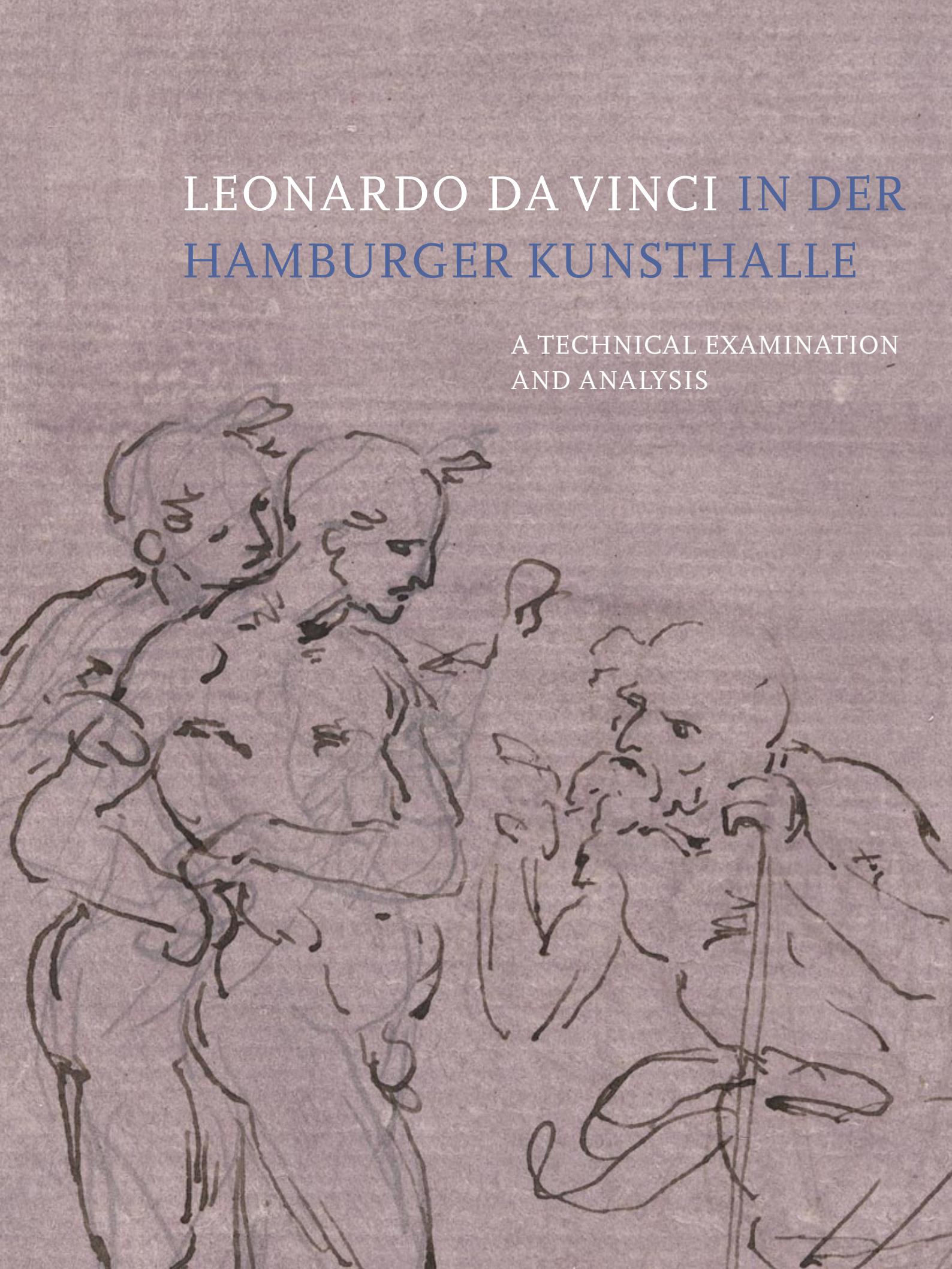
LEONARDO DA VINCI IN DER HAMBURGER KUNSTHALLE

A TECHNICAL EXAMINATION AND ANALYSIS



A TECHNICAL EXAMINATION AND ANALYSIS OF FOUR DRAWINGS BY LEONARDO DA VINCI IN THE COLLECTION OF THE DEPARTMENT OF PRINTS AND DRAWINGS

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INTRODUCTION

The Department of Prints and Drawings at the Hamburger Kunsthalle has held four drawings by Leonardo da Vinci (1452–1519) ever since the museum was founded. They are part of a comprehensive bequest by the Hamburg art dealer Georg Ernst Harzen (1790–1863), given to the City of Hamburg for the use of the Kunsthalle, which was opened in 1869.

By virtue of their provenances[1] and established stylistic placement within the oeuvre of Leonardo,[2] these drawings are considered authentic works by the master. Thus far, it had not been possible to carry out further technical examinations or instrument-based analyses of them. In view of investigations undertaken on other collections, it had become a desideratum that such work should be done. To coincide with the exhibition, "Leonardo da Vinci – the Drawings in the Hamburg Kupferstichkabinett", the chance to rectify this omission presented itself.

For the purpose of this essay, we were able to refer to a number of detailed examinations of drawings by Leonardo da Vinci and other Renaissance artists.[3] Alongside other source material, we consulted these studies to contextualise the findings of our own materials analyses and instrument-based investigations.

THE DRAWINGS

All four drawings (see Appendix) are dated to the period between c. 1475 and 1505. Leonardo was apprenticed to Andrea del Verrocchio (1435–1488) until c. 1477. He was based in Florence until he left for Milan c. 1481–83, in turn leaving that city in 1499. He relocated several times in the years around 1500 and then lived, for the most part, in Florence until 1506.[4] The works he executed during this period reflect the range of materials he employed throughout his life in his sketches and studies on paper, materials also typically used by other Renaissance artists.

PAPER

The sheets of paper used by Leonardo are characterised by a well dispersed fibrous raw material. They feature brownish fibres and the occasional small residue of plant material, but rarely contain blue and red fibres, if at all.

The sheets of paper used by the artist for "Aristotle and Phyllis" and "Head of an Old Man or an Old Woman" are closer in nature to vellum than the laid paper employed at the time. Laid lines are hard to distinguish even in transmitted light, or microscopically, chain lines and shadow zones appear to be missing.[5]

For the drawing of "Saint Sebastian", Leonardo used a fine translucent paper, with the result that the design drawing on the verso of the sheet is visible to the recto. The wire profile with shadow zones running alongside the chain lines is easily discernible in transmitted light. (see Fig. 1).

The drawing "Studies for an Adoration of the Shepherds" was executed by the artist on a heavier paper characterised by distinct laid and chain lines. The chain line to which the watermark was fixed does

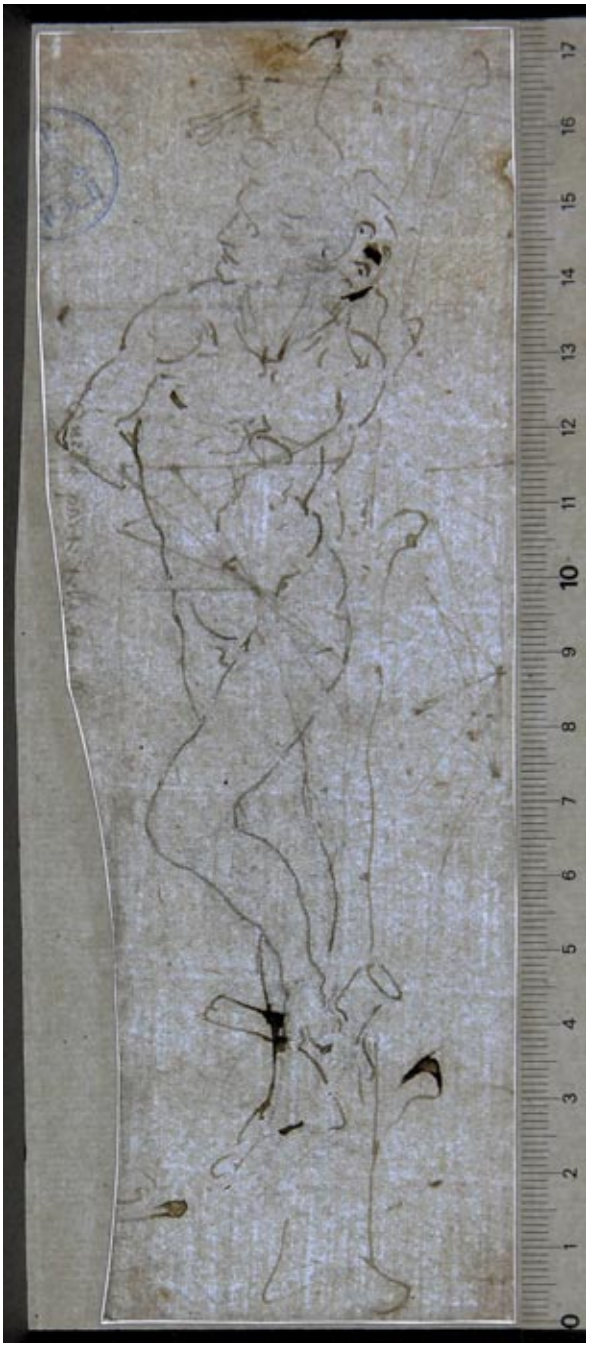

Fig. 1 "Saint Sebastian". Transmitted light image. Structure of laid paper with chain lines running horizontally and shadow zones alongside them. Inv. no. 21489

not, however, exhibit any shadow zone, unlike the other chain lines.[6] This paper is the only one of the four sheets to feature a watermark: it depicts a lily – with brisures – with two clover leaves or flowers.[7]

Examination using X-Ray Fluorescence analysis (XRF)[8] found a higher incidence of lead overall in the sheets, in particular in the non-prepared – papers, for which it was not possible to discover any cause by optical methods.[9]

PREPARATION

Two of the sheets exhibit polychrome preparation.[10] "Aristotle and Phyllis" features a soft blueish-green grey, whilst in "Studies for an Adoration of the Shepherds", a purple-violet colour was applied. When enlarged microscopically, fine dark blue particles are visible in the opaque preparation – in "Aristotle and Phyllis", whereas in "Studies for an Adoration of the Shepherds", the transparent purple-violet is shown to be composed of red particles, with a preponderance of black particles and the occasional blue one (see Fig. 2). A small incidence of larger white particles was also found in both preparations, which glowed white under ultraviolet lighting (UV). The purple-violet ground was simply applied using a 2.5 cm wide brush, and the brushstrokes running horizontal to the drawing are clearly discernible. Slight imperfections in the application of paint in the area of the right margin were caused by air bubbles that were created when the warm solution of hide glue was applied, bursting as the substance dried. In the case of "Aristotle and Phyllis", it was found that the ground had been applied more evenly and in a thicker coat; the brushstrokes run vertically on this sheet. Using VIS and XRF, it was discovered that the blueish-green grey is indigo,[11] and the purple-violet a mix of indigo and kermes.[12] Calcium and phosphorous were elements found in both preparations. This suggests that powdered, calcined bones were employed as a white pigment.[13] In the case of the sheets "Head of an Old Man or an Old Woman" and "Saint Sebastian", larger traces of iron (ochre), lead (lead white) and calcium (white chalk) were found. They may have been components of a wash that hardly differed from the natural colour of the sheets used in these works.[14] The lack of brushstrokes would suggest that the pigments were rubbed into the sheets when dry or were dispersed across the sheets using water alone as a binder.

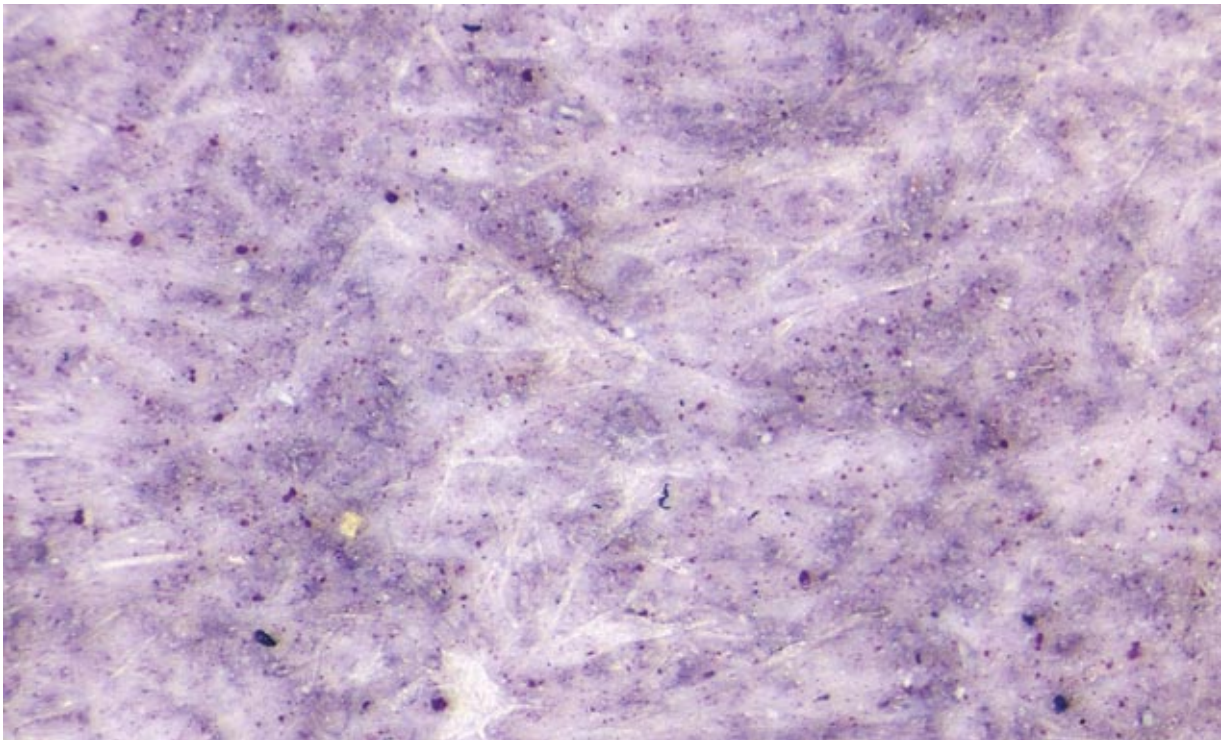

Fig. 2 "Studies for an Adoration of the Shepherds". Normal. Detail: 40x magnified image. Preparation exhibiting red, blackish and white particles. Inv. no. 21488

PRELIMINARY DRAWINGS

The solid, metallic, gleaming lines of the preliminary drawing in Studies for an Adoration of the Shepherds indicate metal styluses[15] common around 1500. Under infrared lighting (IR), the marks of the stylus used by the artist remain fully visible, which would suggest the presence of lead or a lead alloy[16] (see Figs. 3.1 and 3.2). This could be verified using XRF, which confirmed evidence of lead and tin.[17] One can assume that a preliminary drawing made with a metal stylus was also used in the case of "Aristotle and Phyllis" only on the basis of a few visible traces. Nonetheless, Leonardo da Vinci did occasionally use prepared paper in combination with other drawing materials.

The preliminary drawing in "Saint Sebastian" was executed using a dry, black material finely dispersed in parts. The lines are equally discernible under IR lighting. Since the XRF analysis was able to exclude the presence of metals, one can assume that the artist employed a carbon-based drawing medium. The optical characteristics of the lines made and the fine dispersal of the particles and their absorption in the fibres of the paper indicate that the material was charcoal.

ALTERATIONS TO THE PRELIMINARY DRAWINGS/TRACES OF ERASING

Aside from the lead-tin stylus lines, easily discernible by optical means, in "Studies for an Adoration of the Shepherds", indented lines[18] can be distinguished under raking light in the right half and in the lower quarter of the drawing. These occur in other works by Leonardo as well.[19] Since the indented lines appear darker under IR and UV lighting in comparison to the visible ones, however, one must assume that the lines were drawn with the same stylus and that the medium used was largely removed in the respective areas. This is also indicated by the slight optical alterations in the ground in some of these areas[20] (see Figs. 4.1 and 4.2). Marks made by lead-tin styluses, and in charcoal,

Figs. 3.1 and 3.2 "Studies for an Adoration of the Shepherds". 3.1: normal light image, 3.2: close-range infrared reflectograph (940 nm). Detail. The lead-tin stylus lines of the preliminary drawing are clearly visible where lines in ink are not superimposed. Inv. no. 21488

can be erased relatively easily from paper or vellum; according to primary source material, soft bread was used for the removal.[21]

DRAWING MEDIA

The study "Head of an Old Man or an Old Woman" appears completely transparent under IR lighting, which is typical of red ochre or red chalk. Similar to white and black chalk, this material was sawn into pieces and fastened into a holder so that, when sharpened (with a knife), it could be used in the manner of a crayon. Leonardo da Vinci was one of the first artists working in the Renaissance to use red chalk not just for sketching lines, but also for drawings themselves.[22] The sheet exhibits pricking holes in the area of the neck and facial contours, which would have served to aid the transfer of the drawing to another support[23] (see Fig. 5).

Ink and a quill pen were characteristic drawing instruments for Italian Renaissance artists, and Leonardo da Vinci also very frequently employed them in his drawings.[24] Carbon-black inks and iron-gall ink were the most common media used for writing and drawing. Under IR lighting, it was possible to confirm that iron-gall ink was the medium employed in all the Hamburg drawings[25] executed in pen and ink.[26]

Figs. 4.1 and 4.2 "Studies for an Adoration of the Shepherds". 4.1: UV induced image, 4.2: normal light image. Detail. Areas with removed lead-tin stylus lines. Inv. no. 21488

In order to more precisely distinguish between inks, which vary in terms of their coloration – even within the same sheet in the case of "Studies for an Adoration of the Shepherds" – XRF measurements were taken and compared with one another.[27] In this manner, it proved possible to determine variations in the compositions of the inks used for the four sheets (see Fig. 6). Thus, for instance, in "Studies for an Adoration of the Shepherds", aside from the ink featured predominantly within the image, we were able to establish that another ink formula was employed (for the angel to the lower right). Since the lines in this area of the drawing vary in terms of thickness, one can assume that a different pen was used, and, thus, this part of the drawing may also have been executed on a different date.

Fig. 5 "Head of an Old Man or an Old Woman". Transmitted light image. Detail. Pricking holes of a transfer process in the area of the neck and facial contours. Inv. no. 21482

CONCLUSION

By comprehensively examining the four drawings, we successfully gathered additional information in respect of Leonardo's creative working practices and the materials he employed. Thus, we were able to trace his working methods, such as the application of ground and the partial removal of preliminary drawings. We were also able to conclusively identify the artist's use of instruments, such as lead-tin styluses, and materials, such as iron-gall ink(s). Thus, it was possible to combine the results of an optical examination and the readings made to form a coherent overall picture of Leonardo's working methods. Comparing our own data with other research findings allowed us to place our findings in respect of the four drawings within a larger context.

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1 The works listed as inv. no. 21487 ("Aristotle and Phyllis") and inv. no. 21488 ("Studies for an Adoration of the Shepherds") both exhibit an oval blind stamp with the initials "RD": Alexandre Pierre-François Robert Dumesnil, 1778–1864. See Frits Lugt, Les Marques de Collections de Dessins & d'Estampes, Fondation Custodia, no. L. 2200, http://www.marquesdecollections.fr/detail.cfm/marque/9093 [last consulted on 8 May 2019].
2 See Klemm 2009, pp. 211–215.
3 Ambers et al. 2010; Menu 2014; Misiti 2014; Donnithorne 2019 and others.
4 Also see Bambach 2003, pp. 227–241.
5 It has been documented that Leonardo also used paper of this kind for other works; see Bescoby/Rayner 2014, p. 256; Donnithorne 2014, p. 105.
6 A chain line without a shadow zone with a watermark attached to it was a characteristic of paper used in the Florentine region. See Lunning 1989, p. XXXVI.
7 See Piccard 1983, p. 90; as with no. 422, but the distinctive chain line is aligned to the right of the watermark, as is also the case in no. 423.
8 The equipment used to examine the drawings and the methods employed are summarised in the respective sections at the end of the article.
9 This phenomenon was also described in the case of the drawing, inv. no. 1895,0915.474 (Warrior) in the collection of the British Museum; see Ambers et al. 2010, p. 116.
10 With the exception of softer lead styluses, metal styluses required a preparation. This was made of a hide glue solution mixed with coloured and white pigments, which was applied when warm to the paper. See Cennini 1888, pp. 12–14.
11 Blue plant pigment (Indigofera tinctoria L.), C.I. Natural Blue 1.
12 Red insect pigment (Kermes vermilio), C.I. Natural Red 3.
13 Also see Montalbano et al. 2002, p. 612; Montalbano/Migliori 2005, p. 17.
14 The results are similar to findings in relation to the drawing "Virgin Mary with Child and Saints" by the artist Battista Angolo del Moro. See Montalbano/Migliori 2005,

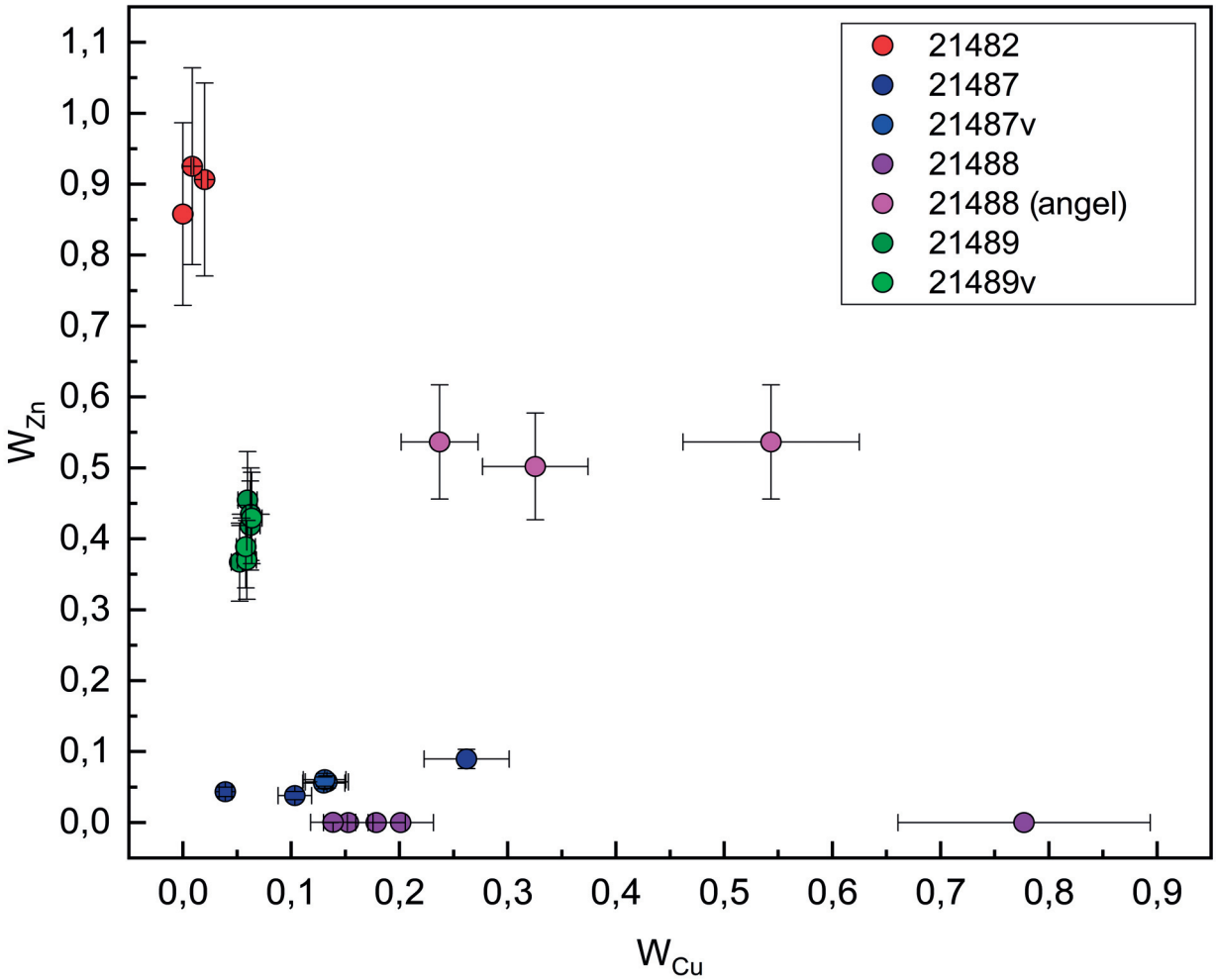

Fig. 6 Fingerprint profile to distinguish between iron-gall inks present on the four sheets and the verso (v) of 21487 and 21489. The relative concentrations of the secondary components, copper (W_{Cu}) and zinc (W_{Zn}), in comparison with the main component of iron demonstrate variations in the ink compounds.

pp. 19–20. On the lack of brushstrokes and the dry application of pigments, see Donnithorne 2014, p. 107; also see Russel et al. 2016, p. 23. Calcium and iron may be contained in the paper as a result of the manufacturing process.

15 The range of metal styluses included silver, gold, copper and lead as well as various alloys, brass and bronze, amongst other things.

16 Carbon based materials such as charcoal, black chalk and graphite appear similarly dark. Graphite which can be mistaken for some metal styluses due to their metallic gleam, have thus far not been evidenced in the works of Leonardo da Vinci.

17 Lead-bismuth alloys were used as well as lead-tin compounds.

18 Indentations into the support material with a stylus or comparable instruments.

19 This was the case in some of Leonardo da Vinci's design drawings. See Verri/Ambers 2010, pp. 91–92; Bescoby/Rayner 2014, pp. 257–258.

20 Donnithorne/Russel 2014, pp. 270–272 describe an age-related disappearance of the marks made by a metal stylus, but due to the original quantity of material present and the altered appearance of the ground in these areas, this can be ruled out here.

21 See Cennini 1888, p. 10.

22 See Donnithorne 2019, p. 112.

23 The spolvero technique, in which dotted lines were transferred to another support by dabbing red chalk or charcoal dust into them.

24 See Donnithorne 2019, pp. 100–101.

25 Readings were taken from inv. no. 21487 ("Aristotle and Phyllis"), drawing recto, inscription verso; inv. no. 21488 ("Studies for an Adoration of the Shepherds"), drawing recto; inv. no. 21489 ("Saint Sebastian"), drawing recto, design drawings verso; and inv. no. 21482 ("Head of an Old Man or an Old Woman"), inscription verso.

26 It was possible to distinguish the inks conclusively from one another under IR lighting: whereas pure iron-gall inks only absorb up to around 1300 nm, carbon-black inks continue to be easily visible at far infrared wavelengths. Also see Mrusek et al. 1995, p. 78.

27 Fingerprint profile: differentiation between iron-gall inks based on the relative concentrations of the secondary components of copper and zinc in comparison with the main component of iron. See Malzer et al. 2004, p. 231. A low incidence of nickel could be determined in some measurements, which may point to a Northern Italian provenance.

EXAMINATION METHODS AND INSTRUMENTS EMPLOYED

Stereomicroscopy	Wild, M3C, 5x magnification changer, 6.5x; 10x; 16x; 25x; 40x, normal lighting microscope:LED ring light (CoolRing), 8 segments x 5 LED lights 5000° K
UV light source; UV fluorescence photography	UV light microscope: LED 25 UV (CoolSpot), 1 watt UV LED 10° radiation angle; UV handheld light: UVAHAND 250 (Dr. Hönle AG)
IR light source; digital microscopy (Dino)*	Digital microscopy (Dino) – AD4113T Dino-Lite (Metav Werkzeuge GmbH): LEDs: VIS (external white light source), UV (395 nm), NIR (940 nm), magnification: 10x-50 x resolution: 1280 x 1024 CMOS sensor: 1.3 MP; port: USB 2.0
Photography	Canon Eos 550 D; AD4113T Dino-Lite
X-ray fluorescence analysis (XRF)*	ARTAX (Bruker Nano GmbH): molybdenum tubes: 30 W, 50 V, spot size 600 µA: 70 µm CCD camera for positioning of electrothermically cooled Xflash Detector (SDD, 30 mm2, resolution <150 eV at 10 kcps) motorised probehead for positioning and linear measurement. Line scans: at least 10 individual measurements along a line at intervals of 0.1–0.2 mm with a measuring duration of 20 secs/ individual measurement
Spectrophotometry in visible range (VIS)*	SpectroEye (Gretag-Imaging AG): light source: tungsten 2W; spot size: 3 mm; spectral region of visible light: 380–730 nm; spectral resolution: 10 nm; first derivative of raw data (reflexion, R)

* The measurements were carried out by the Collaborative Research Centre 950, “Manuscript Cultures in Asia, Africa and Europe”, at the University of Hamburg and were funded by the German Research Foundation (DFG).

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Aristotle and Phyllis · ca. 1475

Pen and dark brown ink over traces of metalpoint on pale blue-grey prepared paper; traces of framing outlines in pen and dark brown ink · 93 x 136 mm

Saint Sebastian · 1478–1483

Pen and dark brown ink over charcoal · 173 x 63 mm (irregular borders; bottom: 56 mm)

Studies for an Adoration of the Shepherds · ca. 1480

Pen with black-brown ink and lighter brown ink (child) over lead-tin stylus on purple prepared paper · 172 x 110 mm

Head of an Old Man or an Old Woman · ca. 1495/1505

Red chalk on lightly prepared paper, pricking holes in the area of the neck and facial contours · 99 x 82 mm

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