

Article

The Rediscovered Watermark in the Drawing *Leda and the Swan* by Raphael Kept at Windsor Castle

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Abstract: This article presents an in-depth study of Raphael's drawing of *Leda and the Swan* (RCIN 912759), preserved at Windsor Castle. The research aims to make the paper's physical properties accessible and extend the information on the watermark. The methodology follows an artistic-design-oriented approach. The data extraction process uses a back-lighting photographic technique combined with image post-processing operations. The work catalogues in scientific terms the complete paper mould lines of the Windsor sheet according to the International Standard of Paper Classification (IPH). Based on comparisons with a series of drawings by Leonardo da Vinci, the contribution suggests a chronological and provenance estimate of the paper used by Raphael.

Keywords: Raphael; Leonardo da Vinci; Leda; design; paper-based watermark; digitisation; graphical representation; image-processing; art; preservation



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1. Introduction

The drawing *Leda and the Swan* in the Royal Collection at Windsor Castle, RCIN 912759, dated 1507, is one of Raphael's best-known mythological studies and conceivably among the most remarkable portraits on paper dedicated to the figure of Leda. The examination of the drawing from life came about almost by chance. A research visit to Windsor was made to analyse the paper supports of a series of drawings made by Leonardo da Vinci. Due to the busy exhibition schedule of 2019, the year of the celebrations for the 500-year anniversary of da Vinci's death, some of the drawings selected for investigation were not available for consultation, and these included those relating to the Leda studies. Therefore, the writer decided to survey the most directly related thematic and chronological contribution—Raphael's Leda—and this intuition proved fortunate. It became evident that the information regarding the physical properties of sheet RCIN 912759 is limited and not easily accessible.

The drawing has been widely analysed from the historical-artistic perspective and is often described and compared, as a copy, to Leonardo da Vinci's studies regarding the standing Leda. However, the vast bibliography on the subject does not satisfy the needs of those who wish to conduct an in-depth study of the aspects relating to the type of paper chosen by Raphael for his work. This important cognitive gap presents the opportunity to start a new study on the Windsor sheet to detect the codicological parameters necessary to provide new chronological and provenance indications on the document, auxiliary information compared to that provided by the history of art, paleography or examinations of the graphic *ductus*. These alternative markers of investigation define the impression left on the sheet by the mould of the metal frame originally employed during the papermaking process, especially in the watermark's graphic appearance. Considering the artistic value of the artefact, the lack of any in-depth study of the paper medium is quite significant, especially in the light of the ever-increasing and efficient use of diagnostic techniques in the cultural heritage domain to interrogate materials for various purposes: study, archiving, monitoring, conservation, restoration and exhibition.

Thus, the idea emerged of focusing on the disciplinary edge between the artistic analysis of the drawing and the technical analysis of the paper, halfway between Raphael's

and Leonardo's productions, circumscribed within the studies on Leda and between drawings bearing watermarks of the same classification. The article is not intended to be exhaustive, either in terms of a critical commentary on Raphael's drawing, or in terms of reconstructing the Leonardo sources from which Raphael is said to have derived his work.

2. Hypothesis and Aims of the Essay

The information regarding the physical properties of the paper on sheet RCIN 912759 is modest. This problem affects Raphael's complete production on paper because there is no systematic investigation regarding the watermarks on his drawings (Bambach 1999, p. 389, note 54). This lack of knowledge limits research and requires scholars to carry out lengthy bibliographical investigations before finding information on the subject. For example, the *opera omnia* on Raphael's drawings edited by Knab et al. (1983) does not have a section on the paper data of the folios. Few editions include notes on watermarks in parallel with the analysis of the drawing. These are generally drawing catalogues created to accompany exhibitions (Dalli Regoli et al. 2001; Nanni and Monaco 2007, pp. 226–27) or as an anthology of a specific museum collection. In both cases, it is a matter of research on individual sections of drawings, and not on the artist as a whole. The curators' choices determine the presence or absence of specific studies on the papers and the degree of depth.

The issue of generating a set of new content on the physical aspects of the document is crucial for implementing dissemination bodies. A key example is that not even the online catalogue of the Royal Collection provides information on the mould lines of sheet RCIN 912759. This fact is highly anomalous because notes on watermarks are available for other documents in the same collection (Leonardo's sheets).

This study seeks to make the physical data for the paper (RCIN 912759) accessible, on the one hand, by extending the information on the watermark, and on the other, by trying to establish plausible relationships between Raphael's and Leonardo's drawings.

The novelty of the work does not consist in presenting an innovative watermark digitisation procedure because the researcher preferred to make use of an already tested and effective data acquisition system. According to an art–design-oriented approach, the contribution of the work is to decode and catalogue the physical properties of Raphael's paper in quantitative and qualitative terms to provide a valuable basis of information for future research on the sheet.

Based on the watermark's arborescence (design or motif) analysis, the essay also proposes new elements to contextualise the drawing chronologically and to circumscribe the paper's geographical area of origin. In order to do so, the author has compared the Raphael watermark with the most similar marks among those registered in the main watermark archives for the central-Italian region (Briquet, Piccard, Niki) and has also established relations with six drawings by Leonardo da Vinci. The work adds to this last consideration a reinterpretation of the concept of comparison between Raphael's Leda and the iconographic model of Leda developed by Leonardo, elaborating the information obtained from historical sources and classification of watermarks.

3. The Drawing

Created in black chalk and overlaid with pen and ink, the impressive drawing depicts the scene of the encounter between Leda, Queen of Sparta, and Zeus, who is concealed in the guise of a swan (Figure 1).



Figure 1. Raphael, *Leda and the Swan*, ca. 1507, pen and ink over black chalk underdrawing, 210 × 192 mm, RCIN 912759, Royal Collection, Windsor Castle. Royal Collection Trust/© Her Majesty Queen Elizabeth II 2021. Used with permission.

Leda is shown standing naked in the centre of the composition. Next to her on the right is the swan-lover, placed on a rock. Below, there is a child, symbolising the union between the god and the woman. The drawing is astonishing for the beauty of the subject and balanced fluid *contrapposto* of the figures. The statuesque pose of the main character, Leda, avoids rigidity and conveys to the viewer the idea of a vibrant body caught in the moment of action. The left leg is slightly bent forward as if about to take a step. A sinuous spiral movement criss-crosses the upper anatomy, clearly defined by the rotation of the bust. The chest is three-quarter length and turned towards the swan. Leda's arms are stretched out to embrace the animal's neck, which encircles the woman's sides with its right wing. This is in contrast to the general direction of rotation is Leda's face, which is gracefully turned to the opposite side. The woman's gaze is directed forward towards a hypothetical observer, while her eyes are languid and elongated, and her mouth is pulled

into a soft smile. Although expressing an attractive tension, the woman's body maintains a distance from the lover's body, as can be seen from her profile's linearity. Following the myth philologically, Leda's actions are interpreted as an approach to her lover, but they can also be read as a distancing: a volitional act of modesty and independence. The traits of a real, carnal woman, but animated by feelings of grace and autonomy; virtuous osmosis between *voluptas* and *venustas* (Duò 2020, p. 13).

4. Leonardo's Paragone

If one looks closely at the drawing, one notices a fascinating fact: Leda resembles a sculpture. In this case, the surprising volumetric effect not modelled with *chiaroscuro* effects is given through the figure's exquisite "*di naturale*" bearing. The image transcends the double dimension typical of a graphic work because the plasticity of the features and the balanced proportions of the limbs highlight the profound morphological research underlying this stylistic construction, which yields an apparently real Leda according to the physical laws of nature. However, the originality of this compositional structure is not Raphael's invention. Critics agree that Leonardo's *Leda* inspired Raphael.

Leonardo's *Leda* was a lost painting executed on wood, datable to around 1505–1510—but possibly still in process at the time of Leonardo's death (Clayton 2018, p. 94). Critics have always considered the attribution of the lost *Leda* painting to Leonardo to be plausible, yet the issue is still to be resolved. Since it is a missing object and in the absence of direct scientific investigation, Fiorio says: «*we cannot be certain whether Leonardo ever painted a picture of this subject*» (Fiorio 2015, p. 545). For the same reason, it is equally difficult to gauge whether Leonardo worked in terms of total or partial autography, the latter hypothesis admitting the intervention of a pupil (Zöllner 2016, p. 188). Several sources authenticate the existence of the painting. First of all, the work is mentioned in the inventory of Salai's possessions after his death (1525) and is recorded as one of Leonardo's most expensive legacies (Marani 2019, p. 341). The painting is then mentioned by Anonimo Gaddiano in Milan in 1525 (c. 1540); by Lomazzo on three different occasions, in the *Trattato* (1584); in the *Rime* (1587); in the *Idea del Tempio della Pittura* (1590); and finally, by Cassiano dal Pozzo (Fiorio 2015, p. 545). The latter saw the painting in the castle of Fontainebleau in 1625, revealing its poor state of conservation: «*Una Leda in piedi, quasi tutta ignuda, col cigno e due uova a piè della figura dalle guscia delle quali si vede esser usciti quattro bambini. Questo pezzo è finitissimo, ma alquanto secco, in ispecie il petto della donna, del resto il paese (paesaggio n.d.c.) e la verdura (vegetazione n.d.c.) è condotta con grandissima diligenza; ed è molto per la mala via, perché com'è fatto di tre tavole per lo lungo, quelle scostate via han fatto staccare assai del colorito* [...]». Translated into approximate English, since the Italian language of the 1600s is not particularly straightforward, it says: «A standing figure of Leda almost entirely naked, with the swan by her and two eggs, from whose broken shells come forth four babies. This work, although somewhat dry in style, is exquisitely finished, especially in the woman's breast; and for the rest of the landscape and the plant life are rendered with the greatest diligence. Unfortunately, the picture is in a bad state because it is done on three long panels which have split apart and broken off a certain amount of paint». The subsequent fate of the painting is uncertain; it is thought to have been destroyed in the 18th century (Clayton 2018, p. 94) or to have disappeared from 1775 onwards (Poggi 1919, pp. 36–38). Leonardo's *Leda* is known chiefly through pictorial derivations by pupils or followers (Fiorio 2015, p. 545).

The material on the subject, collected between original production on paper and copies, suggests a careful and gradual development for Leda's model, distinguished by revisions and corrections. There is enough material on the subject to believe that Leonardo put a great deal of effort into this new work structure, which led the artist to modify his initial compositional ideas over time. Two different versions of the same theme are known: a kneeling Leda and a standing Leda. The painting attributed to the Lombard painter Giampietrino in Kassel (Staatliche Museen, inv. 1749, no. 850) is currently the only pictorial derivation of Leonardo's studies for the kneeling Leda, while the replicas depicting the

standing Leda are much more numerous. Among the most reliable are the *Leda Spiridon* in Florence (Uffizi Gallery, inv. 1890, no. 9953); the exemplar in the Pembroke Collection at Wilton House near Salisbury; and the versions in the Philadelphia Museum and the Galleria Borghese in Rome, the latter of which was attributed for centuries to Sodoma. Variants on paper, not by the hand of Leonardo, in addition to the version by Raphael, include the small sketch by Baldassare Peruzzi on the sheet in the Prints and Drawings Cabinet of the Uffizi (inv. N. 528A) and the drawing by an anonymous artist in the Musée du Louvre in Paris (inv. N. 2563) in red chalk (Clayton 1999, p. 57).

Leonardo's autograph traces on the subject survive exclusively in the manuscripts. The sketches from Chatsworth (Chatsworth, Duke of Devonshire Collection Trust, inv. 717) and Rotterdam (Rotterdam, Museum Boijmans van Beuningen, inv. I 446) document an interest in the rendering of a kneeling Leda, while the sheets from Milan (Codex Atlanticus, f. 423 recto), Turin (Biblioteca Reale, inv. 15577) and Windsor (RCIN 970129) refer to a standing Leda. Also, in Windsor, there is a beautiful series of studies of female heads and hairstyles that can probably be traced back to drafts of the iconographic model of the lost painting of Leda (RCINS 912515, 912516, 912517, 912518). The sources for creating this work come from the comparison with antiquity. There are explicit references to the statuary of *Venus Pudica* (Nanni 2001, p. 38) and the marble *Ganymede with the Eagle*, (Marani 2015, p. 138) already considered possible models of inspiration. Recent investigations have also brought to light an interesting new reference to a late Hellenistic marble bust housed in the Liviano Museum in Padua (Figure 2).

The technical-formal characteristics of the Paduan *Torsetto* directly correspond to Leonardo's prototype, allowing us to consider this production as one of those directly involved in the process of iconographic assimilation of Leda, and more generally of a new female canon (Ghedini 1984), by those Renaissance artists most sensitive to the reinterpretation of the ancient, including Leonardo. Between the 15th and 16th centuries, a lively collectors' trade fostered the concept of recovering classical art. This phenomenon facilitated the circulation of Hellenistic-Roman artefacts, often reproductions of lost Greek collections, helpful in activating creative processes of iconographic reworking of the antique. This impulse was also fostered by visits to archaeological sites, a sort of *ante-litteram grand tour* among classical wonders. Documents testify that Leonardo and Raphael also made journeys for this purpose. The artists went to Tivoli, at different times, to admire the sculptures and pomp belonging to the archaeological complex of Hadrian's Villa. Leonardo's visit to Tivoli would have allowed the artist to observe the statues of the *Muses* found in the theatre of the Villa (now in the Prado Museum in Madrid). The period would have been between 1497 and 1503, during the pontificate of Pope Alexander VI.

Leonardo's presence in Tivoli is certified in a folio of the *Codex Atlanticus*. In f. 618 verso, on the right-hand side of the page, Leonardo notes: «A Roma. A Tivoli vecchio, casa d'Adriano». Below the sheet fold, there is also the following indication: «Laus deo 1500, a dì 10 marzo». Restated by the adoption of the Florentine style of dating (*ab Incarnatione Domini*), the date should be understood as 10 March 1501 (Marani 2003, p. 259) even if at first this note by "another hand" (not Leonardo), was transcribed by Marinoni "albeit with some doubt" as 20 March 1500 (Leonardo da Vinci 2006, vol. 11, pp. 175–76). The name of the locality "Tivoli Vecchio" confirms that it is indeed Hadrian's Villa, because this was the name by which the villa was generally identified during the transitional period between 500 AD and 1400 while it was used as a brick and marble quarry (De Franceschini 1991, p. 5). Even during the Renaissance, the toponym remained in force when the area became a popular archaeological site for studying classical architecture and art. News of Raphael's pilgrimage, on the other hand, comes from Pietro Bembo, a skilled scholar and poet, and a close friend of the Urbino painter: «Io col Navagero col Beavano e con M. Baldassar Castiglione e con Raffaello domani anderò a riveder Tivoli, che io vidi già una altra volta vintisene anni sono. Prenderemo il vecchio e il nuovo, e ciò che di bello fia in quella contrada». The letter is dated 3 April 1516 and is addressed to Cardinal Bernardo Dovizi da Bibbiena (Bembo 1809, p. 45).



Figure 2. Micro-Asian island statuary production (Greek island/Rhodium), *Torsetto femminile* (female torsos), mid-II century BCE Parian marble Lakkoï/sculpture, 280 × 135 mm, Museum no. MB95, Padua, Museo di Scienze Archeologiche e d'Arte dell'Università degli Studi di Padova. By permission of the University of Padua (Università degli Studi di Padova) and Museum of Archaeological Sciences and Art of the University of Padua (Museo di Scienze Museo di Scienze Archeologiche e d'Arte dell'Università degli Studi di Padova), photos by Michele Barollo and Simone Citon, Department of Cultural Heritage, University of Padua. Used with permission.

How Raphael gained access to Leonardo's studies for the *Leda* has yet to be clarified, but the opportunity may have occurred in the city of Florence. Although there is no firm evidence of direct contact between Raphael and Leonardo, some of Raphael's writings speak of a meeting with Leonardo, whom he described as hospitable and welcoming, to the point of inviting the young colleague into his studio (Duò 2020, pp. 18–19). The meeting may have taken place in Florence between Autumn 1504, Raphael's arrival in the city, and June 1506, when Leonardo departed for Milan (Zöllner 2016, p. 247). It is also possible that Raphael viewed Leonardo's drawings and cartoons for *Leda* outside the artist's studio and through the mediation of a pupil or trusted person who had access to the master's material. The hypothesis of an engagement between the two artists in Rome (1513–1516) is less probable since Raphael's style is restricted to the Florentine period and 1508 at the latest (Clayton 1999, p. 57). Between 1504–1506, Leonardo was in the city to follow the demanding commission of the *Battle of Anghiari* for the Sala del Gran Consiglio in Palazzo della Signoria.

Leonardo would have started thinking about the composition of *Leda* at the time of the *Battle of Anghiari* around 1504. This fact can be seen on sheet RCIN 912337 at Windsor (ca. 1503–1504). On the recto of the sheet, next to the main drawing of a prancing horse with rider, an apparent reference to the *Battle* scene for the mural painting in the Sala del Gran Consiglio, are three sketches with a figure of a kneeling woman with children.

The woman's crouching position is very reminiscent of the Chatsworth and Rotterdam proposals, which are unanimously regarded as studies for an early version of Leda. Two of the female sketches are bordered by a frame to indicate a different subject from the main one on the sheet (the horse) and perhaps relate to the proportions of the figures from a pictorial work. The third is depicted in an outline and is not overlaid in pen, making it difficult to read. Critics have discussed the study of this sheet widely in relation to the genesis of the Leda studies. The horse's position in the centre of the page speculates that it was drawn chronologically prior to the others on the sheet. This fact could set the execution of the three Leda miniatures to a historical period not earlier than 1504. The watermark in RCIN 912337, with the motif "ladder in oval with 6-pointed star", close to Briquet 5920 and 5922, confirms a Tuscan provenance of the paper and a historical reference period between 1495 and 1506 (Briquet 1907, vol. 2, p. 345).

Vasari says that the direct comparison with Leonardo's art struck Raphael to the point of wanting to interiorise the most distinctive features of Leonardo's poetics. Here is a passage from *Le Vite* . . . (Vasari 2019, pp. 636–37): «Perciò che vedendo egli l'opere di Lionardo da Vinci, il quale nell'arie delle teste, così di maschi come di femmine, non ebbe pari e nel dar grazia alle figure e ne' moti superò tutti gl'altri pittori, restò tutto stupefatto e maravigliato; et insomma, piacendogli la maniera di Lionardo più che qualunque altra avesse veduta mai, si mise a studiarla e lasciando, se bene con gran fatica a poco a poco la maniera di Pietro, cercò, quanto seppe e poté il più, d'imitare la maniera di esso Lionardo. Ma per diligenza o studio che facesse, in alcune difficoltà non poté mai passare Lionardo; e se bene pare a molti che egli lo passasse nella dolcezza et in una certa facilità naturale, egli nondimeno non gli fu punto superiore in un certo fondamento terribile di concetti e grandezza d'arte, nel che pochi sono stati pari a Lionardo. Ma Raffaello se gli è avvicinato bene più che nessuno altro pittore, e massimamente nella grazia de' colori». Rendered into English: «Therefore, when he saw the works of Leonardo da Vinci, who had no equal in the rendering of the heads of both males and females, and who surpassed all other painters in giving grace to the figures and in the movements, he was completely astonished and amazed; In short, liking the manner of Leonardo more than any other he had ever seen, he began to study it and, leaving behind the manner of Pietro, albeit with great effort, he tried, as much as he could, to imitate the manner of Leonardo. However, no matter how hard he tried or how much he studied, he was never able to surpass Leonardo in certain difficulties; and if it seems to many that he surpassed him in gentleness and certain natural ease, he was nevertheless not superior to him in a certain powerful foundation of concepts and greatness of art, in which few have been equal to Leonardo. Nevertheless, Raphael came closer to him than any other painter, and especially in the grace of the colours».

Nevertheless, in the case of Leda, Leonardo's work must have fascinated Raphael not only from a methodological point of view of recovering ancient culture, through original reinterpretations or from a purely formal point of view, but also for its beauty. In this sense, the results of such convincing artistic modelling in spatial terms are also enhanced by Leonardo's ability to transfer into drawing a three-dimensional vision of sculptural forms, a quality he developed as a young man during his apprenticeship with his master Verrocchio. The lesson learnt from the ancients was valuable to Leonardo in appropriating a more monumental language full of pathos, never transferred in a slavish way, but sublimated according to a 'natural' and scientific meaning of art, which would gradually become increasingly conceptual. According to comparisons with surviving paintings by Leonardo's pupils, Raphael's desire to make a copy of Leonardo's Leda is a response to his falling in love with this subject. It is perhaps also the reflection of a Raphael who was not fully mature and therefore sensitive to absorbing the most convincing figurative inventions from outside to form his own iconographic-stylistic technique from which he could rework new and personal languages.

5. Paper-Based Data on the Sheet

5.1. General Historical Background of the Watermark in Ancient Papers

In general terms, the European watermark is an element that is inseparable from ancient paper. It forms a figurative impression on the sheet during the paper production process. Visible in transparency, this *signum* represents the identifier mark of the original paper mill and, in this sense, is an innovative *ante-litteram* design product. This “logo” was conceived and introduced in Italy at the end of the 13th century in the territory of Fabriano. It became the “signature” of the manufacturer, a certificate of the sheet and, in a short time, a quality indicator of the finest papers, similar to the goldsmith or lapidary marks (Spoer 1996, p. 153). Watermarks characterise the production of medieval paper, prints and drawings that today are preserved and exhibited in libraries, archives and museums. If paper was already widespread in the Mediterranean area during the 12th century, watermarked paper began to appear permanently in Europe from the 14th century onwards. It came to replace expensive parchment during the following century and has continued as the primary material for writing until today. Since the development of mechanical processes in the 19th century, papermaking techniques have changed completely, and the use of the watermark as a quality logo has become more marginal. It has, however, not lost its usefulness even in recent times. It has always proved to be a valuable and alternative resource among the possible methods of dating a paper document, which is why “filigranology” (the study of watermarks) is to be considered one of the secondary disciplines of history. It elected as its founding father the Geneva historian Charles Moïse Briquet, who in his “dictionary” of 1907 collected a total of 16,112 watermarks dating between 1282 and 1600. The methodology used to date a document employing the watermark is that advocated by Briquet since the beginning of the twentieth century, according to which, it is possible to estimate a date within 15 years through a figurative comparison between two papers with the same watermark (one of which already has the year indicated) (Briquet 1907, vol. 1, pp. 20–21). Subsequent investigations, mostly from German scholars, such as Weiss, Piccard and Tschudin, have narrowed the time range of operation of a watermark, achieving dating estimates at best with a margin of error of two years. This was made possible by identifying that the maximum activity term of a pair of marks for the most common sheet size seldom exceeds a couple of years (Tschudin 2012, p. 33). Nowadays, the value of watermarks as an auxiliary tool for dating ancient documents has found significant examples in the field of art history as well, especially when there is a need for additional information, such as a comparison between documents when there is doubt about location and dating. In this sense, notable contributions are the studies conducted on Italian maps from 1540 to 1600 (Woodward 1996); on prints by Rembrandt (Ash and Fletcher 2000); and on drawings by Mantegna (Boorsch and Landau 1992) and Michelangelo (Roberts 1988).

5.2. Preliminary Information about the Watermark in the Sheet

In Raphael’s *Leda and the Swan*, the first documented mention of a watermark in the sheet comes from Popham and Wilde (1949, p. 309). The authors identify it as a figurative motif, “a three-peaked mountain”. In 1999, the catalogue of Raphael’s drawings at Windsor, edited by Clayton, confirmed the watermark motif noted by Popham and Wilde but under the name “three hills” (Clayton 1999, p. 57). Clayton’s volume also provides a first graphic reference of the watermark (Clayton 1999, p. 213). The publication includes an appendix listing the watermarks found in the sheets and reproduced in drawing form. The tracings of the watermarks are at full scale, which is very useful for using them in comparisons or dimensional measurements. The chronological gap between the 1999 survey of sheet RCIN 912759 and the 2019 survey, illustrated here, marks a profound temporal gap during which there has been an inevitable process of refinement of diagnostic imaging techniques for the study of the documents, for data acquisition and the post-processing phases of the images. The desire to use modern digital systems has also warranted in revision, in some cases, of the working methods to provide an increasingly scientific and extensive picture of the contents of the processed documents.

5.3. Watermark Re-Loaded

To collect the new data on the paper, drawing RCIN 912759 underwent a new diagnostic survey. The methodology of analysis was a *design-driven* type according to an applied research approach. A data digitisation procedure was developed on a tripartite model: *survey-acquisition-reprocessing*. The working model had to guarantee certain conditions: non-destructive character of the analyses; absolute reliability of the extraction criterion; good quality of the visual content recorded; and stable data that could be edited according to iterative working dynamics. In order to select the most suitable recording technique, the most common watermark reproduction technologies were studied and compared, evaluating their advantages and disadvantages. In accordance with the Scientific Committee of the Royal Collection at Windsor, the author chose to perform data recording using the “Backlight Technique” (transmitted light) in conjunction with high-resolution photographic shooting. The procedure is reliable and does not use invasive methods. Two famous examples demonstrate the effectiveness of this technique: the acquisition campaigns for Michelangelo’s watermarks (Roberts 1988, p. 12) and the collection of Sardini-Martinelli architectural drawings kept at the Prints and Drawings Room of the Castello Sforzesco in Milan (Scotti Tosini 2006). The backlight method proved to be particularly suitable because it did not require voluminous and expensive equipment, strict logistical criteria, as is the case for radiographic tests, or the need for external support staff or services. This method also minimised the handling of the original manuscript sheets and ensured greater efficiency when working with documents that are difficult to move. The Leda folio was placed on a light device for conservation purposes, incorporating a metric dimensional reference, followed by photographic imaging. The digital image acquired was appropriately optimised and scaled according to the metric reference. In this way, it was possible to obtain a faithful digital reconstruction of the drawing and proceed with a vector graphic recalculation of the sheet’s paper mould’s main lines.

The work phases followed a diagnostic protocol—developed with the methodology and tools of the design for cultural heritage—quite similar to that developed to digitise some watermarks of Leonardo’s *Codex Atlanticus*, described elsewhere by the author (Cali 2019). Following the experience gained with the Milanese manuscript, the primary phase (with a live drawing) and the secondary phase (with a digital image) of data acquisition became more subtle, and this made it possible to record new metadata taken from the sheet. Therefore, it was necessary to redesign the associated document cataloguing schedule, expanding it with new information keys on the physical properties of the paper (Cali 2021). Hopefully, a new feature is the revised, improved visual reference of the watermark: the image with exposure to reflected light has been made to have more contrast and brought to a blue scale level where the watermark path is more easily appreciated (Figure 3).

5.4. Watermark and Mould Data Details

The technical specifications of the watermark and paper mould can be summarised as follows. The watermark has dimensions of 47 × 50 mm (w × h) and is in a central position near the left edge of the sheet, with the recto of the sheet facing the observer. The correct reading direction of the watermark is rotated by 180 degrees from this orientation. From the observation of the recto and verso of the sheet, the mould side of the paper is likely on the document’s verso, as the *signum* impression is more readable. The document is in a good state of preservation due to the quality of the paper, which reveals an efficient and well-tested manufacturing process. The pulp fibres are fine and the imprints left by the wires are quite thin. This fact results in a high density of the wire rods in the sheet. The colour of the paper is ivory white with good contrast in trans-illumination tests. The *filoni*, or wooden strips, are placed underneath adjacent chain lines as revealed by the paper’s shading. A significant feature of the mould is the use of a supporting chain line for the watermark, technically known as a *pseudo-filone*. This element is a usual detail of papers produced in Italy through technical know-how typical of the Fabriano tradition (Albro 2006, pp. 194–96). Complete attributes on the sheet’s mould data are catalogued in

a well-defined scheme in both graphic and descriptive form. The dataset is structured by themes, complete with measurements, references to archival repertoires of watermarks, and paper classifications according to the International Standard for the Registration of Papers with or without Watermarks (IPH). The list and a full-scale technical diagram (scale factor 1:1) of the watermark are available in Appendix A at the end of the article (Figure 1A).



Figure 3. Raphael, *Leda and the Swan*, ca. 1507, pen and ink over black chalk underdrawing, 210 × 192 mm, RCIN 912759, Royal Collection, Windsor Castle. Royal Collection Trust/© Her Majesty Queen Elizabeth II 2021. Detail of the diagnostic tests and virtual reconstructions on the drawing *Leda and the Swan* by Raphael (RCIN 912759). On the left, the sheet in diffuse (standard) light conditions; in the centre the sheet in transmitted light; on the right the sheet in transmitted light with a colour level on blue hues to achieve a higher contrast of the lines of the paper mould. Used with permission. Image in transmitted light created by author.

5.5. Watermark Analysis and Contextualisation

The watermark is similar to Charles M. Briquet's classification "*trois monts s'élevant au dessus d'une ligne horizontale*" from numbers 11,648 to 11,663 in his repertory (Briquet 1907, vol. 3, p. 590). The motif is vaguely similar to numbers 11,660 (Bologna 1497) and 11,661 (Bologna 1507–1510), but the dimensional disproportion of Raphael's *Leda signum* is too stark to suggest analogies. The watermark (or examples of similar size and shape) is also absent from the G. Piccard archive and the Niki online catalogue of the Dutch University Institute for Art History in Florence. It cannot be ruled out that this could be a new watermark, which has never been registered before and is therefore not present in the archives. According to Briquet, the "*three mounts*" typology is of Italian origin and was widespread throughout the peninsula but with a greater concentration in central Italy. The circulation of this type of watermark seems to have already been active with similar patterns from 1432 in Florence (no. 11662), then in Rome 1439, Naples 1441, Vicenza 1449, Udine 1452, Genoa 1464, Padua 1466 and finally Bologna 1493–1497. Some variants of this mark have accessory motifs, such as a cross placed above the main figure or the three mountains inscribed in a circle. These two variants are found in some papers with drawings by Antonio Pollaiuolo (1431–1498) kept in the Uffizi (Prints and Drawings Cabinet, inv. 246E, 47F, 100F) by Fra Bartolomeo (1472–1517) at the Museum Boijmans Van Beuningen in Rotterdam (inv. M14) and by Maso Finiguerra (1426–1464), Uffizi (inv. 163E). This watermark class was also widely spread beyond the Italian borders, especially towards

the north of Europe, as evidenced by the recordings in Germany by Briquet and Piccard. This event also generated an eclectic range of nomenclatures for this family of signs. Here are some examples of tags: “three mounts”, “3 mounts”, “3 monts simple”, “mountains/hill”, “mountain of calvary”, “triple mont”, “three hills”.

Weaving concordances is not an easy task, but it is possible to make several considerations based on bibliographic sources. In at least six of Leonardo’s papers, critics have cited a watermark that can be attributed to the same general classification “three mounts” as in the Raphael sheet. Four drawings are the *Bust of a warrior in profile to the left* from the British Museum (museum nr. 1895-0915-474); a *Studies for the Uffizi ‘Adoration of the Magi’* from the Isabella Stewart Gardner Museum (museum nr. 1.1.r.13); *A horse with lines of proportion* (RCIN 912318); and *Horses and soldiers* (RCIN 912330). The first three sheets date from around 1480–1481, before Leonardo left Florence, while the fourth is attributed to 1503–1504. In the British Museum’s online catalogue, the commentary on the drawing (museum no. 1895.0915.474) makes explicit the “three mountains” motif of the watermark. The website offers several images with different viewing styles for this resource, resulting from non-destructive (infrared and ultraviolet) diagnostic imaging tests carried out on the document. However, the watermark cannot be verified because the images do not distinguish the *signum*’s outline with sufficient certainty. Instead, the impression of an inscription in the centre of the sheet is instead more legible, although not very clear, and is perhaps a watermark linked to the name of the papermaker or a place. The word could be “BRA∞EANO” (?). Even a live examination of the drawing at the British Museum (a test performed by the author in 2019 without technical equipment) did not provide definitive proof of the presence of a “three mountains” watermark. Examination of the drawing with the naked eye reveals on the recto of the sheet the presence of slight vertical traces that create a lowering of the sheet surface near the warrior’s face. The impressions are concentrated under the figure’s chin and continue towards the bottom of the sheet until they reach the line of the warrior’s armour. These parallel marks could be the edges of the watermark design. On the Boston drawing, Patricia Trutty-Coohill ([Pedretti and Trutty-Coohill 1993](#), pp. 52–53) indicates a “three mountains” watermark, similar to Briquet no. 11,931 (Pisa 1479; Pistoia 1483–1492).

Regarding the Windsor drawings, the watermark “calvary mountain” was mentioned for the first time by Kenneth [Clark \(1968–1969\)](#) edition, specifying only for sheet RCIN 912318 a reference to Briquet n. 11,678, while for sheet RCIN 912330, the watermark was considered not distinguishable because it was cut. More recently, new research on the Royal Collection sheets confirmed the watermark classification only for sheet RCIN 912318 ([Pedretti 1987](#), vol. II, p. 45), with some variations, while for sheet RCIN 912330 the watermark remains undetermined.

Two further correspondences add to these previous ones: *A study of St Anne, the Virgin and Child* (c. 1501) in Paris (Musée du Louvre, museum nr. RF 460, recto), and *A study of seated figures in conversation* (c. 1480) in Windsor (RCIN 912702). Ariane [de La Chapelle \(2003](#), p. 445) analysed the watermark of the French drawing. The beta-radiography reproduction of the sheet reveals a “three disjoined mounts” subject that La Chapelle places in the Florentine area between 1490 and 1500. The watermark is also documented by Pietro C. [Marani \(2008](#), pp. 78–79) with Briquet’s reference no. 11,925 (Reggio Emilia 1438) and mentioned in the online catalogue of the *Cabinet des dessins du Louvre*. In the Windsor drawing (RCIN 912702), the watermark is incomplete. The transmitted light image of the sheet, available online (Royal Collection Trust), shows a partial *signum* in which only the three mountain peaks are visible. Photographic evidence suggests that this watermark is part of the sub-category “three aligned mountains” a figurative type to which the watermark on the Raphael sheet belongs (Figure 4).

Of Leonardo’s six drawings above, only the last two currently have an accessible visual reference. In the case of the other four documents, the absence of diagnostic images of the paper mould data precludes immediate recognition of the watermark and undermines the usefulness of the watermark as a comparison tool. Considering these factors, it is not easy

to use the first four watermarks to date the Raphael sheet. Complicating the chronological estimates is the fact that an exact specimen of the Raphael watermark does not seem to be present in any of the significant repertoires. Since it is a potential new mark, it does not provide any auxiliary dating for the document. The historical criteria for Raphael's Leda are based on the stylistic and thematic analysis of the drawing. On the contrary, the date attributed to the graphic work (1507) becomes the *terminus ante-quem* of the paper's manufacture and the *terminus post-quem* of the use of the sheet as a graphic instrument. As far as the origin of the paper is concerned, Leonardo's sheets provide valuable evidence: papers with a "three mounts" watermark were widespread in Florence at least as early as 1480, both with a subject of three aligned mountains (RCIN 912702) and with a subject of three disjointed (unconnected) mountains (Musée du Louvre, no. RF 460, recto). In this regard, it is worth mentioning the passage from [de La Chapelle \(2003, p. 445\)](#): «*Les filigranes au trois monts disjoints les plus proches sont présents, par ailleurs, sur plusieurs gravures de l'école florentine autour de 1500, et tout particulièrement l'une d'elle, La Vierge et l'Enfant entre sainte Hélène et saint Michel, vers 1490–1500*».

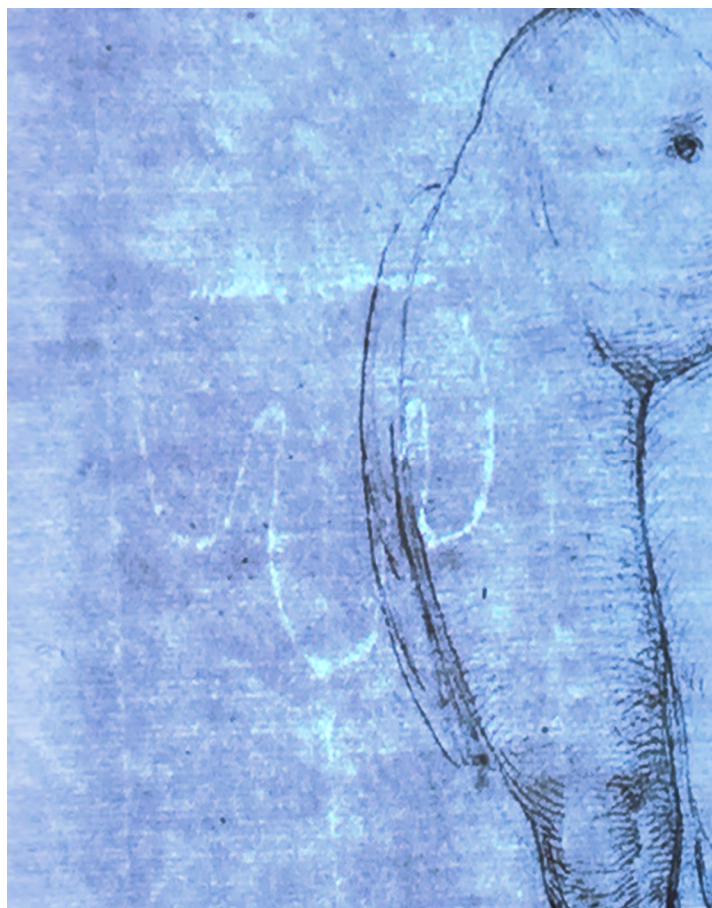


Figure 4. Raphael, *Leda and the Swan*, ca. 1507, pen and ink over black chalk underdrawing, 210 × 192 mm, RCIN 912759, Royal Collection, Windsor Castle. Royal Collection Trust/© Her Majesty Queen Elizabeth II 2021. Detail of the watermark "three aligned mountains" in transmitted light exposure. Used with permission. Image in transmitted light created by author.

In light of these considerations, Raphael probably purchased the drawing paper in Florence. However, it is more difficult to determine the place of manufacture of the ream of paper from which the sheet is derived. The paper could have been produced in the Florentine area, but could also have come from other places in Tuscany (e.g., Lucca, Pisa, Pistoia, or Colle val D'Elsa) or in northern Italy (e.g., Bologna), supported by trade. These background data from the Raphael document are interesting when read in relation to

another drawing by Leonardo (RCIN 912518), commonly considered as evidence for the head of Leda. The watermark (“Tulip”, close to Briquet no. 6664, Florence, c. 1508) in the RCIN 912518 also endorses the date of 1505–1508. Although the watermark’s motif has a different classification than that of Raphael, it suggests two similarities between the papers: chronological affinity and the detection of Florence. This suggestion is not evidence that Raphael’s watermark is Florentine, but it does help reinforce the validity of the theory that Raphael executed the drawing during his stay in Florence, which is also confirmed by stylistic investigations of the composition.

6. Author Statement

The article concludes with a final reflection. Comparison of the watermarks in the drawings by Leonardo (RCIN 912518) and Raphael (RCIN 912759) show a fairly similar temporal relationship, yet perhaps diachronic enough to determine some differences between the works (Figure 5).



Figure 5. On the left, Raphael, *Leda and the Swan*, ca. 1507, pen and ink over black chalk underdrawing, 210 × 192 mm, RCIN 912759, Royal Collection, Windsor Castle. Royal Collection Trust/© Her Majesty Queen Elizabeth II 2021. On the right, Leonardo da Vinci, *Head of Leda*, ca. 1505–1508, black chalk, pen and ink, 177 × 147 mm, RCIN 912518, Royal Collection, Windsor Castle. Royal Collection Trust/© Her Majesty Queen Elizabeth II 2021. Detail of Leda’s head. Comparison between Raphael’s and Leonardo’s drawing. Used with permission.

It is conceivable to believe that Raphael observed Leonardo’s model of Leda around 1505–1506, during the transitional phase between the composition of the kneeling Leda and the standing Leda, the latter generally considered to be later (Allison 1974, p. 383; Pedretti 1973, p. 97). At this time, Leonardo’s work would have been at an early or intermediate stage of the second version, with figures still sketched and details yet to be defined. These probably included the study of Leda’s head, a key element in expressing the subject’s psychological charge and, therefore, an element worthy of careful reworking (this theory would be confirmed by taking the date of the drawing RCIN 912518 to 1508, which would make it later than Raphael’s Leda). If this had been the case, Raphael would have had to interpret Leda’s pose and especially her expression on his own, generating a genuine divergence between the two representations and thus a creative act. At the same time, Leonardo would have continued to develop new solutions until arriving at the potentially definitive solution in the drawing RCIN 912518 at Windsor.

7. Results

This research can provide simplified guidelines for beginning or updating new digitisation initiatives on manuscripts and drawings in the art sector. The working methodology applied has provided the following results: paper images in reflected light (ambient light) and transmitted light (backlight), proportioned to full scale without photographic distortion; vector tracing of the watermark; vector tracing of the main lines of the paper mould (chain lines, laid lines, sizes of the sheet, etc.); full-scale representation of the complete mould data lines in a millimetre diagram; multilayer image format with various visual levels of content (e.g., PNG); full descriptive cataloguing of paper-based contents following IPH classification standards.

The results of the work made it possible to catalogue the physical properties of the paper used by Raphael and to confirm the dating of the drawing around 1506–1508, through the analysis of the correspondence between Raphael's sheet and a series of studies on *Leda* drawn by Leonardo, in particular through the watermarked sheet with the *Head of Leda* sketch (RCIN 912518) dated 1505–1508. Based on the chronological estimation expressed by art historians, the date attributed to Raphael's drawing also establishes the *terminus post-quem* of use of the sheet and, thus, an initial *terminus ante-quem* of paper manufacture. A review of the main repertoires of papers reveals that the watermark recorded on the Raphael sheet may not have an identical known morphological correspondence (already filed with date and provenance), and therefore the *signum* may be new. Owing to this, 1507 also becomes the first chronological reference for the watermark on the sheet. From the bibliographical and historical examination of the watermarks on the six Leonardo sheets, which were compared with Raphael's drawing, the author demonstrates that the origin of the paper used by the Urbino artist is most likely Tuscan. The "Three Mounts" watermark was circulating in Florence as early as 1480. These facts suggest that Raphael purchased the paper in Florence, confirming the Florentine nature of his artistic contribution.

8. Conclusions

This article has highlighted the value of the watermark as an investigative tool to support art historians in the process of understanding a drawing or manuscript. Technical analyses aimed at recording the physical properties of the paper were necessary to access a more comprehensive order of understanding about the cultural artefact. As with "archaeological excavations", these operations, which sought to uncover the stratigraphy of the paper element, have led to improvements in knowledge on various levels: both on the papermaking features of the artefact, and indirectly on the contextual elements of the graphic work. In the humanities, and particularly in art history, awareness of the paper used by an artist helps to confirm or reject attributions not only chronologically but also in terms of authorship, especially in the case of seminal protagonists in their cultural field—such as Raphael and Leonardo who had pupils and followers.

A key point of this work was to express the importance of the concept of access to information. The design process develops a model for extracting, digitally retracing and archiving the mould lines of the paper's sheet successfully and with a simple solution. The article highlighted the need to scientifically account for the results achieved by instrumental investigations with a view to dissemination and generating new research. Hence, the importance of a data cataloguing system includes the paradigmatic references of the analyses, complete with bibliographic sources and supplemented by academically accepted international archiving and classification parameters. The output scenario covers a wide range of applications in the context of graphic oeuvre for authentication, enhancement, monitoring, archiving and dating and, therefore, is useful for cultural institutions, museums, archives, libraries and private collections.

Future research in this project intends to make the paper data cataloguing system more effective by implementing the watermark representation diagram with an interface that communicates the primary quantitative data of the paper in an informative-visual format. In parallel, the project plans to continue sampling watermarks in Raphael and Leonardo

drawings. The consequences of the new research could have relevance to constitute a corpus of information concerning the operating habits of a specific artist concerning the paper used, quality preferences, format, place of production and frequency of use. Finally, these investigations can actively contribute to enriching the repertoires of watermarked papers. Although the excessive proliferation of new types of marks may in the future complicate the choice of the most suitable comparative sample, the community of scholars will only be able to increase the effectiveness of historical attributions through an exhaustive and constantly updated cultural heritage of watermarks.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Appendix A.1. Watermark Diagram and Paper Data Classification

Appendix A.1.1. Bibliographical Data of the Sheet

Author: Raphael (1483–1520); Identification of the collection: Royal Collection; Number of the original sheet: RCIN 912759; Institution holding the original document: Royal Library—Royal Collection Trust; Institution location holding the original document: Windsor; Institution country holding the original document: United Kingdom.

Appendix A.1.2. Bibliographical Data of the Content in the Sheet

Author: Raphael (1483–1520); Title of a work of art (subject): Leda and the Swan; Country of use (paper): Italy; Place of use (paper): Florence; Earliest possible date of use: 1506–1507; Latest possible date of use: 1508; Kind of dating: traditional date.

Appendix A.1.3. Paper Data

State of the sheet: Trimmed; Height of the sheet (mm): 310 mm; Width of the sheet (mm): 192 mm; Allocation to a standard dimension: Not classifiable; Colour of the sheet: Natural; Specific colour of the sheet: Ivory; Colour-dyed side of the sheet: Absent; Intensity of the colour: light; Quality/aspect of paper sheet: Fine and transparent; Orientation of the sheet—according to the drawing: Vertical; Orientation of the sheet—according to the mould: Vertical; Position of wire side: Wire side facing down (on verso).

Appendix A.1.4. Mould Data

Paper production type: Hand-made; Paper type according to mould: laid, vergé; Number of laid lines over a distance of 20 mm: 20; Distance in mm of 20 laid lines: 20 mm; Width of the chain compartments in mm from left to right: (26-32)-41-39; Shadow zones: Zones below the chain lines.

Appendix A.1.5. Watermark Data

Classification of the watermark by researcher: Three aligned mountains (?); Classification of the watermark by collector—Briquet: Monts/3 Monts simple; IPH- Class: J3/3—Three mountains (hills); Kind of watermark in the sheet: Main watermark; Structure of watermark: Line watermark; Main motif; State of the watermark: Complete; According to the mould side—Height of the watermark in mm: 51 mm; According to the mould side—Width of watermark in mm: 47 mm; According to the drawing—Position of the

watermark in the sheet: Middle—Left part; According to the mould side—Distance in mm between the watermark and the nearest chain line: on the left 3 mm, on the right 8 mm; According to the mould side—Distance in mm between the watermark and the edge of the sheet: from the bottom 137 mm; from the top 122 mm; from the left 16 mm; from the right 128 mm; Correct reading sense of watermark—according to the mould side: From top to bottom—on verso side of the sheet; Briquet Reference: no. 11662, Florence, 1432; Piccard Reference: no. 150149, Pisa, 1390.

Appendix A.1.6. Reproduction Method of Mould Data

Acquisition method of mould data: Transmitted light photography; Digital tracing method of mould data: CAD and Adobe Graphic softwares; Reproduction scale of mould data: 1:1; Side of the reproduction tracing paper data: tracing according to the mould side of the sheet (on verso).

Appendix A.1.7. Credits and Notes

Editing year: 2021; Author(s) of the research: Claudio Calì.

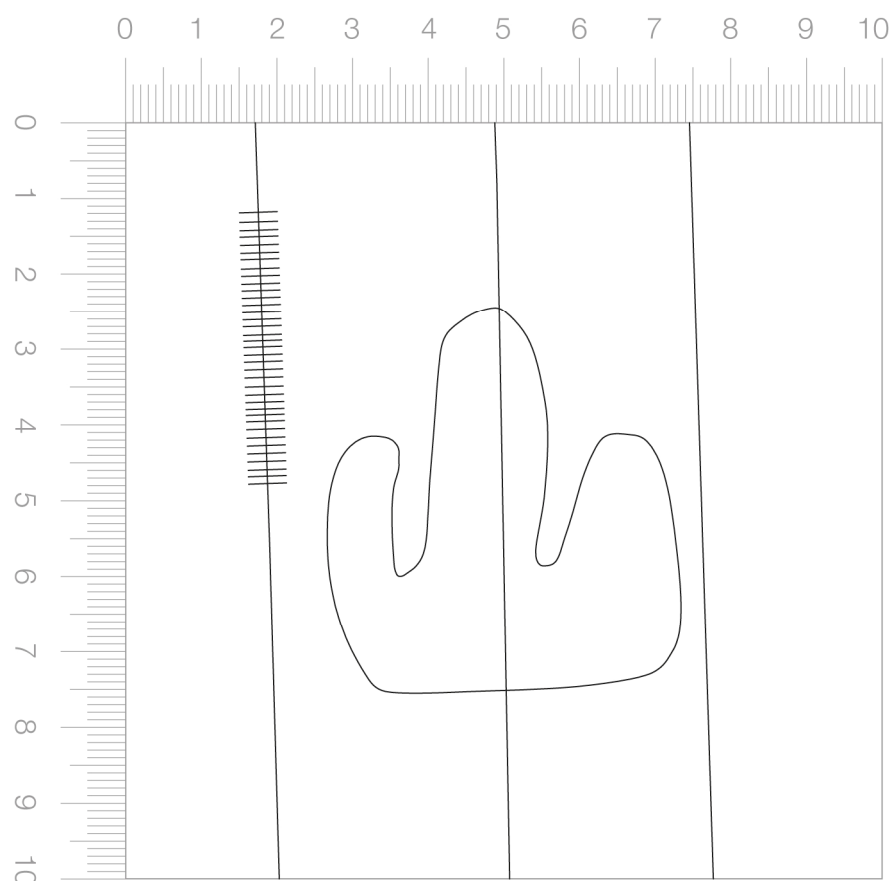


Figure A1. Watermark design diagram. Digital retracing of the main lines of the paper mould of the sheet RCIN 912518. Reproduction according to the verso side of the folio, likely the mould side of the paper sheet. Created by author.

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