Fragmentology

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Indices

Identifying Medieval Fragments in Three Musical Instruments Made by Antonio Stradivari

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Abstract: This article identifies ten fragments, used as reinforcements in the sounding boxes of three instruments made by Antonio Stradivari (Cremona, ca. 1648–1737), which are now kept in the Ashmolean Museum in Oxford (the 'Cipriani Potter' violin, 1683, and the 'Hill' guitar, 1688) and the musée de la Musique in Paris (the 'Vuillaume' guitar). The fragments appear to come from a single book of hours, made in Italy no later than the mid-fifteenth century. This identification allows the documentation of the use of parchment fragments in the making process of Stradivari. The authors discuss what the common origin of parchment fragments found in three distinct instruments implies for the authenticity and relative dating of their making. Finally, this study sheds light on the potential of documenting reused parchment fragments, which are widely present in many string musical instruments produced in the sixteenth to eighteenth centuries.

Keywords: musical instruments, organology, parchment, fragment, book of hours

While the reuse of parchment as binding materials is well-known by book historians, book conservators, and fragmentologists, it was not a topic of research for many organologists or conservators of musical instruments.[1] Manuscript fragments found in historical

* Jean-Philippe Échard warmly thanks Colin Harrison, curator, and the staff of the Ashmolean Museum in Oxford for the excellent conditions provided to access the two musical instruments in the collection, as well as Justine Provino, Nicole

musical instruments are rarely studied and documented for their codicological aspects or textual content.[2] It is well known, however, that strips of parchment or paper were used to keep in position the adjacent thin curved ribs of the egg-shaped sounding boxes of lutes, or in citterns, viols, and 'baroque' guitars when the backs and ribs of these instruments are made of several adjacent thin boards.[3] When parchment and paper strips are encountered in instruments of the violin family, they generally correspond to later repairs or restorations.

This article reports on parchment fragments found in the interiors of three musical instruments and documented systematically with a dedicated endo-photographic system assembled for this campaign. Indeed, the fragments discussed in this article all remain in situ, glued onto wooden surfaces, in the interior of the sounding boxes. The photographic system was designed so that it can enter inside the sounding boxes, and be able to access and photograph most if not all of the fragments. A rigid endoscope (TS 060 VAR 50 045 QR, Foretec) was used, mounted to a SLR camera (Nikon

Gilroy, Andrew Honey, Philippe Bruguière, Sebastian Kirsch, John Milnes, Oulfa Belhadj, and Marie Radepont for the fruitful discussions in the course of this research. This work benefited from the support of Constant Vétillart for the acquisition of endoscopic photographs of the 'Vuillaume' guitar, Alexandre Gillon for their processing, and of Oulfa Belhadj and Marie Radepont for the XRF acquisitions.

1 Organology is the discipline studying the history of musical instruments, of their making techniques and of their makers.

2 Among the rare examples of studies are the identification of Hebrew fragments in a bass viol and two virginals, reported in D. Melini, and R. Tonnarelli Corsi, "Frammenti Ebraici E Strumenti Musicali : Un'insolita Relazione", *Materia giudaica : rivista dell'associazione italiana per lo studio del giudaismo* 22(2017), 249–257, and the identification of ca. 1240–1280 script on parchment fragments in a sixteenth-century vihuela da mano, by D. Escudier (IRHT) in 1999, mentioned in S. Vaiedelich, "Vers une organologie scientifique et prospective : l'exemple des deux vihuelas parisiennes", in *Aux Origines De La Guitare : La Vihuela De Mano*, ed. J. Dugot, Paris 2004, 74–82.

3 Reused parchment strips bearing traces of medieval writing and used in the making of the instruments are documented in several instances in the collection of the musée de la Musique in Paris, such as the cittern by Girolamo Virchi, Brescia, sixteenth century, E.1271 or the lute by Laux Maler, Bologna, before 1552, E.2005.3.1.

D600 equipped with a Micro-Nikkor objective). Its diameter (6 mm) allowed its insertion through the slightly conical openings located on the ribs of all three instruments, on the side opposite to the neck. Its length, (450 mm), the variable optical axis of its viewing system (45°–115° to the endoscope's main axis) as well as the integrated fibre-optic lighting and focusing systems were features well-adapted to the specific constraints. Given the limited dimensions of the sounding boxes, the 50° field-of-view of the optical system was too narrow to frame a whole fragment in one shot: a series of images was made from various angles in order to record all accessible information from each fragment. Despite its intrinsic geometrical and optical limitations, the endo-photographic system overcame part of the challenges linked to the documentation of such fragments.[4]

The identification of this limited set of ten fragments leads to the conclusion that they all originate from a single dismembered book of hours. This result has implications on the attribution and relative dating of the three instruments studied, the practice of using parchment fragments in Stradivari's workshop; and the possible provenance of such material used in a Cremonese workshop in the end of the seventeenth century.

A Bifolium for a Violin

In a chapter dedicated to the violin, known as the 'Cipriani Potter' (Antonio Stradivari, Cremona, 1683, Ashmolean Museum, WA1946.272), Carlo Chiesa and John Dilworth report that: "The most striking aspect of the interior is the parchment backing for the ribs, which appears to be cut from the pages of a book, with a very beautiful printed (or possibly handwritten) Latin text, with capitals illuminated in vivid red and blue."[5] Given the positions,

4 In particular, the images obtained had stronger geometrical distortions (fish-eye effect) than those obtained with more conventional cameras or digitization systems.

5 J. Dilworth and C. Chiesa, "Violin, the 'Cipriani Potter'", in *Musical Instruments in the Ashmolean Museum – The Complete Collection*, ed. J. Milnes, Oxford 2011, 146–153. The 'ribs' of a violin are the thin bent wooden boards, which are the sides of the sounding box, placed between and glued perpendicular to the front board (or: soundboard) and the back.

shapes and very small dimensions of the openings allowing for a direct visual observation of the inside of a violin, this observation is quite remarkable, despite the scarce details it contains.

The sounding box of a violin — new or at least in good condition — usually does not require such internal reinforcements: The wooden structure, and in particular the wooden corner blocks and linings are indeed sufficient in most cases to strengthen the ribs together with the soundboard and the back of the resonant body. The outstanding decoration technique of the ribs on this very violin — a technique described as a 'bravura piece' — is certainly the reason for the use of reinforcements from the inside: for this instrument indeed, Antonio Stradivari carved the wood of the ribs following a floral design and inlaid with black mastic the maple boards, which are barely more than 1 mm thick [Figure 1]. The carving of channels locally reduced the thickness of the ribs and lowered their contribution to the mechanical equilibrium of the violin structure. The gluing of parchment strips on the inner side of the ribs has certainly helped this instrument to survive to the present.

Eight fragments (here named *vln_1* to *vln_8*) are observed in the 'Cipriani Potter' violin [Figure 2]. They share many similar features. These fragments are all made of parchment, and are approximately rectangular, of the same height, estimated at 13 mm.[6] For those on which writing is visible (*vln_1–2*, *vln_5–7*), the leaf was cut parallel to the writing lines. The shape of the letters and the distance between writing lines (approximately 4.4 mm) seem very consistent throughout the whole set of the written fragments. The script is a Southern *Textualis*, characterized by the roundness of the bows, especially in the *b, d, o, p*, and *q*. The contrast between bold and thin strokes is extremely emphasized, and ascenders and descenders are very short. The Italian origin of this script is recognizable in the high level of formalization and in the shape of some letters: *a* with a triangular lobe and an upper lobe closed by a hairline; uncial *d*

6 The ribs height corresponds to the distance between the inner surfaces of the soundboard and the back plate, at the ribs. In this violin, it measures between 29.5 mm, at the neck, and 30.7 mm, at the end-button. See *Musical Instruments in the Ashmolean Museum*, 214. An average value of 30 mm was used to interpolate the height of the fragments from the endoscopic photographs.

Figure 1: Detail view of the upper rib on the bass side of the 'Cipriani Potter' violin. © John Milnes / Ashmolean Museum.

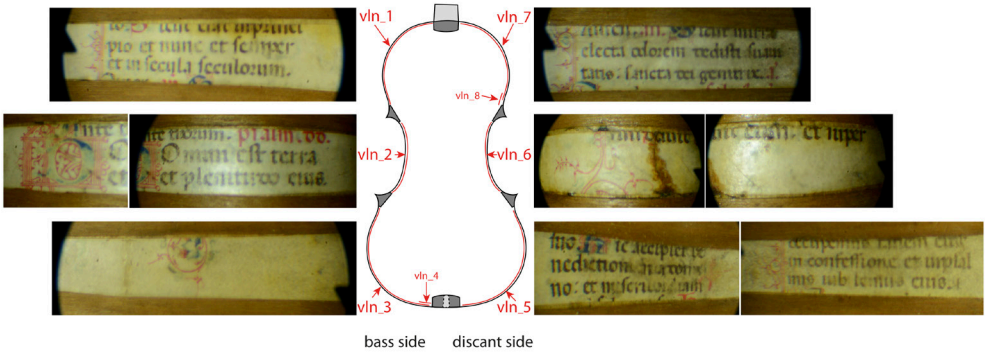


Figure 2: Position of the parchment fragments inside the 'Cipriani Potter' violin, and endoscopic photographs of the written or decorated areas.

with the short and almost horizontal shaft; *g* with a round lower lobe that gives the letter the form of a figure *8*. The writing is in dark ink mainly, with minor initials — painted in blue or red, and pen-flourished in the other colour — for the first letters of the psalms. The same colours and pen-flourishing decoration are used for the major decorated two-line-high initial visible on fragment

vln_2, extending as a linear and arabesque embellishments on the whole left border of the corresponding text block. The end of a similar decoration is visible on fragment *vln_3*, otherwise unwritten. Sewing holes are visible for most fragments (one or two per fragment). These observations suggest that these fragments, found in the same musical instrument, may come from the same manuscript.

Indeed, closer comparison of truncated writing lines at the top or the bottom limits of some fragments indicates that fragments 1, 7 and 2 were contiguous, in that order.

The three exhibit pen-flourished decoration in the left margin. Farther on the left, sewing holes are noticeable. This indicates their text was on the recto side of the folio. The text itself is transcribed as:

vln_1.1	[Gloria... sanc]to. Sicut erat in princi-
vln_1.2	pio et nunc et semper
vln_1.3	et in secula seculorum.
vln_1.4/vln_7.1	Amen. *an*(*tiphona*). Sicut mirra
vln_7.2	electa odorem dedisti suavi-
vln_7.3	tatis : sancta dei genitrix.[7] *a*(*ntiphona*).
vln_7.4/vln_2.1	Ante thorum.[8] *psalm*(*us*). *d*(*avi*)*d*.
vln_2.2	Domini est terra
vln_2.3	et plenitudo eius.[9]

This reconstituted text corresponds to an excerpt from the liturgical doxology *Gloria Patri*, followed by the antiphon for the Virgin Mary, taken from Psalm 18(19), and then by the first verse of Psalm 23(24), marked as *Psalm of David*.

The single writing visible on top of fragment *vln_6*,

vln_6.1	[fun]davit e[um] : et super[10]

is a part of next verse of the same psalm. Since this fragment also has sewing holes and pen-flourished decoration on its left side, and given the large bottom margin, we hypothesize that this fragment was initially located on the same folio as the previous fragments,

7 R.-J. Hesbert, *Corpus Antiphonalium Officii*, I–VI, Rome, 1963–1979 (=CAO), no. 4942.
8 CAO 1438.
9 Ps. 23.
10 Ps. 23:2.

showing the last line of its text-block. From the amount of lacking text between the fragments, we estimate that three lines of texts are actually missing.

Fragment *vln_5*, glued on the discant lower rib, is significantly longer than the previously described fragments. It shows two distinct groups of writing lines. Two sewing holes, as well as traces of a vertical folding line, are visible in the unwritten area between these two groups. This indicates the two groups correspond to conjugate leaves of the same bifolium, once part of a codex. Local damage to the group on the left prevents a full direct transcription. Nevertheless, its central two lines read "nediction[e]m a do[mi-] / no : et m[i] sericordiam". This is an excerpt from the fifth verse of Psalm 23(24). The other two, lacunar lines correspond well to the text surrounding this excerpt in the Psalm. Indeed, the last word of verse 4 is "suo", and the full fifth verse is "*Hic accipiet benedictionem a Domino et misericordiam a Deo salvatore suo*"

vln_5L.1	suo. Hic accipiet be-
vln_5L.2	nediction[e]m a do[mi-]
vln_5L.3	no : et m[i]sericordiam
vln_5L.4	[a deo] s[a]l[vatore] s[uo.] H[ec]

Given its position in the fragment, this text would have been located on the verso side of a folio in a codex. This verso side exhibits an excerpt of the Psalm of David (end of v. 4, v. 5) that appears later in the text of the same Psalm found on a recto side on *vln_2* and *vln_6* (v. 1, excerpt of v. 2). A reasonable hypothesis is that these were originally the recto and verso of the same folio, which is supported by the number of missing lines (9) between the last line of the recto and the first readable line of the verso.

The last writing group, on the right of the fragment vln_5,

vln_5R.1	occupemus faciem eius
vln_5R.2	in confessione et in psal-
vln_5R.3	mis iub[i]lemus eius.

corresponds to the second verse of Psalm 94 of the Latin Psalter, the so-called invitatory psalm.

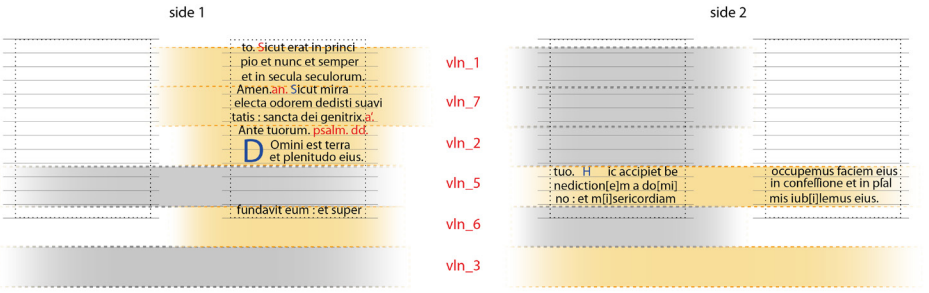


Figure 3: Reconstruction of the bifolium from which Stradivari cut out fragments for the 'Cipriani Potter' violin. In grey, fragment sides glued onto the wood.

Organization of the Fragments in the Bifolium

Fragments *vln_1–2* and *vln_5–7* are certainly all cut out from a single bifolium. In particular, fragments *vln_1*, *vln_7* and *vln_2* are contiguous fragments since the visible sides can be assembled/matching in this order. The texts visible from the inside of the violin on fragments 1, 7, 2 and 6 are all written on the same side of the parchment. The sewing holes visible on the left of the text blocks, indicating that this side corresponds to the recto of the folio. From the verso of this folio, only the left block of *vln_5* is visible from the inside of the violin. These fragments thus show that this folio had 13-line text block no less than 58 mm high.

The text block on the right side of *vln_5*, an excerpt of the second verse of Psalm 94, is located on the recto side of the conjugate folio. A red linear and arabesque embellishment decorates the left border of the text. This would suggest that a major initial, very probably the first letter for Psalm 94, is present above in the previous lines of the text block — similarly to the instance for the beginning of Psalm 23 (*vln_2*, f. Ar).

A red and blue decorative element is visible on *vln_3*, close to the central fold. Since the exposed side of the fragment is otherwise blank, another very similar red and blue decorative element can be faintly observed on the hidden side of the conjugate folio, close to the central fold. Given their locations on the fragment, these two ornaments could hypothetically correspond to the *top* end of

embellishments, which would decorate the *right* borders of text blocks. But, assuming that this fragment originates from the same leaf as the other ones in the violin, and given that embellishments are present on the *left* borders of their texts, the most plausible conjecture is that fragment *vln_3* was located towards the *bottom* of the leaf, below fragment *vln_6* [Figure 3].

With the six main fragments glued inside the 'Cipriani Potter' violin now spatially organized in a single original bifolium [Figure 3], it is possible to make additional conclusions from the texts themselves.

The texts of the bifolium are those of the Office of the Virgin Mary, and since Psalm 94 is placed at the beginning of the matins, this leaf should be placed before the other one, which contains the antiphons and psalms of the first nocturne. The Office follows the use of Rome, which has for the first nocturne[11]:

Ant. *Benedicta tu*; ps. *Domine dominus noster* (Ps. 8)
Ant. *Sicut mirra*; ps. *Caeli enarrant* (Ps. 18)
Ant. *Ante thorum*; ps. *Domini est terra* (Ps. 23)

The amount of text that is lacking between the invitatory psalm and the doxology of what we assume to be Psalm 18 allows us to state that about eight pages (that is four leaves or two bifolia) are missing between these two leaves. This bifolium could then have been the third from the center of a quire.

Two Guitars, and Two More Fragments

Two parchment fragments were also identified in two guitars made by Antonio Stradivari, using the endoscopic system described above. The guitar known as the 'Hill' (after the name of its previous owners) is dated 1688. It is in the collection of the Ashmolean Museum in Oxford (WA1939.32). The guitar known as the 'Vuillaume' (after the name of its previous owner) is undated. It is in the collection of the musée de la Musique in Paris (inv. E.904).

11 See Victor Leroquais' discussion of the use of Rome in his notes on the Office of the Virgin, Paris, Bibliothèque nationale de France, NAL 3162, f. 16r–v.

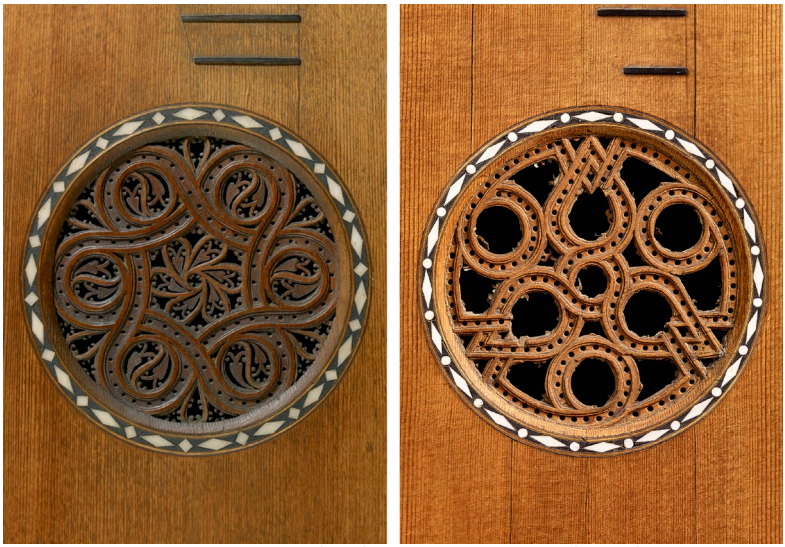


Figure 4: Roses of the 'Hill' (left) and 'Vuillaume' (right) guitars. One manuscript parchment leaf is glued underneath each of these roses. Soundhole diameters: 82 ad 88 mm respectively.

The soundholes of these two guitars are circular openings that are cut out in the spruce soundboards. Openwork roses, made of three layers of wood, each about 0.5 mm thick, cut out in geometrical patterns in order to give visual impression of depth when seen from the outside, are glued on the inside of the soundboards, partially sealing the soundholes [Figure 4]. Our examination revealed that a parchment fragment was glued underneath the lowest thin layer of wood of each of the sculpted roses.[12] The parchment leafs were certainly used as the reinforcing substrate for the three superimposed layers of wood when assembling and making the roses.

The 'Hill' fragment

The 'Hill' rose is in very good condition, and the holes in the parchment are limited to the delicate openings that were cut out to

12 Prior to 1999, the conservation staff had already performed endoscopic examination of the 'Vuillaume' guitar, since corresponding photographs are kept in the file for this instrument. These photographs only showed, however, manuscript paper fragments glued on the ribs. No corresponding examination report was found. J.-P. Échard, *Stradivarius et la lutherie de Crémone*, Paris (in press).

Figure 5: Assemblage of multiple endoscopic photographs of the fragment inside the 'Hill' guitar. Not all distortions could be corrected, and the reconstruction is not geometrically accurate.

create the rose design.[13] The shape of the parchment leaf, located on the inside of rose of the 'Hill' guitar, can be described as an octagon approximately 90.5 mm high and 82 mm long [Figure 5].

Thirteen lines of writing are visible. The white areas surrounding the written area suggest that the whole text block is present. The lines are perpendicular to the guitar's main axis, the top of the text opposite to the soundboard side. The script is again a Southern *Textualis* of Italian origin, as can be seen from the rounded shape of the letters: in particular, we notice the typical 3-shaped final *m* (line 9) and the Southern Tironian note for *et*. The shape of the *a, d* and *g* suggests that the Hill fragment was written by the very same hand as the Cipriani Potter fragments.

It is possible to transcribe almost fully the text, which consists of Psalm 39(40), v. 14–17:

Hill.1 me domine ad adiuvan-
Hill.2 dum me respice. Con-
Hill.3 fundantur et revereantur

13 No previous endoscopic examination of this guitar has been reported. G. Gregori, *Antonio Stradivari, Le chitarre – The guitars*, Cremona 2019; S. Barber, S. Harris, and L. Sayce, "Ash.49 Guitar", *Musical Instruments in the Ashmolean Museum*, 298–307.

Hill.4 simul qui querunt [animam]
Hill.5 m[ea]m et auferant eam.
Hill.6 Conuertantur retrorsum
Hill.7 et revereantur qui vo-
Hill.8 lunt michi ma[la.] Ferant
Hill.9 confestim confusionem
Hill.10 suam, qui dicunt michi e-
Hill.11 uge e[u]ge. Exult[e]nt et
Hill.12 letentur super te omnes
Hill.13 querentes te. Et dicant

Psalm 39 is the first psalm of the third nocturne of the Office of the Dead, which is usually part of a book of hours. The four initials are alternatively painted in red and blue. Additionally, one observes a line running parallel to the vertical left border of the text block, at a distance of approximately 10.1 mm. Red curved lines of a pen-flourished decoration are in the bottom left corner, farther to the left of this line, which could correspond to the central fold of a bifolium (the main visible text would then correspond to the recto of a page), or to the border of visible part of the main fragment (the decorated part on the left would then be another smaller fragment used as a patch).

The 'Vuillaume' fragment

The current condition of the 'Vuillaume' rose is far from that of the 'Hill' rose. In particular, the delicate openings cut out in the thinnest part of the three-layered wood structure have been brutally destroyed in the past, leading to larger openings, and consequently, more important lacunas in the parchment and in the text it is bearing [Figure 6]. These larger openings are probably responsible for more dust entering the sound box, leading to a darkening of the parchment surface, reducing the readability of the remaining writings. Also, a triangular-shaped part was inserted during repair work.

The shape of this fragment, located on the inside of rose of the 'Vuillaume' guitar, can be described as a disc approximately 96 mm in diameter.[14] Thirteen lines of writing are visible. The size of the

14 The two guitars have similar circular soundholes in their soundboard (diameters of 82 and 88 mm for the 'Hill' and the 'Vuillaume' respectively), to which are glued from the inside their carved rose.

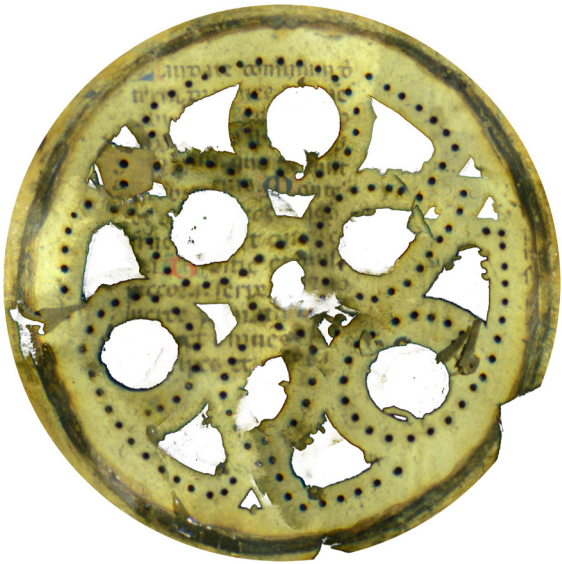


Figure 6: Assemblage of multiple endoscopic photographs of the fragment inside the 'Vuillaume' guitar. Not all distortions could be corrected, and the reconstruction is not geometrically accurate.

unwritten borders surrounding the written area suggests that the whole text block is present, except for the upper part of the first initial, in the upper left corner. The orientation of the text forms a ca. 63° angle to the guitar's main axis. Despite the difficulty in reading the text, the script is undoubtedly an Italian *Textualis* that shows the very same features as the Hill and Cipriani Potter fragments.

It is possible to transcribe partially the text, which can be identified as Psalm 148, v. 7–11:

	Transcribed text	*Psalm 148:7–11*
Vuillaume.1	Laudate Dominum de	Laudate Dominum de
Vuillaume.2	terra dr[...]nes [.....]es	terra dracones et omnes
Vuillaume.3	aby[....] I[.]n[....]o	abyssi. Ignis grando
Vuillaume.4	[...]s sp[...] pro	nix glacies spiritus pro-
Vuillaume.5	[...]rum que [...]unt	cellarum quae faciunt
Vuillaume.6	[...]b[...] eius Montes	verbum eius. Montes
Vuillaume.7	et o[...] co[.]le[...] na	et omnes colles ligna
Vuillaume.8	fruc[....]t omnes c[.]	fructifera et omnes ce-
Vuillaume.9	[...]i B[.]stie e[.] n[..]fa	dri. Bestiae et universa
Vuillaume.10	peccora. [...] serpe[...] et vo	pecora serpentes et vo-
Vuillaume.11	lucres p[..]n[..?] Re[..]es	lucres pinnatae. Reges
Vuillaume.12	[...] et [.]mnes [..]pu[..]	terrae et omnes populi
Vuillaume.13	[...]ipes et [...]es iu	principes et omnes iu-

Interestingly, three black traces on the right border of the fragment may correspond to letters at the beginning of other lines of script. This would indicate that the fragment was part of a bifolium in a codex, and that the main visible text corresponds to the verso of a page.

It was possible to use X-ray based imaging techniques on the 'Vuillaume' guitar in order to gather additional information about this fragment. Indeed, with X-ray radiography, the denser materials used for red and blue paints/inks (probably the mercury-containing vermilion pigment and copper-containing azurite, respectively) provide a good contrast, since they absorb X-rays significantly more than the other materials that are present. This quite conventional examination technique revealed more pen-flourished initials than the ones that were observed using endoscopy, indicating that the other side (the recto) of the leaf also had writing [Figure 7]. It was possible to access, in part, the otherwise unreadable writings inscribed on the other side of the fragment — that is, on the side glued to the wood of the rose.

X-ray fluorescence imaging is another X-ray based technique, allowing for the spectral and spatial detection of specific chemical elements. It is widely used in the field of heritage sciences to identify various materials including pigments, as well as metal-containing inks.[15] The area of the text block was scanned using this technique. It not only revealed the presence of pen-flourished initials on the glued side, but also allowed a determination of the composition, and thus the colour of these initials. Indeed, the detection of mercury corresponds to the red pigment vermilion, whereas the detection of copper points to an azurite-containing ink/paint [Figure 8].[16]

15 See for instance the analysis of ink inscriptions on tools from the Stradivari workshop: M. Malagodi, G.V. Fichera, and M. Licchelli, "A Study of the Inks" in *Antonio Stradivari. Disegni, Modelli, Forme. Catalogo Dei Reperti Delle Collezioni Civiche Liutarie Del Comune Di Cremona*, ed. F. Cacciatori, Cremona 2016, 85–100; H. de la Codre, M. Radepont, J.-P. Échard, O. Belhadj, S. Vaiedelich, and V. Rouchon, "The Use of XRF Imaging for the Chemical Discrimination of Iron-Gall Ink Inscriptions: A Case Study in Stradivari's Workshop", *X-Ray Spectrometry* 50 (2020), 1–9.

16 Other elements were detected during this experiment. In particular, iron, copper and zinc located on the writing lines give insights on the composition

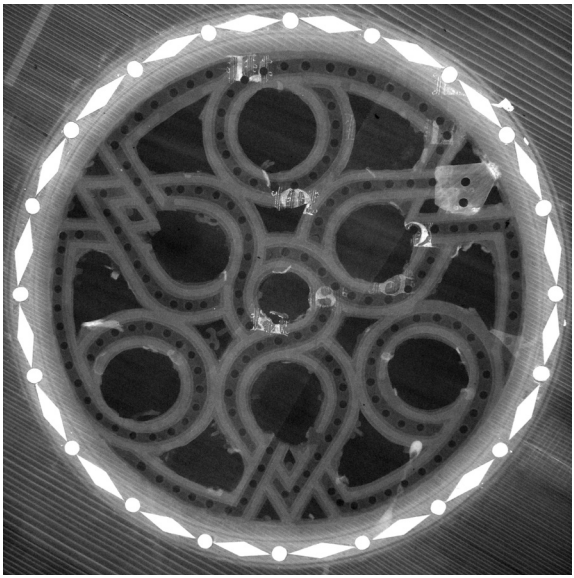


Figure 7: X-ray radiography of the rose area of the 'Vuillaume' guitar.

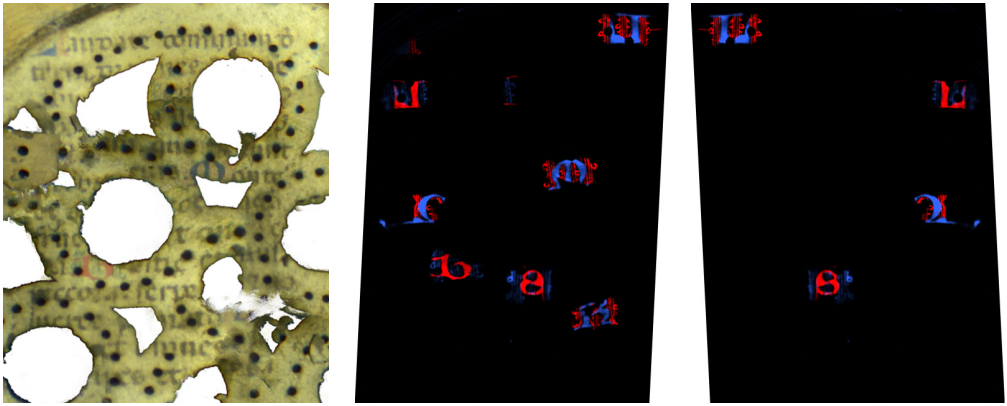


Figure 8: Left: View of the text block visible by endoscopy inside the 'Vuillaume' guitar; Middle: false-colour XRF map of the corresponding area where copper (Cu) is represented in blue and mercury (Hg) in red; Right: Mirrored XRF map, where only the initials invisible to endoscopy are shown, giving an image of the initials present on the parchment side glued onto the wood.

of the dark ink. However, the simultaneous detection of the writing lines on both sides of the leaf strongly overlap in the XRF maps, making it impossible at this stage to image solely the writings on the hidden (recto) side. Analyses

Assuming that the text blocks, as well as the writing lines, on the two sides of the folio are aligned, one may deduce that the initial "L" is the first letter of the first line (hence of the text block) of the hidden side, another "L" is towards the end of line 3, a "Q" towards the end of line 7, and an "S" in the middle area of line 10. This sequence of initials corresponds almost perfectly to the first letters of the preceding verses of Psalm 148 (v. 3 to v. 6), and the length of each verse would be compatible.[17] This would confirm that the hidden side (the one glued against the wood rose) corresponds to the recto of the folio, and the visible side to the verso. The alternating colours of the whole sequence of initials detected on the two sides of this fragment also support this conclusion.

Virtual Reconstruction of the Dismembered Manuscript

Many Corresponding Features... Pointing to the Same Dismembered Codex

An array of consistent textual, script, and dimensional features leads to the conclusion that the fragments found in the three instruments are *membra disjecta* from the same codex [Table 1]. Indeed, all texts are liturgical, in the Latin language, and written in Southern, typically Italian, *Textualis*. Also, many features are strongly similar or compatible: the height and width of the text block, the distance the between writing lines, the type and colour of the decoration for the initials and in the margins. For some letters, it was even possible to compare the way they were written [Appendix]. Even though the

were conducted by Marie Radepont and Oulfa Belhadj, using a Bruker M6 Jetstream XRF scanner (Rh source, 50 kV, 600 µA, spot size 100 µm, step size 100 µm, time per pixel 230 ms).

17 These three verses are: "[v. 3] Laudate eum sol et luna laudate eum omnes stelle et lumen [v. 4] Laudate eum celi celorum et aqua que super celum est [v. 5] Laudent nomen domini. Quia ipse dixit et facta sunt ipse mandavit et creata sunt [v. 6] Statuit ea in saeculum et in saeculum saeculi praeceptum posuit et non praeteribit."

	'Cipriani Potter' violin, 1683	**'Hill', 1688**	**'Vuillaume', undated**
Leaf material	parchment	parchment	parchment
Language	Latin	Latin	Latin
Type of script	Southern *Textualis*	Southern *Textualis*	Southern *Textualis*
Text content	excerpts of *Gloria Patri*, antiphon, Ps 23 and 94	excerpt of Ps 39	excerpt of Ps 148:3–11.
Number of lines	13	13	13
Text block height	≥ 58 mm	est. 59 mm	59 mm
Text block width		est. 46 mm	43 mm
Line height	est. 4.4 mm	est. 4.5 mm	est. 4,5 mm
Leaf height	≥ 82 mm	≥ 90.5 mm	≥ 95 mm
Leaf width	≥ 180 mm[18]	≥ 82 mm	≥ 95 mm
top margin		≥ 7 mm	≥ 6.3 mm
bottom margin	≥ 22 mm[19]	≥ 24.5 mm	≥ 30.2 mm
gutter (binding side)		≥ 10.1 mm	est. 15.8 mm
outer margin		≥ 23.1 mm	≥ 18.3 mm

Table 1: Comparison of features. Note: given that all fragments in the 'Cipriani Potter' violin are glued onto curved surfaces, the assessment of some dimensions is more uncertain or impossible (left blank).

fragments are not taken from the same bifolium or quire, they are certainly part of the same book.

Characterizing the dismembered codex

The above-mentioned features points to three bifolia coming from a single book of hours made in Italy, in the first half of the fifteenth century, and dismembered before 1683.[20] The 'Cipriani Potter'

18 This is an assessment of the length of the longer fragments (*vln_3* and *vln_5*) in the violin; glued on the inner side of the lower bout ribs (length 202 mm each), these two fragments are shorter, because they are between the lower block and the corner blocks [Figure 2].

19 This value is obtained by adding the height of *vln_3* to that of the blank area in *vln_6*.

20 A book of hours is a relatively thin book, with no more than 200 leaves (100 bifolia).

bifolium is taken from the Office of the Virgin; the 'Vuillaume' leaf also comes from the Hours of the Virgin, since it contains Psalms 148–150, which were sung at Lauds for the very same office,[21] but probably from another quire of the same codex. The 'Hill' leaf comes from the Office of the Dead of the same original manuscript, certainly from another — third — quire, placed farther in the codex.

Since all leaves taken from the same codex should be approximately of the same dimensions, and all text blocks should be positioned similarly on the folios, it is possible to describe in greater detail the general characteristics of the codex by considering the dimensional values obtained for the three leaves [Figure 9]. It is thus possible to deduce that the parchment bifolia were originally no smaller than 80 mm high and 180 mm wide, leading to a book of hours at least 9 cm wide, and certainly more than 8 cm high. The most conventional height:width ratios in medieval books are 4:3 (≈1.33) and the golden ratio (≈1.61).[22] Therefore, it is highly probable that the fragments observed here were severely trimmed in height. The original leaves could have been about 12–15 cm high.

The small number of writing lines on each page, allowing for wide margins, show the importance given to the aesthetic value of the artefact, in good agreement with the use of such books of hours by lay people for private devotion. The great care in the writing process, which is evident in the regularity of the letters and of the alignment on the ruled baseline, and the elegant pen-flourished initials suggest a quite fine product, probably copied for a member of a noble family.

21 Psalms 148–150 are always sung at Lauds, even in the Office of the Dead; in books of hours, the Office of the Dead usually follows that of the Virgin, so the same psalms are usually not copied twice. As a consequence, it is likely that the 'Vuillaume' fragment is taken from the Office of the Virgin.

22 C. Bozzolo, and E. Ornato, "Les dimensions des feuillets dans les manuscrits français du Moyen Âge", in *Pour une histoire du livre manuscrit au Moyen Âge. Trois essais de codicologie quantitative*, Paris 1980, 215–332.

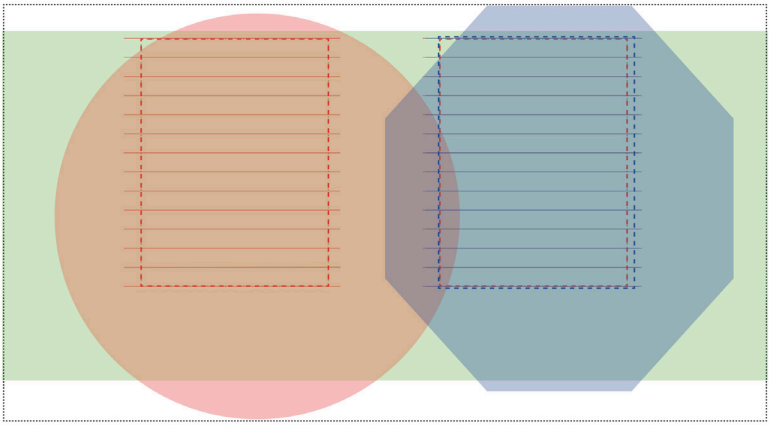


Figure 9: Overlay of the geometrical features of the leaves found in the 'Cipriani Potter' (the green rectangle), the 'Hill' (the blue octagon) and the 'Vuillaume' (the red circle). The black dotted rectangle represents the minimum bifolium size of the original book of hours (80 mm high by 180 mm wide).

Discussion

Fragments as Instrument-Making waste: Implications for the Authenticity and Relative Dating of the Instruments

While the workmanship of Antonio Stradivari has unanimously been recognized in the 'Cipriani Potter' violin and the 'Hill' guitar, corroborating the signatures they bear (on an original label, and incised on the back of the headstock, respectively), the attribution of the 'Vuillaume' guitar to this maker was questioned and debated[23] until recently, when an array of evidence supported considering this guitar as an authentic work by Stradivari.[24] Identifying the parch-

23 Suspected in the 1970s to be a copy of the 'Hill' guitar, it was notably given an anonymous origin in F. Gétreau, "Catalogue sommaire des guitares du Musée instrumental du Conservatoire de Paris", in *Guitares : Chefs d'œuvre des collections de France*, Paris 1980, 307–317.

24 P. Bruguière, "Guitar 1711? 'Vuillaume'" in *Antonio Stradivari – Volume V–VIII*, Bedburg 2016, 72–81; J.-P. Échard, *Stradivarius et la lutherie de Crémone*.

ment fragment under the rose of this guitar as originating from the same book of hours as fragments found in two instruments unquestionably made by Stradivari confirms this attribution of the 'Vuillaume' guitar. In addition, it could provide an indication for when this otherwise undated guitar was made; it may indeed be conjectured that Stradivari used the fragments from this book of hours in a relatively short time-span.[25] Since the 'Cipriani Potter' is dated to 1683, the 'Hill' is dated to 1688, and the other dated guitars by Stradivari were made between 1675 and 1681, the 'Vuillaume' guitar would thus date from the same period, circa 1680.[26]

Furthermore, it is frequently considered that the craftsmanship involved in the design and carving of such roses, which are later patched to the instruments' soundholes, is quite distinct from that required to make musical instruments, and that instrument makers would commission the roses to other craftsmen. This consideration is highly improbable in the case of the two guitars under study here. Indeed, reinforcement of the ribs, such as that found in the 'Cipriani Potter' violin, was typically performed by the violin maker himself; Stradivari selected, cut and glued the parchment fragments found inside the violin. It seems sound thus to consider that he made the two roses, gluing them onto fragments of the same origin, until additional historical information proving the contrary is unearthed.

Insights can also be gained from these observations into the practice of cutting and using parchment fragments in Stradivari's workshop. In the 'Cipriani Potter' violin, some fragments slightly cover the corner blocks and linings. This allows us to situate precisely the reinforcement of the ribs during the making process of

25 Antonio Stradivari (c.1648–1737) opened his own workshop in 1666 or 1667, which remained active over seven decades.

26 The former dating of the instrument (i.e. 1711), based on an apocryphal label glued inside the sounding box, has been questioned in the past decade. P. Bruguière, "Guitar 1711? 'Vuillaume'" in *Antonio Stradivari – Volume V–VIII*, 72–81. Dendrochronological analysis of the soundboard wood, indicating a tree falling date slightly after 1659, and a very strong correlation to the wood of the 'Hill' guitar soundboard, is compatible with such dating of the instrument. J. Topham, "A Dendrochronological Survey of Stringed Musical Instruments from Three Collections in Edinburgh, London and Paris", *The Galpin Society Journal* 56(2003), 132–146.

the instrument, and determine that Stradivari glued the fragments after having glued the linings and even after having chamfered their edges. The fragments were certainly cut from the bifolium at the same time, in order to optimize the height and the width of each strip. The gluing of the fragments thus was one of the last steps — if not the last — before Stradivari closed the sounding box by gluing the soundboard.

Remarkably, Stradivari has obtained the most from the single parchment leaf he used to reinforce all the parts in the violin, as shown on the virtual reconstruction of the bifolium. The longer curved ribs, in the lower bout of the violin, required fragments as wide as the full width of the bifolium (*vln_3* and *vln_5*).[27]

Similarly to bookbinders reusing parchment fragments, Antonio Stradivari seemed to grant no importance to the written text and its meaning, since fragments are glued with no consistency, neither in terms of visible side nor in terms of text orientation: on fragments 2, 5, 6, 7, the top of the text is on the back plate side, while on fragment 1 it is on the soundboard side. Also, the part visible on fragments 5 and 3 is from the bifolium side opposite to the one shown on fragments 1, 2, 6 and 7. For each of the fragments on the guitars, it simply seems that one main axis of the geometrical pattern of each of the guitar roses follows the vertical direction of the parchment page glued underneath the rose.

Other instruments made by, or attributed to, Antonio Stradivari may contain more parchment fragments, possibly even originating from the same book of hours, in particular in this period of his career, circa 1680.[28] Future endoscopic or X-ray based examinations could reveal such fragments, for instance in the 'Canobio-Pagliari' guitar dated 1681 (private collection), or in a seventeenth-century, five-course guitar (Rome, Museo Nazionale degli Strumenti

27 As observed for binding materials, I. Dobcheva, "Reading Monastic History in Bookbinding Waste: Collecting, digitizing and interpreting fragments from Mondsee Abbey", *Fragmentology* 2(2019), 35–63, esp. Figure 2, p. 47.

28 It makes sense to imagine that instrument makers would be using fragments from the same source when making a series of instruments in a given period, similarly to binders when they would work on runs of printed books, in which are frequently found pastedown materials coming from the same manuscript. N.R. Ker, *Pastedowns in Oxford Bindings*, Oxford 1954, VIII.

Musicali, inv. 739) which may have sculpted roses by Antonio Stradivari.[29] As for the violins, the 'Cipriani Potter' is only one of the extant instruments where Antonio Stradivari carved the ribs to create arabesque-based designs. Reinforcing fragments may thus be also preserved in the 1677 'Sunrise', the 1679 'Hellier' (both in private collections) or the 1687 'Ole Bull' (Washington D.C., National Museum of American History, Smithsonian Institution), to name a few. Finally, parchment fragments may also be found in other instruments made by this maker. In particular, the technique for making the single harp or the few mandolins remaining would suggest the use of such reinforcing materials.

The Fate of a Fifteenth-Century Book of Hours

Stradivari worked on these instruments in the last two decades of the seventeenth century; yet, he used parchment leaves from a book of hours that was copied in the first half of the fifteenth century. How and when did the manuscript arrive in Stradivari's hands? At the current state of our knowledge, it is not possible to determine whether the book of hours belonged to Stradivari's family or if he acquired it.

The phenomenon of the destruction and reuse of parchment books for another purpose is well known: libraries and archives all over Europe keep an enormous number of fragments, mostly reused as binding material for manuscript and printed books. Even though bindings are the privileged place for reusing parchment leaves, a number of other locations are attested, such as lampshades and cartridges. Numerous studies underline the importance of studying fragments for recovering unknown and rare or even unique texts that would otherwise be irretrievably lost. Such research focus mostly on the fragments themselves and on the reconstruction of their original context, but often neglects their "Nachleben", that is, their history in their secondary function. Liturgical books often become waste material on account of the obsolescence of their texts, since the liturgy is continuously renewed and books need to be updated. But what about devotional books?

29 G. Gregori, *Antonio Stradivari, Le chitarre – The guitars*, 156 and 159.

Books of hours do not seem to become obsolete, since their content is still valid and useful even decades or centuries after their production. Printed books of hours are shaped on the content and form of their manuscript equivalent; in this respect, throwing away a handwritten book of hours, especially one that follows the use of Rome,[30] does not make any sense to us. It is still possible that, once a printed version was acquired, the manuscript book of hours seemed somewhat old and out of fashion to the eyes of the owner.

There is some evidence for the trade of manuscript waste in the early modern period;[31] however, this evidence is scarce, making it difficult to see what were the supply channels and, most of all, the extent of the phenomenon. It is even harder to trace where the manuscript waste came from; even if we can assume that the crisis and decline of religious houses in the early modern period caused the sale of at least a part of their artistic and cultural heritage, books of hours still stand outside this traditional milieu.

Conclusions and perspectives

The approach presented in this article, using endoscopic photography and X-ray based imaging techniques, has promise for documenting fragments used as reinforcements inside the sounding boxes of musical instruments, and, by extension, for many other artefacts whose inner structure is not easily accessible to the eye. Image processing techniques are currently being investigated to overcome the limitations of endoscopy in terms of geometry and measurements. Future work will also include developments using X-ray fluorescence imaging, which allows both access to unreadable texts, and determination of the elemental composition of the writing materials.

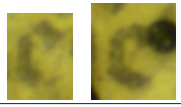
30 The use of Rome in the Office of the Virgin and in the Office of the Dead was one of the most widespread liturgical uses for late medieval books of hours.

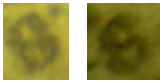
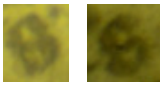
31 F. Manzari has shown that there was a market for art crafts since the seventeenth century. F. Manzari, "Bibliofili, mercato antiquiario e frammenti miniati : le peripezie dei fogli di Vittorio Giovardi tra XVIII e XX secolo", in *Frammenti di un discorso storico. Per una grammatica dell'aldilà del frammento*, ed. C. Tristano, Spoleto 2019, 205–225.

The collection of data about fragments found in instruments, such as their type, dimensions, etc. will serve historians of musical instrument making, who could use them to refine this little-studied aspect of makers' working techniques, as well as to document the origin and possible trading routes and suppliers of such fragments, found in a specific instrument, in the production of a luthier's workshop or even at a larger scale. Given the widespread use of such fragments in sixteenth- to eighteenth-century instruments, it is probable that this approach, involving paleographical, codicological and fragmentological expertise can strongly benefit the field of organology.

Conversely, the collection of data about such fragments, involving access to a large body of historical musical instruments, and thus the expertise of musical-instrument-museum curators, conservators and conservation scientists, would shed light on, and give access to a newly accessible body of fragments of medieval, Renaissance and early modern written materials, which could then be studied and interpreted by codicologists, paleographers, philologists and historians in general.

Appendix: Letter Shapes and Decorations

shape	'Cipriani Potter' violin	'Hill'	'Vuillaume'
a			
c			
d			
d'			
do/de			
e			
f			
g			
n			
o			

shape	'Cipriani Potter' violin	'Hill'	'Vuillaume'
r			
final s			
t			
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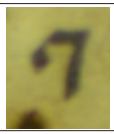
Tironian et			
initials