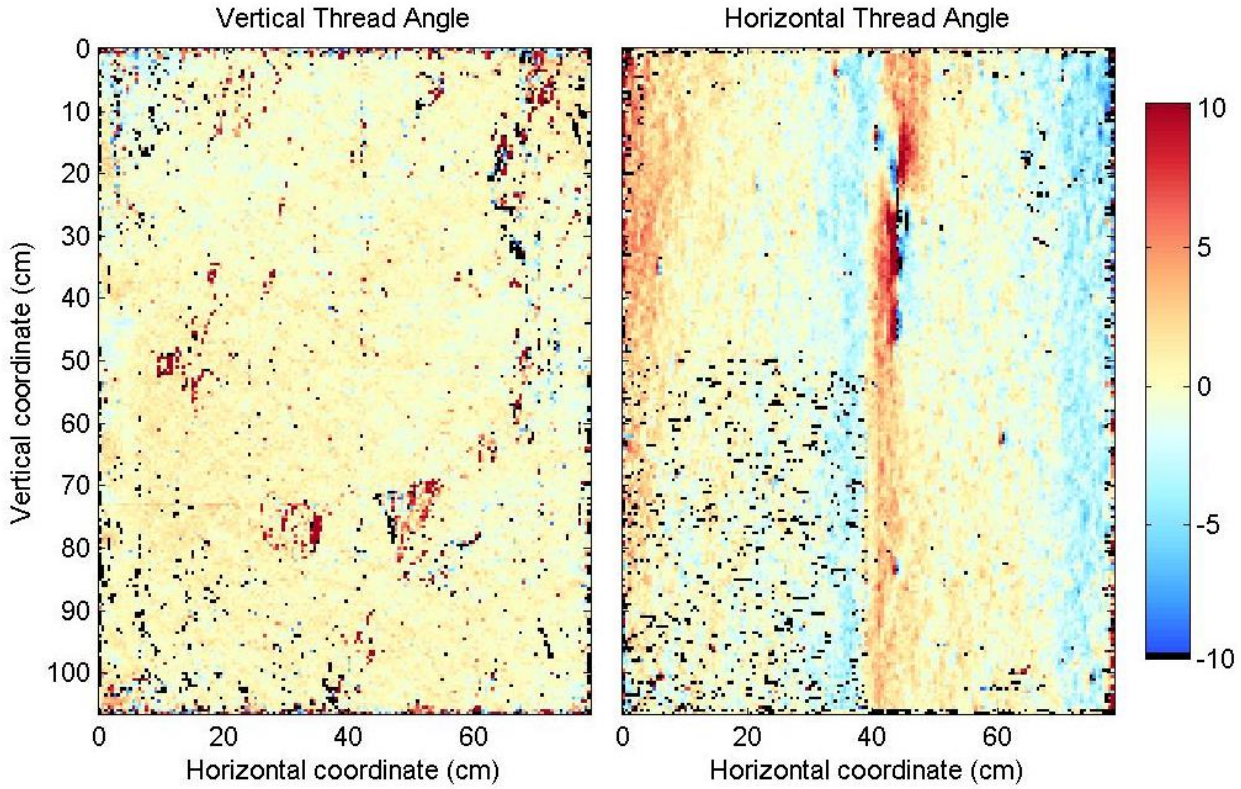


Plate 10.a Maps showing variation in canvas thread angle.

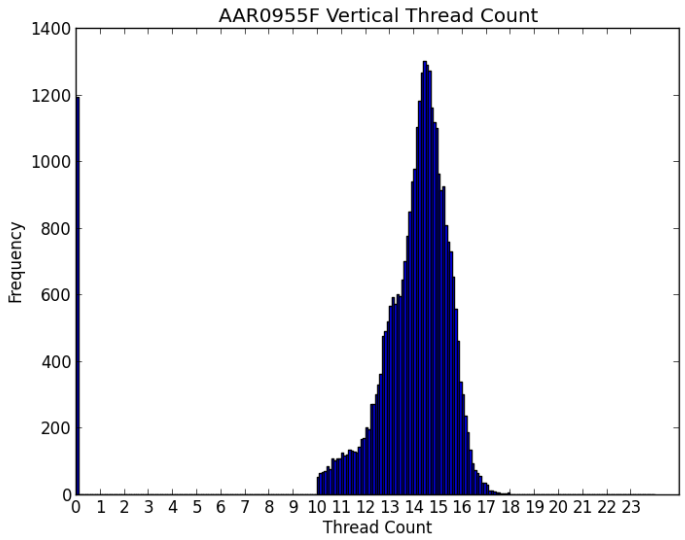


Plate 10.b Histogram of vertical thread count readings.

Showing variation in thread count per centimetre.

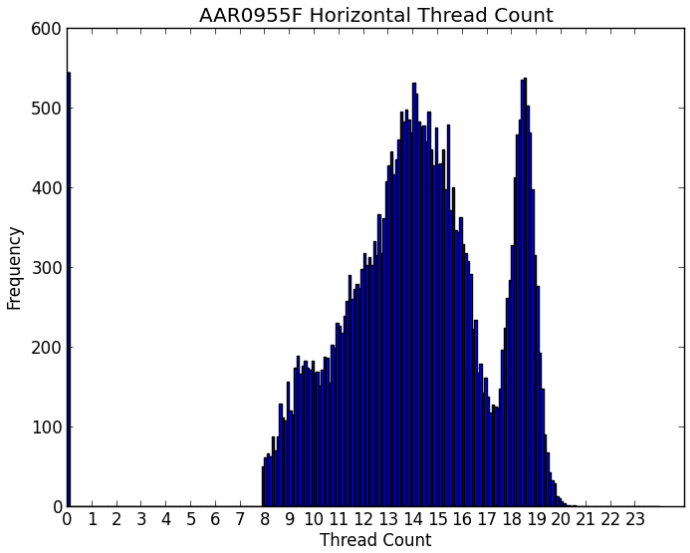


Plate 10.c Histogram of horizontal thread count readings.

Showing variation in thread count per centimetre.

Plate 10.d Table of thread count data (threads per centimetre)

	Mean	Estimated thread count (mode)
Vertical	14.16	14.4
Horizontal	14.37	14.0 and 18.5 (bimodal)

Plate 11.a Detail of canvas, tacking edge.

Showing the simple tabby weave with some slubby inclusions. The fibre a bast type, probably linen.

Plate 11.b Detail of canvas edge from verso.

Showing multiple layers of canvas and lining.

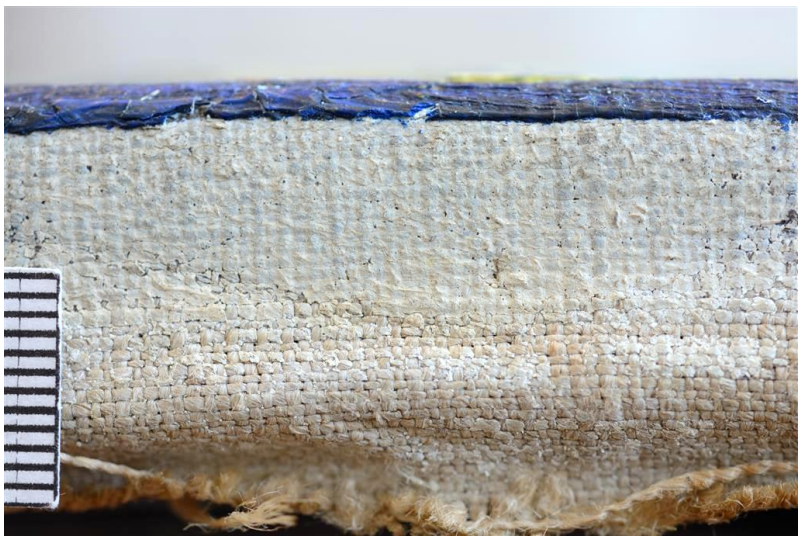


Plate 11.c Detail of tacking margin, left, showing the priming.

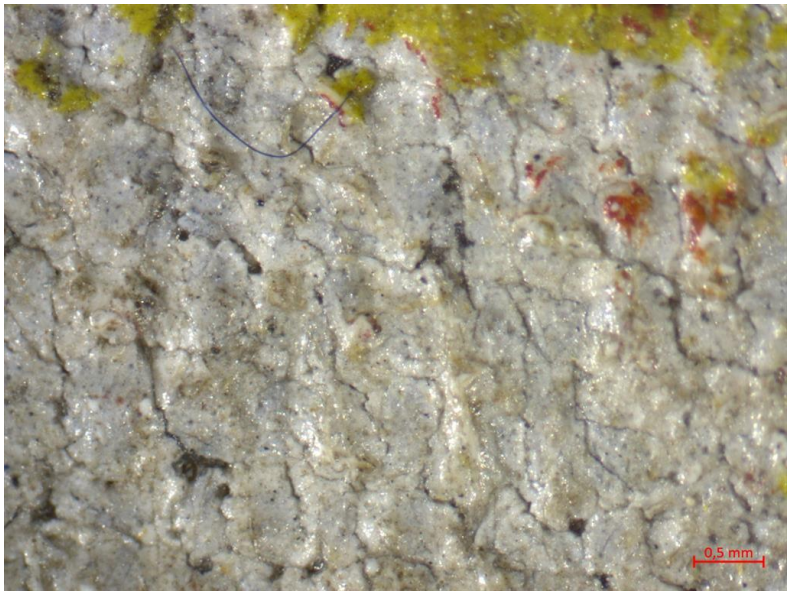


Plate 12.a Microscope detail of the surface of the white priming, recto.

It is relatively smooth and thinly applied, allowing the canvas texture to show.

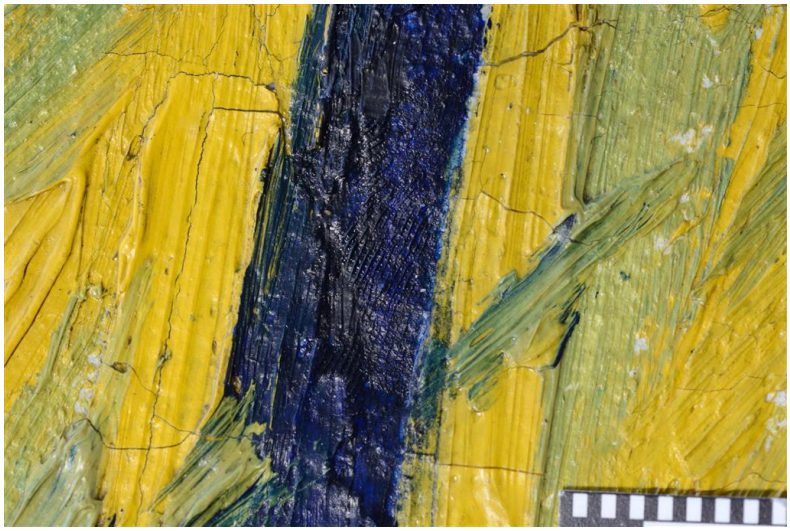


Plate 12.b Macro detail of the paint surface, showing a partial fingerprint in the blue paint.

This print, in comparison to that in Plate 12.c, is clearly not part of the original surface structure.

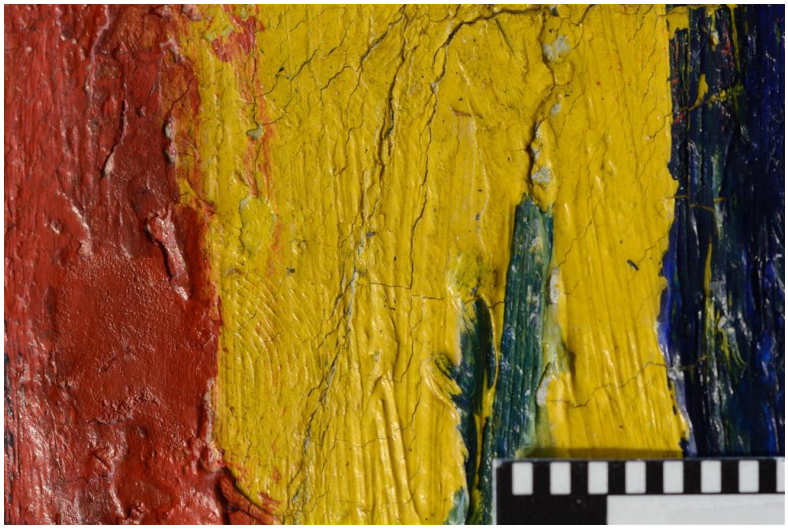


Plate 12.c Macro detail of the paint surface, showing a partial fingerprint in the yellow paint, upper left.

This looks to be in the original paint film.

Plate 13.a Detail showing wet-in-wet brushwork, as well as brittle cracking with repairs (above).

Plate 13.b Detail (left) showing brittle cracking and flattened impasto with repairs.

Plate 14.a Macro detail of the mouth.

An area of loss that has been inpainted is visible, just left of centre.

Plate 14.b Macro detail of the paint surface, showing flattened impasto.

Plate 14.c Macro detail of the paint surface, right of the head.

The texture of the canvas is visible in thin areas, fully covered where the paint is more thickly applied.

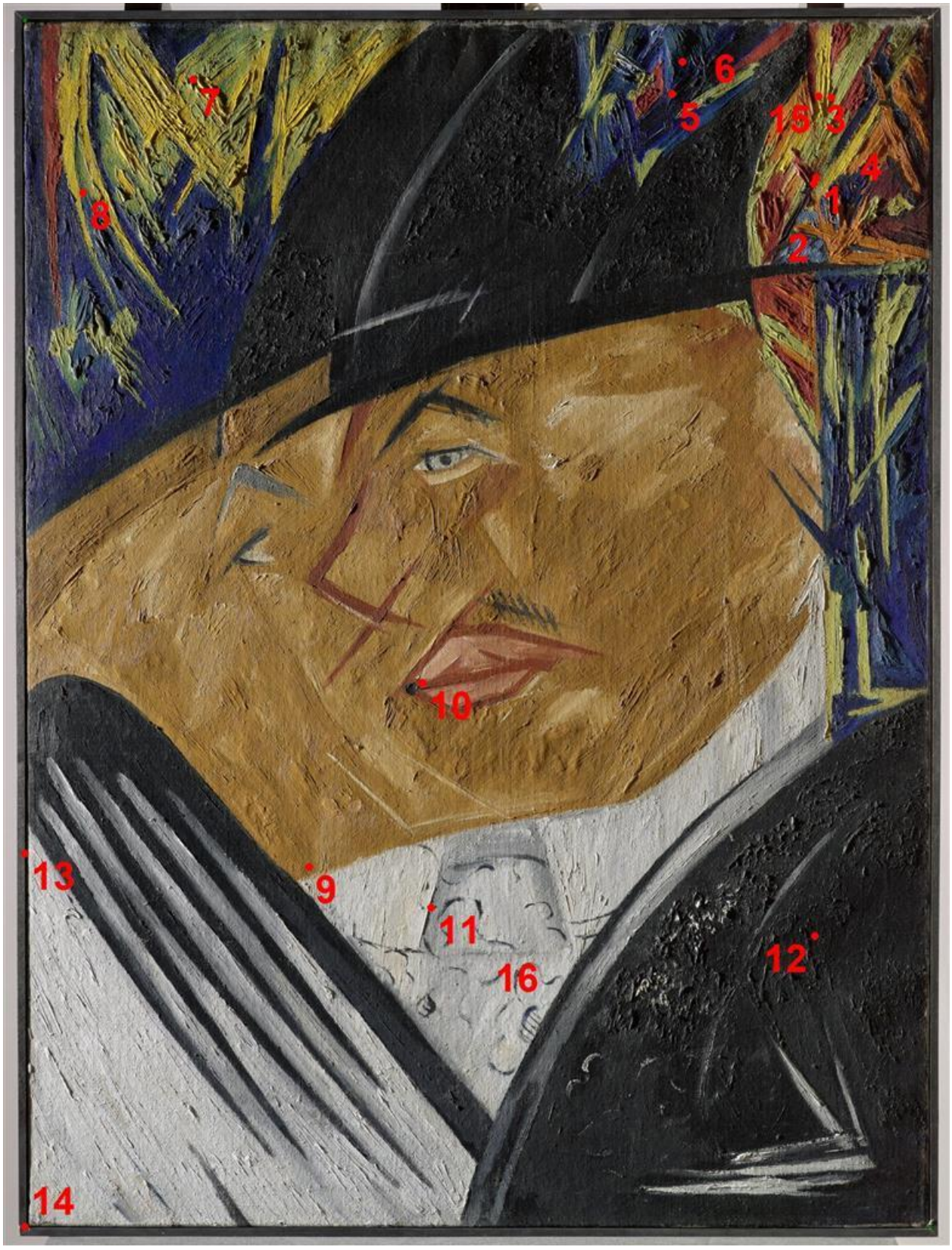
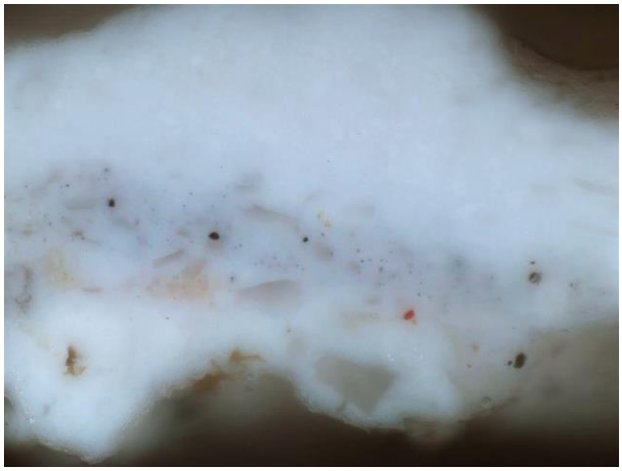
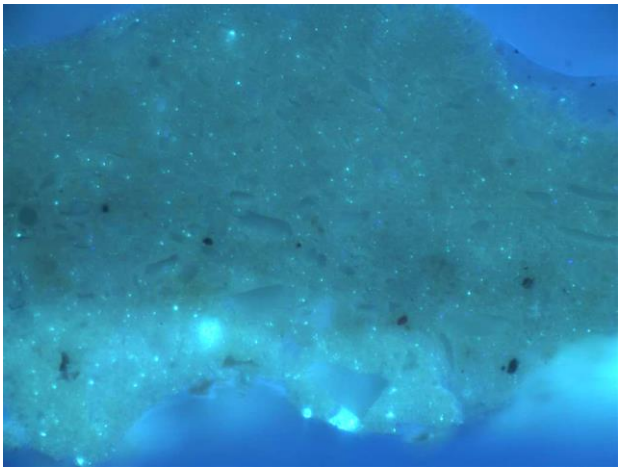


Plate 15. Image showing approximate location of samples taken for materials analysis.

App.5 Cross-sections[28]

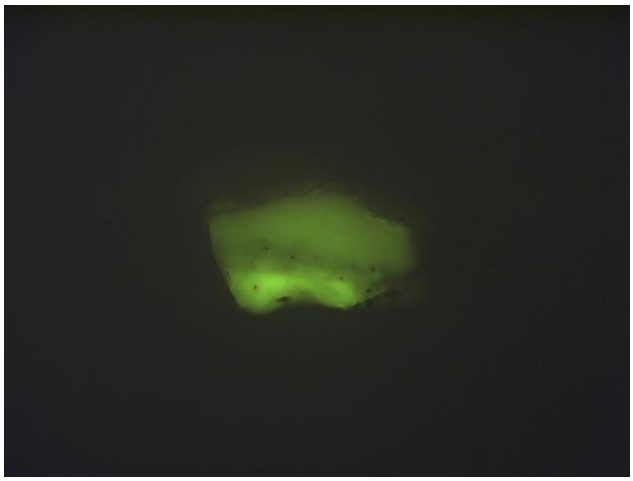


a.

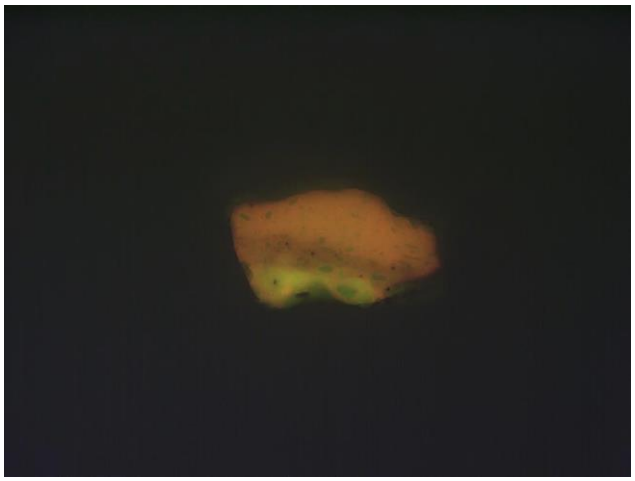


b.

Plate 16. Cross-section, Sample [13].
Image ~260µm high. White. The sample has a white ground layer followed by a thin layer containing some red particles, a very pale grey layer and a thicker white layer, although the layers are not distinct. The large, translucent, sharp edged particles visible in all of the layers are gypsum. Particles displaying a green luminescence in UV, indicating the presence of zinc oxide, are visible throughout the sample, but appear more concentrated in the lowest layer.



a.



b.

Plate 17. Cross-section, Sample [13], stained with SYPRO® Ruby.
Image ~1mm high viewed with Leica I3 filter before (left) and after (right) staining. Patchy pink staining of the ground layer indicates that some protein is present in the ground. Clear pink staining of the upper pale grey and white layers suggests that a protein is also present in the primary paint strata.

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