Fragmentology

A Journal for the Study of Medieval Manuscript Fragments

Fragmentology is an international, peer-reviewed Open Access journal, dedicated to publishing scholarly articles and reviews concerning medieval manuscript fragments. Fragmentology welcomes submissions, both articles and research notes, on any aspect pertaining to Latin and Greek manuscript fragments in the Middle Ages.

Founded in 2018 as part of Fragmentarium, an international research project at the University of Fribourg (Switzerland) funded by the Swiss National Science Foundation, Stavros Niarchos Foundation (SNF), and the Zeno-Karl-Schindler Foundation, Fragmentology is published by the University of Fribourg and controlled by the Editorial Board in service to the scholarly community. Authors of articles, research notes, and reviews published in *Fragmentology* retain copyright over their works and have agreed to publish them in open access under a Creative <u>Commons Attribution</u> license; images may be subject to other licenses. Submissions are free, and Fragmentology does not require payment or membership from authors or institutions.

Founding Editors: William Duba (Fribourg), Christoph Flüeler (Fribourg)

Editor: William Duba (Fribourg) Associate Editor: Veronika Drescher (Vienna)

Editorial Board: Lisa Fagin Davis, (Boston, MA), Christoph Egger (Vienna), Thomas Falmagne (Frankfurt), Scott Gwara (Columbia, SC), Nicholas Herman (Philadelphia), Christoph Mackert (Leipzig), Marilena Maniaci (Cassino), Stefan Morent (Tübingen), Åslaug Ommundsen (Bergen), †Nigel Palmer (Oxford)

Typesetting: Trine Wismann (Fribourg)

Instructions for Authors: Detailed instructions can be found at https://fragmentology.ms/about/submissions/. Authors must agree to publish their work in Open Access.

Fragmentology is published annually at the University of Fribourg. For further information, inquiries may be addressed to *fragmentarium@unifr.ch*.

Editorial Address:

Fragmentology Center for Manuscript Research University of Fribourg Rue de l'Hôpital 4 1700 Fribourg, Switzerland.

tel: +41 26 300 90 50 Funded by:





Fondation ZENO KARL SCHINDLER ZENO KARL SCHINDLER Foundation ZENO KARL SCHINDLER - Stiftung

Fragmentology VI (2023), DOI: 10.24446/vbin

Finding the Prior Leaf: Manuscript Fragments and Original Codices

William Duba, Université de Fribourg* william.duba@unifr.ch



Abstract: Fragments of Latin-script medieval manuscript books evoke the whole to which they once belonged, encouraging us to build a mental model of the now-broken whole. Discussing fragments thus requires a way to describe not just the surviving objects and how they relate to their current context, but also how they related to the original. At the most basic level, relating individual pieces to an original codex requires identifying the fragment's physical role and orientation in the codex. Then, if the text of the fragment is known, extrapolation can be used to reconstruct leaves, gatherings, and codicological units. An extrapolative method is documented and validated using experimental data and examples from the *Fragmentarium* web platform.

Keywords: experimental fragmentology, reconstructions, methodology, applied synecdoche

Fragments draw attention to the missing whole. The base of a column invites speculation on the building that once stood, a fossilized jawbone asks for the monster that held such teeth, a potsherd evokes an amphora, and a scrap of a manuscript begs the original codex. The immediate impulse is towards reconstruction, using context, conjecture, and contrivance to integrate the remaining pieces into an imagined whole.

^{*} I would like to thank Laura Albiero, Pieter Beullens, Lisa Fagin Davis, Veronika Drescher, Liz Mullins, and the two anonymous referees for their comments on drafts of this paper. Some of the research presented here was produced while I was employed on the Swiss National Science Foundation Projects *Fragmentarium* (Grant number 156569) and *Fragmentarium Phase II* (Grant number 182173), PI: Christoph Flüeler.

Duba

By definition, fragments evoke two realities: what they currently are (fragments) and what they were, namely, the something of which they are now a fragment. Working with manuscript fragments, these two realities correspond to two physicalities, the current, fragmented state of the object, and the prior whole from whence it came. It is impossible to think of a manuscript fragment as a fragment without imagining the role that piece played in its previous context. For fragments of manuscript codices in the Latin script tradition (the focus of this study), this role was as part of a book, and by recognizing a fragment as such, we build a mental model – a reconstruction – of that book.

Fragmentology does not limit itself to reconstruction, but reconstruction is an inescapable part of the study of manuscript fragments. The contributions to the web platform *Fragmentarium* made by research projects, individual scholars, and seminar students have revealed some of the problems posed by the dual physicality of fragments. First, the naming and numbering systems used are largely (and rightly) taken from library practices that refer to intact codices, and using them to refer to parts of books can be confusing. Second, those charged with cataloguing fragments need to identify and situate them; that is, they need to build a mental model of how the fragment functioned in the prior whole, and from that model, determine whether the unbound fragment is part of a leaf or a bifolium and which side is which. Often, however, constraints of time and ability make them rely on material and paratextual cues to do this work of identifying and situating fragments, and yet there is a lack of guidance in the literature. Finally, if the fragment is of a known work, the visible text on the fragment can be used to reconstruct leaves, quire structures, and even entire codices. But, while the methodologies to perform such reconstructions seem obvious, they have not been documented, let alone validated by experimentation. Indeed, in spite of the considerable value such reconstructions can offer to our understanding of the process of fragmentation and to book culture in the middle ages, and in spite of the relative simplicity and ease with which such reconstructions can now be made, they are rarely practiced.

For these reasons, the following contribution presents briefly a way to discuss book fragments as they relate to the structure of the original book, followed by a short discussion of how to orient an unbound codex fragment by determining whether it is a leaf or bifolium and in which way it was bound into the original book. With these basic steps out of the way, the article focuses on the method of extrapolating from the surviving fragment to the larger whole, from rebuilding the page to reconstituting the codex. Much of the material, especially at the beginning, may be obvious to experienced fragmentologists, but, since I was unable to find a satisfactory presentation, I hope that it is at least helpful for those entering the field, and can serve as a point of departure for future treatments.

Talking about fragments from manuscript codices

Researchers and cataloguers tend to name the parts of fragments after the parts of books. Just as a medieval manuscript book is most often foliated, with each leaf receiving a number in sequence and its two pages being distinguished as recto and verso, so are fragments: leaves are most often numbered, typically in the order they appear in situ, or in a pile of detached fragments, and the recto verso sides assigned. Yet, a codex typically is read and understood in sequential order, e.g., 1r-1v-2r-2v..., while reading a fragment often requires following a disrupted order with extensive gaps. As a result, for fragments, the numbering scheme used rarely matches its intellectual order. Fragment cataloguers can increase the confusion when they fail to orient and situate correctly their objects, but the mismatch largely arises due to the inadequacy of the naming scheme to capture both the current physical order and the one that preceded fragmentation.

A dismantled book does not maintain the sequential order of the prior whole. While single-leaf manuscript pages (singletons) do occur, the majority of text is written onto bifolia, single sheets comprised of two attached leaves, side-by-side. Bifolia are stacked into gatherings, typically of four (quaternion), five (quinion), or six (senion) and folded in half. Holes (sewing stations) are cut in the fold, through which a cord attaches the gathering to the sewing supports on the spine of the book. Since bookbindings, like medieval manuscript books in general, are unique historical artefacts, they vary not only by region and time, but also according to the unique needs and historical accidents of the individual book.

A quaternion, therefore, is composed of four bifolia, containing the order of leaves 1-8 (outermost bifolium), 2-7, 3-6, 4-5 (innermost



Figure 1: Quaternion, showing foliation, recto-verso sides, and the relationship to bifolia, which have sides that are inward- and outward-facing, as well as prior and posterior leaves



Figure 2: Diagram of a bifolium, showing outward and inward sides, with the recto and verso of prior and posterior leaves

Fragmentology VI (2023)

bifolium). The sides of a bifolium are not recto and verso, for each side has a recto, on the right, and a verso, on the left [Figure 1]. The sides of a bifolium can be referred to with reference to the fold; the side that is outside, facing the binding and other gatherings in the codex, we call here 'outward-facing', or just 'outwards', and the side that is inside, folded towards itself, we call 'inward-facing' or just 'inwards'.¹ The two leaves of the bifolium are related as prior and posterior; the prior leaf has the recto facing outwards and the verso facing inwards; the posterior leaf has the recto facing inwards and the verso facing outwards [Figure 2].

In practice, however, bifolia often appear foliated in a variety of ways, sometimes as a leaf (with the outward- and inward-facing sides assigned recto and verso), sometimes as bifolia, foliated sequentially, so that two consecutive bifolia would have leaves foliated 1-2 and 3-4, respectively, and any texts on those bifolia would be read f. 1–3-<gap>-f. 4–2, where the <gap> corresponds to the content of any bifolia or singletons inside the bifolium foliated 3-4.

Orienting the Fragment

If the text is known, and can be read, determining recto and verso is usually trivial: the recto comes before the verso. For bifolia, identifying the prior and posterior leaf might be more difficult, especially if there are different texts on each leaf. Often, however, the text is not identifiable, or the person doing the cataloguing does not have the time or ability to make sense of it. In such cases, the fragment's physical characteristics and paratextual elements can help with the orientation.

Leaf or Bifolium?

Often, it is clear whether we are looking at a fragment from a single leaf or from a bifolium: a leaf is longer than it is wide, and a bifolium is wider than it is long. When bound in a book, a bifolium

¹ D. Muzerelle, Vocabulaire Codicologique. Répertoire méthodique des termes français relatifs aux manuscrits, Paris 1985, 91–92 (311.01–12) only includes in his vocabulary the page and the folio as ways of referring to a surface and not the bifolium.



Figure 3a: [<u>F-g70d</u>] Toruń, Biblioteka Uniwersytecka, Ob.6.111.669/2 – a: Single leaf. The gap between the two columns has no signs of a fold. Left: Is. 25: 10–12, Right: Is. 26:21



Figure 3b: [F-g7od] The other (verso) side. Left: Is. 28:4-5, Right: Is. 28:22



Figure 4: [<u>F-nqtb</u>] Montecassino, Archivio dell'Abbazia, 208: Single leaf. The gap between the two columns shows no signs of a fold.



Figure 5: [<u>F-qszj</u>] Antwerpen, Rijksarchief te Antwerpen, Verzameling Losse Aanwinsten, nr. 2.28: Bifolium with sewing station



Figure 6: [F-z87a] Wien, Österreichische Nationalbibliothek, Fragm. 4b: Bifolium with fold





is folded in the middle, where holes are cut for sewing stations. But in some cases, particularly in strips cut for use as quire guards, the distinction is not obvious [Figures 3–7]. If the text is known, then the flow of the text will reveal the difference: text on a two-column leaf flows from one column to the other, and from one side to the other; text on two single-column leaves in a bifolium flows from the right (recto) of one side (outwards), to the left (verso) of the other side (inwards), and, after a gap for any inside bifolia, from the right (recto) of that side (inwards) back to the left of the other side (outwards).

Sometimes, ruling and pricking can make the distinction between bifolium and two-column leaf clear, since pricking occurs only outside of columns, and ruling through the gutter is often more complex than ruling between columns.

Leaves: Recto and Verso

If a leaf is complete, reading the text can often reveal which part goes before the other. Rubrics and numbering along the margins can also be of help. Often, however, the text is not known, or the script is not legible, at least to the person working with the fragment. At this point, evidence of how the leaf was bound and paratext can aid in orientation.

Binding evidence

The evidence that fragments provide of binding structures can be crucial for understanding the original codex. Holes in the support

1 pulante + 1 uit michael acchangelus ai undurudine au ge 10 र्गा ता। सत्रतियि स us a nimas fanc A to the part of the part of the parts of the parts to ril. Ot pourat cas in paradiliun cru 11 state of the Augelus T unnettet 1 1 1 A . A . A . A . A . A . A . A . A P um et en viete man et chtru 54 ra vbi archangelus unchact teletbar te elo il. เงาแนนี้ ดูนรี้ โล่นโล้ร ลนดูงใน ดูนรี en.er.a. tt pt pa p djendin er feraphin fös fös fos udamärus Bi Sto Pales a cit er mæla multa pr adolerer ca autr

Figure 8: [<u>F-eys7</u>], Stuttgart, Hauptstaatsarchiv, C 9 Bü 184, recto (rights): a single leaf reused as a wrapper. The left side shows evidence of the sewing stations.

Image Rights: https://www.landesarchiv-bw.de/nutzungsbedingungen

point to the fragment's previous life. The presence of sewing stations can indicate where the center of the bifolium was [Figure 8]; therefore, in the case of a single leaf, the recto is the side with such holes on the left. Binding fragments, however, provide evidence of both the binding of the original codex and that of the host volume, and make the identification more complex.²

Paratextual elements

Signs of foliation usually appear on the recto; if numbering only appears on one side, that side is likely the recto [Figure 9]. On occasion, however, numbering will be according to facing pages (that is, the verso-recto pairs of an open book); in such cases, the number can occur in the top center margin, or on the verso, in the top left [Figure 10].

Running titles are usually designed to be read with the book open, from verso to recto. The middle-Dutch translation of the Epistle to the Hebrews preserved in [F-ertw] [Figure 11] has the running title *Ad Hebreos*, with *Ad* on the verso and *Hebreos* on the recto. In general, the more specific indication, often a number (of chapter, book, distinction, question, or similar), appears on the recto. Thus, the running titles to [F-xgw4], a copy of Gratian's *Decretum* read "Ca." on the verso, followed by "xx111" on the recto [Figure 12]. In this latter case, the fragment is a leaf that was re-used in a binding as an end-leaf hook, with a large fold and sewing stations (to the host volume) on the outer side of the leaf (right on the recto, left on the verso); the fragment was cut along the original fold, and the indentations of the original sewing stations can be seen on the opposite (inside) of the fragment (left on the recto, right on the verso).

Bifolia

Binding evidence and paratext can also be used to determine the facing of bifolia. Numbering, whether of foliation or of section of a book, on the rectos can aid in determining the sides: the outward side usually has a lower number on it.

² J.M. Sheppard, "Medieval Binding Structures: Potential Evidence from Fragments", in *Interpreting and Collecting Fragments of Medieval Books: Proceedings of The Seminar in the History of the Book to 1500*, Oxford 1998, ed. L.L. Brownrigg, M.M. Smith, London 2000, 166–175.

Trattus Dur foi: mödial und c 1119 ciau di o a et damo rann THE HIE -------uncili al 118 ad tr Ut -APR-I No. me u nifle in tepera ba quia eleuas al hfi m in au min TTE T TIS WOLL DAUGH TOMIS HUIPPY uf 1205 autr Ryn ULO Dunali dicus vlax ad motir ma tus obc trautr กาเกร 2011 ver

Figure 9: [F-wid6] Stuttgart, Hauptstaatsarchiv Stuttgart, C 9 Bü 186, recto: in addition to the foliation at the top, note holes for the sewing stations to the left.

Image Rights: <u>https://www.landesarchiv-bw.de/nutzungsbedingungen</u>

rrn 52 nenobo cellanani er ftepbs conucul? ocumo fallo ante feftu fei cle de Sneef Reginatoul por de coma mets cu menuf. oc foffauf nemonf oc och utuc de monte banar. Sunon freibe and albaf uper composit line de corgraco humband poi fei paute fenon none anabele utaluta De cozz er quedam alu. Argun notum facto unucadis pec fitaten 6 anno mannata ucube co cho ferrel luceral mixeturis of cum defeorora et unt philip vallinc 179.4. naGelino quinto. De danto Houce Mic anali vallum fico pum mabile domicellum er 98. antos. omui ante portani titilo cot unaparte er monachof hal les Vannes cellant by preferres uneral infrecta liflue. er altera figer nepa paratat uleatendno Soucant tatione quorundam follaro queeft kum p que duntio fichatin unmerth go ann manue mafina nekabilefunof albem er reunemoza de ceneliaco et ne connentum Sall'inceruna mora fee enance illam repa ftra du - - Antin Ala Tan tationen fine fine affenti me Inorth?

Figure 10: Cartulary of Vauluisant, Paris, Bibliothèque nationale de France, latin 9901, f. 28v, showing a thirteenth-century number XXVI in the top-left corner of a verso and the number XXVI above the intercolumnar gap. The number XXVI is also visible on the facing recto (f. 29r, not pictured).

Thebreo? con veelve mefchen zonde Remelche worden met avt te Kennen Anderwer beteren offerhande ghe ne fel in fonder zonde ope fuer Danmet defen. ahenen die man more has lighe fte Jacanona 3 hem verseachten mo de met hande ghemund Calichest As NC EDE: 198.4 240 · GE BAR eucha Fadamice va anden doction of an det meastern anest Share wanted the series der sette knowfee annet in et met als a staten heb mer and Ricigia op dat but fit mu berger sie begun ewagem in die stedestar m werken wille un aueren

Figure 11: [<u>F-ertw</u>], Gent, Koninklijke Academie voor Nederlandse Taal en Letteren, KANTL.HS.7c. Upper image: f. 124r, with running title "Hebreos" and foliation; lower image: f. 124v, with running title "Ad"

DOI: 10.24446/j9en

Duba



Figure 12: [<u>F-xgw4</u>] Leuven, Archief van de Abdij van Park, VIIIB20/39, recto (top), verso (bottom). Running titles "CA" and "XXIII"

Situation in Gatherings

Most of the physical and paratextual evidence concerning the orientation of bifolia, however, also helps to situate bifolia and singletons in their original gatherings. The innermost bifolium can be recognized because the text on the inwards verso continues on the inwards recto. In other words, the two leaves are consecutive. Even without the text, sometimes the imprint along the fold left by the sewing reveals the innermost bifolium [Figure 13].



Figure 13: [F-oaw] München, Bayerische Staatsbibliothek, 2° Inc.c.a. 2595, front pastedown, lower bifolium (1B). The innermost bifolium, inward-facing side, showing imprint of sewing along the fold. The text, John 6:40, continues across the fold (*Haec* | *est autem voluntas*).

Likewise, the exterior (outermost) bifolium often has a catchword written on the verso of the outward side, to match against the first word(s) of the next gathering. The presence of such a catchword can indicate the orientation of the bifolium and the position (outermost) in the gathering [Figure 14].

Catchwords sometimes appear in other places, however. For example, in the copy of the [Ps-?]Augustinian *Meditationes* (PL 40, col 938–940), 37A, preserved in Gent, Universiteitsbibliotheek, HS.2582/083 [F-aicg], a catchword appears on the inward verso of the center bifolium in what appears to have been a binion [Figure 15].

Often binders will employ leaf signatures as well; in the thirteenth century, what Gumbert calls "primitive leaf signatures" indicate the order of bifolia within a quire, with a numbering of each of the bifolia or single leaves bound in that gathering, with (Roman)



Figure 14: [F-jx2h] Cluj-Napoca, Biblioteca Academiei Române, Fragm. Cod. Lat. 7, flesh side – Missale; inset: detail of catchword

Hornatio fpe maritah Faller a lume or of proceeding of a lume of a long of Andigo mmaridata mai and fen fre matriel fre zaplar fre ng. welsage loz brins draru 1024 ang cuarel faru men one leunaru mengora men Bererie Ficken nin & Spulleys O. M. Scher Strand Astoria louinari medioria min a om puloria palli of voo cloge in geoplase, granderio agraze p mar calpatete popu pini frigo grand de fand de according Ar to me cupand a morcas his The part of the provide the pr mpitudo po frang demet matulno

Figure 15: [F-aicg] Gent, Universiteitsbibliotheek, HS.2582/083, f. [3]v- [4]r: catchword at bottom of the verso (magnified in inset), *propitiatio*, matches the first word of recto, and the text reads continuously across the fold. *Fragmentology VI (2023)*



Figure 16: [<u>F-4tsf</u>] Bern, Burgerbibliothek, Cod. A 94.24, detail of f. 1r (top left), 2r (top right), 3r (bottom left), and 4r (bottom right), showing primitive leaf signatures III, IIII, v, and VI

number 1 indicating the outermost bifolium. By the fourteenth century, leaf signatures can be found composed of a letter, indicating the gathering, followed by a number, giving the bifolium's position in the gathering.³ Usually written faintly and on the bottom right of the outward (prior) recto, signatures rarely are identified as such on fragments, but they are extremely helpful for determining the orientation of the bifolium and its position in the gathering. For example [F-4tsf] Bern, Burgerbibliothek, Cod. A 94.24 is a gathering of four bifolia, and the rectos of the first four leaves (1r, 2r, 3r, 4r), corresponding to the outward recto of the four bifolia, have signatures [Figure 16]. While the *III* on f. 1r is hardly visible, the indications *IIII*, *V* and *VI* on f. 2r, 3r, and 4r, respectively, make clear the order of the bifolia. Since ff. 4-5 is the innermost bifolium, these signatures indicate that the gathering was originally a senion.

³ J.P. Gumbert, "The Tacketed Quire: An Exercise in Comparative Codicology", *Scriptorium* 65 (2011), 299–320, at 313.



Figure 17: Gregory's Rule as applied to two consecutive gatherings. In this example, the odd-numbered leaves (f. 1, 3, 5, etc.) all have flesh side on the recto and hair side on the verso; the even-numbered leaves have hair on the recto and flesh on the verso.

Relating bifolia from the same codex to each other

The most effective means of grouping bifolia together is via textual elements, discussed below. Paratextual elements, such as foliation, running titles, and signatures, also have obvious importance. There are, however, a few physical indications that can help place, or rather exclude, certain arrangements.

"Gregory's Rule" specifies that parchment bifolia are, as a rule, arranged so that flesh side faces flesh side, and hair side faces hair side. For example, if a bifolium's hair side faces outwards, the next outer and next inner bifolia, if there are any, will have the hair side face inwards. If a codicological unit follows Gregory's Rule (which is usually the case for non-insular manuscripts after the ninth century), then all bifolia in the unit will be oriented in the same way: numbering the bifolia from the exterior to the interior, all odd-numbered bifolia will follow one arrangement of hair/flesh to inwards/ outwards, and all even-numbered bifolia will have the opposite arrangement [Figure 17].⁴

⁴ Muzerelle, Vocabulaire Codicologique, illustration no. 37.

Locating the watermark (and countermark) on paper bifolia could also help arrange the pieces, provided the binding is consistent, that is, made of gatherings that use sheets of paper folded in the same way. For in-folio books, each bifolium will have the watermark on the same leaf and a countermark on the other, and therefore the orientation of each bifolium should be clear. For in-quarto, a bifolium with a watermark in the fold will alternate with one holding the countermark.⁵

Sewing stations and holes for endbands can also be used to situate bifolia. A given codex has one set of sewing supports, and thus all bifolia will have the same number of holes (sewing stations) in the same locations along the fold. But bifolia from the same gathering will have the sewing stations in precisely the same place, while those from other folia may exhibit slight variations.⁶ Nevertheless, re-use post-fragmentation may cause uneven changes to the parchment, so care should be used.

Reconstruction

As the preceding discussion shows, manuscript fragments can provide ample information on the original whole whence it came, even without considering the intellectual content. When the written text is taken into account, however, we can produce compelling reconstructions of the original. The principle is not unlike that used by an archaeologist in reconstructing a temple from a single broken column base; that base can be extrapolated into a whole column, and that column into a structure. Such a reconstruction is normative; contextualization can only with difficulty indicate the unique variations of the original.

⁵ See on this Muzerelle, *Vocabulaire Codicologique*, illustrations no. 40–45.

⁶ Gumbert, "The Tacketed Quire", 299–307, observes that gatherings of Western manuscripts, particularly through the twelfth century, were often assembled prior to being bound into codices; they were tied together at the top and the bottom with what he calls "tackets", pieces of thread or parchment; holes for the tackets can be found in the fold as well, and the spacing between the holes varies considerably from bifolium to bifolium. Such holes should not be mistaken for sewing stations.

Duba

In archeology, discussion has centered on the suitability of the term 'reconstruction': two centuries of 'reconstructions' seem more rooted in the assumptions, biases, and distortions of contemporary scholars than in the historic reality to be reconstituted.⁷ Given that even the best work relies on an imperfect dataset, some have proposed instead that the term 'model' replace that of 'reconstruction'.⁸

Such an extreme seems semantically misplaced, likely only to encourage phraseological bloat such as "simulations of hypothetical spatiotemporal 4D reconstructions",⁹ safely isolating any scholarly work from the past, through reconstruction couched in a hypothesis, itself merely a simulation of the real. To the contrary, the term 'reconstruction' seems perfected suited to its task. Since even the most 'faithful' reconstruction only captures some aspect of the original, the term 'reconstruction' contains within it both the idea of the original and a negation of originality. A reconstruction evokes a lost whole in producing a new reality, and the same vestiges can give rise to multiple, incompatible reconstructions. Conceptually, those who would replace 'reconstruction' with 'model' have a point: for a reconstruction to have scholarly rigor, it must document the

⁷ Z. Bahrani, "History in reverse: Archaeological illustration and the invention of Assyria", in *Historiography in the Cuneiform World: Proceedings of the XLV Rencontre assyriologique international*, ed. T. Abusch, P.-A. Beaulieu, J. Huehnergard, P. Machinist, P. Steinkeller, and C. Noyes, Bethesda, MD, 2001, 15–28, at 17: "Such reconstructions are fantasies that tell us more about the period."

⁸ J.T. Clark, "The Fallacy of Reconstruction", in *Cyber-Archaeology* (British Archaeological Reports International Series 2177), ed. M. Forte, Oxford 2010, 63–73; at 63: "[A]rcheologists may say they have created a 'reconstruction' of some facet of the past, but in fact they have not, and with few exceptions cannot, 'reconstruct' the past; one can only construct models or simulations of the past" (his emphasis). Clark builds on Walter Taylor's 1948 criticism of the term 'reconstruction' and reiterates the need to use 'model' instead, since (p. 68): "By definition, models are not the real thing; they are simplifications. As simplifications, something is left out, and the models are thereby always false."

⁹ This hyperextended cautionary deflationary overqualification comes from the boldly-named Time Machine Organization ("About Us", <u>https://www. timemachine.eu/about-us/</u>). It undoubtedly reflects the strain of maintaining a semblance of scholarly rigor while providing hyperbole in service to the requirements of Brussels-based granting agencies, resulting in this rhetorical phenomenon, which one might call a "Belgian Waffle".

relationship between the reconstructed whole and the surviving parts, physical or conceptual, regardless of whether we call the result a 'reconstruction' or a 'model'. Guidelines and principles for visual reconstructions of the past exist.¹⁰ Although they focus on archeological reconstructions, they are generally applicable to digital synecdochics, including the reconstructions discussed here.

When a fragment contains a text that exists in other witnesses, we can combine the information about the text with the physical and paratextual information from the fragment to rebuild a page, leaf, bifolium, and even the entire expression of that text on the original manuscript. The method followed consists in measuring the surviving part against the prior whole, understood as consisting in the text as witnessed in other sources, and using that proportion to calculate the layout and arrangement of the whole. Although such a method is hardly new – papyrologists, for example, have been using it for centuries – I attempted to validate its results and document its accuracy by means of a simple experiment.

Reconstructing the Leaf: Methodology

For reconstructing elements from a leaf, I wrote a methodology and assembled a test using pseudo-fragments, that is, two-sided virtual cuttings from scientific photographs of surviving whole manuscripts published on the website e-codices (<u>https://e-codices.ch</u>). Veronika Drescher and I then subjected a handful of volunteers to the test, and tabulated the results, without personally identifying information; the test documents and the results are available as research data associated with this article; the presentation of method here summarizes the content of those documents.

¹⁰ The London Charter for the Computer-based Visualisation of Cultural Heritage, v. 2.1, 7 February 2009, at <u>https://londoncharter.org/fileadmin/templates/</u> main/docs/london_charter_2_1_en.pdf; International Council on Monuments and Sites, Principles of Seville: International Principles of Virtual Archaeology, ratified 2017, <u>https://icomos.es/wp-content/uploads/2020/06/Seville-Principles-IN-ES-FR.pdf</u>.

abominatio eft ' Cum omniperore noncorbit net maculaber cum eo Mulier non succumber umento neomifébitur el quia scolur est - nec pollu amini in omnabul but ' to perte aliquan tum ' Unul julg. maren Sumem fuum ennear (Er. p; 1. uer fum He mer a saidal s ner deor conflation Coodification tenaulo solo necremanes Apreas tolliges paque in unearria racemol decidentia con propabil red par peribular car penda dumit ter. gunds di lar Nonfa nonmentemini needeci i L'unul quilque proximi Juami Non persurabil innomine meo. nec polluel nomen di our ego fum dir Non facier calumnicom

Figure 18: [<u>F-od7u</u>] Leipzig, Universitätsbibliothek Leipzig, Fragm. lat. 169a, with overlaid instructions showing how to measure ten lines.

For each of the five fragments, the subjects were provided with an edition (of varying quality) of the source, and asked to provide:

- 1. The height of each line (in mm)
- 2. The width of each column in the original manuscript
- 3. The number of lines per page in the original
- 4. The height of the text block in the original
- 5. The number of columns in the original
- 6. The width of the text block in the original

In this discussion, "text block" refers to the body of the text, the written area in the center of each page, composed of one or more columns.

Measuring the line height

The technique for measuring line height recommended on the test is that advocated by J.P. Gumbert.¹¹ On a fragment, locate ten whole lines, or as many as possible, measure from baseline to baseline [Figure 18]. Avoid using the first line on the page for measurement, since in some hands (especially documentary hands) it can have an exaggerated height. Divide the results by ten (or by however many lines there are). Report the results to the tenth of a millimeter.

A practical example will illustrate this step, and the following ones. [F-nxmr] Wien, Österreichische Nationalbibliothek, Fragm. 210a [Figure 19], is a small ninth-century fragment from

¹¹ J.P. Gumbert, *IIMM: Illustrated Inventory of Medieval Manuscripts in Latin Script in the Netherlands*, Hilversum 2009.



Figure 19: [F-nxmr] Wien, Österreichische Nationalbibliothek, Fragm. 210a, 1r, 1v, with transcription. Angle brackets (<>) indicate text interpolated from the *Patrologia Latina* edition.

Gregory the Great, *Homiliae in Evangelia*, Homilia x. The fragment was digitized and published as part of the project "The Medieval Fragments of the Abbey of Mondsee" funded by the Austrian Academy of Sciences Go!Digital 2.0 program.¹² It was published on *Fragmentarium* with a reference image containing a ruler. Using photogrammetry from this reference image (see the Appendix below), we can determine a resolution of 23.68 pixels per millimeter (=601.5 DPI). We can measure two lines from baseline to baseline; the measurement is 520 pixels, which divided by 23.68 produces 22.0 mm, or a line height of 11.0 mm.

Determining the width of a partial column

If a column is complete, a measurement can be given. If it is only partial, the edition must be used; Word processing software (such as Microsoft Word or LibreOffice Writer) provide word and character counts for selections of text (ideally, after removing all punctuation and paratext). For each line, determine the number of characters (with or without spaces, according to the manuscript) visible (from the fragment) and (from the edition) the total number of characters

Project description at <u>https://fragmentarium.ms/case-studies/case-study-8;</u> I. Dobcheva, "Reading Monastic History in Bookbinding Waste. Collecting, digitizing, and interpreting fragments from Mondsee Abbey", *Fragmentology* 2 (2019), 35–63.

on the line. If the width of each visible line is the same, multiply the width of visible lines by the total number of characters and divide by the number of visible characters. The result will be an average width. With larger lines, words may be used.

original line width = visible line width × $(\frac{\text{total characters}}{\text{visible characters}})$

Returning to the example, on the fragment of Gregory the Great, the text matches that in the Patrologia Latina Edition, scanned and available online (punctuation removed for measurement, corresponding text in the fragments indicated in bold):

Judaeorum corde duritia quae hunc nec per prophetiae donum nec per miracula agnovit Omnia quippe elementa auctorem suum venisse testata sunt Ut enim de eis quiddam usu humano loquar Deum hunc coeli esse cognoverunt quia protinus stellam miserunt Mare cognovit quia sub plantis ejus se calcabile praebuit Terra cognovit quia eo moriente contremuit Sol cognovit quia lucis suae radios abscondit Saxa et parietes cognoverunt quia tempore mortis ejus scissa sunt Infernus agnovit quia hos quos tenebat mortuos reddidit Et tamen hunc quem Dominum omnia insensibilia elementa senserunt adhuc infidelium Judaeorum corda Deum esse minime cognoscunt et duriora saxis scindi ad poe**nitendum nolunt e**umque **confiteri abnegan**t quem **elementa ut dixim**us¹³

Each line has between one and a half and three and a half words per line, and as such, using words per line is too coarse a measure to be useful. Characters per line, however, are more promising. On the recto, there are two full lines (from the same horizontal point in the column to the same point on the line before) that can be used, either from *udaeroum* to *proph*, or from *ritia* to *nec per*. Since we can see the right edge of the column, we know that (r2–r3) *ritia* to *nec per* corresponds to manuscript lines, and pick that. The two lines cover 40 characters (without spaces) in the edition. Of these, 31 are visible. Note that the *neque* on the second line is presented as a *nec* in the edition; since we are measuring the characters in the edition that correspond to those visible, we count the *que* as the single charat

¹³ Gregorius Magnus, *Homilia x in Evangelia, Patrologia Latina*, ed. Migne, v. 76, col. 1111A–B.

On the verso, we repeat the measurement with the two lines (v1–v2), *nitendum nolunt eumque confiteri abnegant quem*, 41 characters, of which 31 are visible. In total, we have 81 characters in the passage in the edition, and 59 visible characters and spaces correspond to those on the fragment. We then measure the visible width of the line; here, the portion of each line on the fragment is 59 mm wide.

Using the formula above,

Therefore, we estimate original column width at 81 mm. The average number of characters per line is 20.25.

Determining the number of lines per page

A similar method of extrapolation can be used to arrive at an estimate how many lines per page there were. In effect, calculate how many characters in the edition corresponds to a column of text in the fragment, and divide by the average number of characters per line. In particularly compact manuscripts, words may be used instead of characters.

The number of lines per page usually equals the number of lines per column. If a fragment has visible parts of two columns, the number of lines per column can be estimated by using the proportion of visible words (or characters) to the total words (or characters) per column. More precisely, the words or characters being measured are not those on the fragment, but those corresponding to the fragment in the edition.¹⁴ If a fragment has only one column visible and there is text on both sides, the number of lines per page can be measured from a line of text on one side through the line just above it on the other side.

On the fragment, choose a side and column where the beginning and end of the text can be found in the corresponding source. Using

¹⁴ The assumption underlying this method is that the text relates consistently to the edition, and therefore, the comparanda are parts of the edition that match the parts of the text attested by the fragment, and those that match the parts not preserved.

Duba

the edition, count the total missing words or characters between the two columns, or between one side of the fragment and the other. In the example here, we select our column from r2 (*-ritia*) through the end of v1, counting the *eumque*, but not *confiteri*. In the edition, the text covered by this manuscript column has 575 characters.

Divide the number of words per column by the number of words per line to get the estimated number of lines per page:

lines per column = words or characters per column words or characters per line

In the example we are using, 575 characters in a column divided by 20.25 characters per line is 28.4 lines per column, so we estimate between 28 and 29 lines per column.

If the fragment is from a two-column manuscript, and only one line is visible, then the measurement will either be from outer column to outer column (rb-va), or from inner column to inner column (ra-vb); in the latter case, the result will be lines per three columns, or three times the number of lines per page. This difference can be detected, as the height of the text block will be disproportionately high compared to the width.

Estimating the height of text block

Multiply the estimated lines per column by the line height to get the estimated height of the column (or three) or text block.

height of text block = lines per column × line height

In the case of the fragment being used as an example, we calculated 28–29 lines per column. At 11.0 mm line height, that puts a column at 308–319 mm, slightly more than the height of an A4 page (297 mm).

Calculating the number of columns

Many fragments have one, two, or three columns visible on a page. When the number of columns is not obvious, however, the calculations made above can provide some evidence. Generally, a written area is taller than it is wide (some exceptions can be made for heavily glossed texts). If it is more than twice as tall as it is wide, however, it is likely a two-column leaf, and the text comes from the outside column (rb-va). If the calculation of the height is more than six times taller than the width, then the leaf likely had two columns, and the columns measured are the inside columns (ra-va).

In the example given here, with dimensions estimated at $308-319 \times 81$ mm, the written area proportions correspond to that of a single, outside column. We are looking at a two-column leaf, and the fragment comes from the right column of the recto and the left column of the verso. To calculate the written area, double the width and add some intercolumnar space: the written area of the original leaf measured around $308-319 \times 175-180$ mm.

Caveats

The test instructions given to the volunteers also included some observations on the shortcomings of the method:

A copy with textual omissions (e.g., *homoioteleuta*) will be smaller than estimated. Titles, initials, illuminations, and so on can also skew the results. Two manuscript columns do not necessarily have the same width. A scribe can vary the density of the script. For example, a scribe can radically abbreviate or expand the script to align textual divisions with column breaks. Many scribes, especially note-takers, have a decidedly more compact script at the beginning of a session than at the end. Finally, what appear to be two columns on the same page may be the inside of a bifolium.

As the discussion and the criticism below show, many of these phenomena occurred, and their effect on the test results can be assessed, at least in part.

Pseudo-Fragments

The method above was illustrated on the instructions (and here) using a genuine fragment. For the experiment, virtual fragments were created from images of individual leaves of five manuscripts published on e-codices, selected to represent different types of texts produced in different periods, with varying layouts. This way, the test results could be compared against the actual manuscript leaves.

Duba

The images of these leaves were produced in accordance with e-codices' Reproduction Guidelines. While these guidelines have not been published, versions in German, French, and Italian have been used by the e-codices photographers since the project's inception, and include the requirement that all photographs of a given MS be taken under the same conditions, including lighting and distance from lens to surface, and the requirement that an image be taken with a ruler on a page. The suitability of the images was confirmed by selecting different images from the same manuscript and comparing the distance in pixels of comparable elements, such as, in the case of the third fragment discussed below, the distance between the chain lines on the paper.

The pages were then measured using simple photogrammetry (below, Appendix), noting the width and height of the columns. The lines per page were counted and recorded as well. This information was combined with that from the description; when reading the results below, should be noted that the description information does not always match precisely the measurements taken on the photographs. In image editing software, the recto and verso of each leaf were copied as layers on the same canvas, one side was mirrored horizontally, and the two sides were aligned. Then, a rectangular section was cut out, representing the front and back (mirrored) of the original leaf. The two sides of the pseudo-fragment were scaled to match the others, and all five pseudo-fragments were arranged and aligned on two canvases, one for the front side and one for the back side. The back side was then un-mirrored, and the two images were placed into a PDF document, designed to be printed front and back on A4 paper, at 1:1 scale [Figure 20].

Finally, an online edition of the text was identified (and the quality intentionally varied from early print to modern critical edition), the appropriate passage was located, and assembled into a PDF that was included with the test materials. The full test packet has been made available on the *Fragmentology* article page as additional material.



Figure 20: Front of test card, with the five fragments. Images from e-codices (Donor Volumes 1-5)

Donor Volumes of the Pseudo-Fragments

1. Schaffhausen, Stadtbibliothek, Gen. 1, pp. 9–10: Adamnanus de Iona, *Vita Columbae* (VII–VIII s.)

https://www.e-codices.ch/en/list/one/sbs/0001

Dimension information from the description: Written Area: 25×20 cm, Two columns, 28 lines¹⁵

Columns: 2

Column height (as measured): 246 mm

Column width (as measured): 88 mm outer, 94 mm inner

Lines per page: 28

- Edition: *Life of St. Columba, founder of Hy, written by Adamnan,* ed. W. Reeves, Dublin 1857 (<u>https://ia801402.us.archive.org/28/items/lifeofsaintcolumooadamuoft/lifeofsaintcolumooada-muoft.pdf</u>), 113–114.
- 2. St. Gallen, Stiftsbibliothek, Cod. Sang. 620, pp. 229–230: Petrus Comestor, *Historia Scholastica* (XIII s.)

https://www.e-codices.ch/en/list/one/csg/0620

Dimension information from the description: Two unequal columns $30/31 \times 7/8$ and 9/10 cm, 60-63 lines, with the second column empty¹⁶

Columns: 1 written column (1 laid out)

Column height (as measured): 314 mm

Column (=text block) width (as measured): 121 mm¹⁷

Lines per page: 63

- 15 R. Gamper and S. Marti, *Katalog der mittelalterlichen Handschriften der Stadtbibliothek Schaffhausen*, Dietikon-Zürich 1998, 67–68. Additions by Rudolf Gamper 2008.
- 16 B.M. von Scarpatetti, Die Handschriften der Stiftsbibliothek St. Gallen, Bd. 1: Abt. IV: Codices 547-669: Hagiographica, Historica, Geographica, 8.-18. Jahrhundert, Wiesbaden 2003, 215-218: "Zweispaltig; für die Lagen Nr. I-XIIII speziell für den Text konzipierte Einrichtung mit zwei Kolumnen ungleichen Ausmasses 30/31 x 7/8 resp. 9/10, 60-63 Zeilen, Linierung gemischt Falzbein und Bleistift. Die rechte Spalte ist durchgehend leer; am linken schmalen Rand figurieren passim Glossen von der Haupthand; für Zusätze und Glossen ist auch im Haupttext vielfach Platz ausgespart."
- 17 The difference in width measured here compared to that in the description is due to the fact that the description gives the column width for the first thirteen gatherings; in most of the gatherings, the margins are ample, to accommodate annotations contemporary with the copying of the manuscript. In this section,

- Edition: Petrus Comestor, *Historia Scholastica*, Lyon 1543, section on Daniel (<u>https://la.wikisource.org/wiki/Historia_Scholastica/Daniel</u>).
- 3. Basel, Universitätsbibliothek, A VIII 6, f. 4r–v: Ps.-Eusebius Cremonensis, *Epistula de morte Hieronymi ad Damasum episcopum Portuensem* (xv s.)

https://www.e-codices.ch/en/list/one/ubb/A-VIII-0006

Dimension information from the description: Written area 16×9 cm, 24–28 lines¹⁸

Columns: 1

Column height (as measured): 165 mm

Column (=text block) width (as measured): 98mm

Lines per page: 27

Edition: *Patrologia Latina* 22, cols. 239–282, at cols. 241–242 (https://archive.org/details/patrologiaecurs165unkngoog).

4. Schaffhausen, Stadtbibliothek, Ministerialbibliothek, Min. 53, f. 127r–v: Gregorius I. papa, *Moralia in Job*, libri 17–22 (XI s.) https://e-codices.ch/en/list/one/sbs/minoo53

Dimension information from the description: Written area 20.5-21×14.4-15.5 cm, 25 lines¹⁹

Columns: 1

Column height (as measured): 210 mm

Column (=text block) width (as measured): 144 mm

Lines per page: 25

Edition: Gregorius Magnus, *Moralia in Iob*, ed. Adriaen (via Brepolis), l. 21.

5. Fribourg/Freiburg, Bibliothèque cantonale et universitaire/Kantons- und Universitätsbibliothek, Ms. L 34, f. 13r–v: Jacobus de Voragine: *Legenda Aurea* (XIV s.) <u>https://www.e-codices.ch/en/list/one/bcuf/L0034</u>

there are no such annotations, and the single written column extends several cm towards the gutter.

¹⁸ University of Basel, *HAN Verbundkatalog Handschriften – Archive – Nachlässe*, 2013 (https://swisscollections.ch/Record/991170513619805501).

¹⁹ R. Gamper, G. Knoch-Mund, and M. Stähli, *Katalog der mittelalterlichen Hand*schriften der Ministerialbibliothek Schaffhausen, Dietikon-Zürich 1994, 147.

Dimension information from the description: 16.5×11 cm, 34 lines

on 2 columns, of 5–5.5 cm width, first ruled line not written Columns: 2

Column height (as measured): 166 mm

Column width (as measured): 52 mm outer, 51 mm inner column. Lines per page: 34

Edition: *Jacobi a Voragine Legenda aurea*, ed. Graesse, Leipzig 1846, 24–25 (<u>https://archive.org/details/jacobiavoragineoojacogoog/</u>).

Results

Between 2018 and 2019, the test was taken completely or in part five times, by A) a team of BA students, B-C) two MA students, D) a doctoral candidate, and E) a postdoctoral researcher. The anonymized results, in no particular order, are presented in Table 1. For each field, the measurement obtained on the image of the whole leaf presented, followed by the estimates produced by the test-takers working with pseudo-fragments; evident errors are in bold.

Table 1: Test Results

Test 1: Schaffhausen, Stadtbibliothek, Gen. 1, pp. 9–10: Adamnanus de Iona, *Vita Columbae* (VII-VIII s.)

	as measured	estimates
Columns	2	2, 2, 2, 2, 2
Width of written area (mm)	2×88,94 (=182 mm)	190, 170, 190, 200, 196
Height of written area (mm)	246	246, 252, 240, 252, 312-333
Lines per page	28	28, 28, 28-30, 37

Test 2: St. Gallen,	Stiftsbibliothek,	Cod. Sang. 620,	pp. 229-230:	Petrus
Comestor, Historia	Scholastica (XIII s	.)		

	as measured	estimates
Columns	1	1, 2 , 1, 1, 1
Width of written area (mm)	121	120, 160 , 112, 107, 117
Height of written area (mm)	314	180 , 200 , 290-300, 220 , 210-215
Lines per page	63	36-37 , 40 , 58-60, 60, 43

35

Test 3: Basel, Universitätsbibliothek, A VIII 6, f. 4r-v: PsEusebius Cremo-
nensis, Epistula de morte Hieronymi ad Damasum episcopum Portuensem
(xv s.)

	as measured	estimates
Columns	1	1, 1, 1, 1, 1
Width of written area (mm)	106	105, 108, 100, 110, 105
Height of written area (mm)	171	170, 221 , 240 , 186, 158-168
Lines per page	27	27, 28, 40 , 29, 25

Test 4: Schaffhausen, Stadtbibliothek, Ministerialbibliothek, Min. 53, f. 127T-v: Gregorius I. papa, *Moralia in Job*, libri 17-22 (XI s.)

	as measured	estimates
Columns	1	1,1,1,1
Width of written area (mm)	144	145, 146, 165 , 142
Height of written area (mm)	210	176 , 190-200, 208, 202-206
Lines per page	25	22, 21-22, 24, 24

Test 5: Fribourg/Freiburg, Bibliothèque cantonale et universitaire/Kantonsund Universitätsbibliohtek, Ms. L 34, f. 13r–v: Jacobus de Voragine: *Legenda Aurea* (XIV s.)

	as measured	estimates
Columns	2	2, 1, 2, 2
Width of written area (mm)	52, 51	105, 56 , 130 , 110
Height of written area (mm)	166	163, 176, 175, 162-163
Lines per page	34	34, 35, 35, 34

Discussion

The participants had not practiced the technique previously, and the number of gross errors indicated shows the need to document methods and double-check results.

One problem that arose with the results is due to a shortcoming in the test instructions: the instructions asked the test takers to estimate both the width of the columns and the width of the text block, but no information was provided to establish the latter for manuscripts with more than one column. Yet, on the two pseudo-fragments with two columns (#1 and #5), the results returned were for the entire written area; it is not clear whether they include estimates of the gap between columns.

Resolving the column-width problem by dividing the results for #1 and #5 (of the three who specified two columns) in half, the results for the width are very good: 20 of 23 estimates fall within 10 mm of the measured width; indeed, when the seventh/eighth-century manuscript (#1) is excluded, 15 of 19 fall within 5 mm, which is the accuracy used in the descriptions of those manuscripts.

Except for #2, the method proved quite effective for calculating lines per page. In the case of fragment #2, the edition used was a 1543 print, and the text, the *Historia Scholastica*, is notorious for having been continually modified by its users after its appearance.²⁰ The manuscript contains a significant passage that does not appear in the print edition, and using the edition for the extrapolative method underestimates the content by about one third. This result underscores the need for a reliable edition that reflects the text. For the other four cases, the estimations of lines per column were either exact (5 cases), within 2 lines (8 cases), within 3–4 lines (2 cases), or significantly off to suggest error (2 cases). The estimates for Fragment #4 were consistently low, and this is because the text not covered by the fragment included the explicit/incipit for books 20/21 [Figure 21].

According to this method, the height of the written page depends on the calculation of lines per page and the measurement of the individual line height, and the results reflect that. Excluding #2, 12 of 17 measurements are within 10 mm of the actual height of the written area; of the remaining measurements, 2 are within 20 mm, 2 made an error in calculating lines per page, and a third appears to have erred in calculating line height.

This small test shows that the extrapolative method can, based on a fragment of a leaf, produce remarkably accurate estimates of the dimensions of the written area and lines per page of the original manuscript. Variation in the manuscript source text with respect to

²⁰ M. Clark, *The Making of the Historia Scholastica*, 1150–1200, Turnhout 2016, 254: "This was [...] a living, protypically scholastic text, which changed constantly at the hands of the *magistri* who were at the same time teaching with it and adding to it."



Figure 21: Schaffhausen, Stadtbibliothek, Ministerialbibliothek, Min. 53, f. 127v (e-codices), with pseudo-fragment section highlighted



DOI: 10.24446/j9en

the edited text and elements such as initials, incipits and explicits, can influence the results; if the fragment allows for multiple extrapolations (e.g., a strip cut from a bifolium), this effect can even be used to determine the content of the un-reported text. The exact margin of error depends on the type of text, method of production, and time and place of production, but in the cases here, a skilled measurement can produce results with an accuracy of 10 mm in height, 5 mm in width, and 2 lines per page.

Criticism

This experiment arose informally, and its formulation and execution have a few shortcomings that need to be noted. The test specified two different methods of measuring text, one based on characters, the other based on words. It also provided for measurements in two media: digital and physical. This ambiguity produced an unknown variation in the results. In the future, a simpler test should specify a single method and be given to a larger number of participants.

The ambiguity of the difference between measuring the width of a column and that of a written page provided for less than desirable results on the width of a page. The complete lack of guidance on how to estimate intercolumnar space needs to be addressed. To estimate intercolumnar space, place the fragment in the context of contemporary manuscripts of the same genre and ideally from the same region.

Let us return to the example used for the instructions, [F-nxmr] the fragment from a ninth-century Mondsee manuscript of Gregory the Great. The Austrian National Library has published online Cod. 732, a Mondsee manuscript also containing a ninth-century copy of texts of Gregory the Great in two columns [Figure 22].²¹

38

²¹ On ÖNB Cod. 732, see: http://data.onb.ac.at/rec/AC13956701; Description in H.J. Hermann, Die deutschen romanischen Handschriften (Beschreibendes Verzeichnis der illuminierted Handschriften in Österreich. II. Band: Die illuminierten Handschriften und Inkunabeln der Nationalbibliothek in Wien, II. Teil: Die deutschen romanischen Handschriften, Leipzig 1926, 323–324; Lowe, Codices Latini Antiquiores, no. 1487. The manuscript was located using manuscripta. at and searching for manuscripts from a dating from 700 to 1000 and with Mondsee listed as the Lokalisierung.

folum uor up for. tiemas folemne fed discon omner TICCOM feam can quiceduorpement. rica luxono ficp Ferendic polluere: Cum ommi honef tite caftor fobrof Tune enim probi conferutif.unde fér iohannir quic do greener agenr quid policite po cent obanere. Fupudeorum cordecu dec Quashuncheq; finos festurcace rea house dona horp facen pacerficor incipere ; conce captor fubnorcor dice not felicem q; ullo cur pi pleuerconticom loquio cognouent colobra live; custodire. qui base ergo fir him cumpicope & piu feo mure deregnat pro paccorna foli in faccula fetozam; croudine fuzzero; INCIPIT omelia Nam do propras INNATALEADES rece de uestre rulorum pe devotione con TRI eT pauli: fido. quod non

Figure 22: Wien, ÖNB Cod. 732, f. 166r, with Fragm. 210a [<u>F-nxmr</u>] digitally superimposed



DOI: 10.24446/j9en

Duba

The description provides the dimensions 300 × 210 mm for the page. The digitization provides no reference image for the codex, and the image is taken slightly out of vertical (note the head-edge is visible), rending photogrammetry approximate. Nevertheless, a quick measurement of the page compared against the given dimensions (300 × 210 mm) provides 23.66 px/mm in the vertical and 23.48 px/mm in the horizontal. Since 600 DPI is 23.62 px/mm, these images were almost certainly taken with a 600 DPI scanner, and this value (23.62 px/mm) can be used, recognizing some loss in precision. The fragment, as we saw above, was also scanned at practically 600 DPI; it is likely that the same equipment was used. In any case, the fragment and the leaf are imaged to scale, and the fragment can be digitally superimposed.

Measured via simple photogrammetry (see Appendix), the written area is roughly 236 × 165 mm, with two columns that at one point measure 73 (inside) and 81 mm (outside) wide, with an intercolumnal space of 11 mm.

Dimension	Cod. 732, f. 166r	Fragm. 210 A
Column Width	73-81 mm	81 mm
Line height	11.4 mm	11.0 mm
Lines per page	21	28-29

Table 2: Comparison of layout between Wien, ÖNB Cod. 732 and Fragm. 210 A

A comparison of the primary measurements shows that the reconstruction is not out of scale, although, comparatively, the lines per page (and thus column height) seems a little elevated. An intercolumnar space of 10–15 mm would be expected. The nature of ninth-century manuscript production at Mondsee, as elsewhere in Europe, features considerable variation in the trailing (right) edge of each line: on the outside (b) column, the shortest non-rubric line is 67 mm wide and longest is 81 mm; the inner column (a) is also, on the average, narrower than the outer one. If the fragment were to come from one of the shorter lines, the calculation of characters per line would be relatively low, and the number of lines required per column would be higher. In other words, a +/- 5% variation

in column width, as seen in ÖNB 732, would, when extrapolating, translate into a +/- 5% inverse variation in column height.

The extrapolative method to calculate the height of the written area can induce a slight overestimation, as line height is measured from baseline to baseline, but the top line of a page, at least before the thirteenth century, is not bounded by a line. In effect, the whitespace above the first line is included in the extrapolation.

Taking into account the variation from line to line, the errors in extrapolating documented above, and a comparison to a contemporary manuscript,we can arrive at an estimate of the original dimensions of the example fragment:

Lines per page: 28-29 = +/-5% = 27-31Column Height: 27-31 lines × 11.0 mm/line, subtract 3 mm for the top line, and rounded to 5 mm = 295-340 mm Outer column width: 81 mm +/- 5%, rounded to 5 mm = 75-85 mm Intercolumnar gap: 10-15 mm Inner column width: 75-90 mm Total width: 165-195 mm.

The original written area was approximately $295-340 \times 165-195$ mm. A small piece of parchment allows us to obtain an idea of what the original leaf looked like.

In fact, we can validate this estimate. The fragment being measured here (210 R) is one of several from the same original codex that have survived in the Austrian National Library.²² Some of the larger parts appear under the shelfmark Cod. ser. n. 2066 [<u>F-jyai</u>] [Figure 23]. Similar measurements and extrapolations on f. 3r-v, a more complete leaf that preserves the entire width of the written area and 22 lines of text, produces an estimate of 29 lines per page and of a written area ca. 307×167 mm. Therefore, the estimate from a small piece produces results that are coherent with larger fragments of the same codex.

²² The reconstruction has yet to be published, but Ivana Dobcheva has made information available on her Github page: <u>https://ivanadob.github.io/mondsee/</u> <u>desc_vr_f-jyai.html</u>. I thank the anonymous referee for this indication.

rubdendo manifesta malib: franzis mamouro Lung nonfum dignuf chife An Brigenerical chang raluere compric calar As propriet quindremente monte, morcopudue toful mor ticinic nrac Mr fure. ut fiquiterom corruptions adruption ndeshepphskiedicit. g. Tibiconpelerelaca pare unoren nollalille er cal cramon lum & uprol. COLOUR AND MONOCHROME SEPARATION GUID 18 9 quia coo hanc fr ... fur superprinquest marusitel, TL Judgitur in horand K xpf-minifcae & lefiae fiponful Appertar. 8 R) equo & rde to ham dicit qui haba pontai C Roomannes Stolquer 10hanne thoundroom T effo punniguni sauge readen when inst ne such Recar form da ma y Porcal plusich amoric our calciamiand demundance, MAGO

Figure 23: [<u>F-jyai</u>] Wien, ÖNB Cod. Ser. n. 2066, f. 3v with color control card



Summary of the Extrapolative Method

The test, its results, and contextual considerations lead to recommending a methodology for estimating the original written area from a now-fragmented codex:

- 1. Measure the width of the visible lines, to one-mm accuracy (visible line width).
- 2. Measure the line height to one-tenth mm accuracy (line height).
- 3. Locate a source for the fragment text; ideally, use the text from a critical edition.
- 4. Establish that the edition matches sufficiently the fragment text.
- 5. Determine the width of a line: count edition-characters per manuscript line (characters per line), and edition-characters corresponding to the visible part (visible characters).

original line width = visible line width × $(\frac{characters per line}{visible characters})$

- 6. Calculate the edition-characters per column (characters per column), or from the front to back of the fragment.
- 7. Calculate the number of lines per page.

lines per page = $\frac{characters per column}{characters per line}$

8. Determine the column height.

column height = lines per page × line height

- 9. In the case of manuscripts with writing above the top line (generally before 1230),²³ measure the distance between the top of one line and the baseline above it, and subtract that value from column height.
- 10. Determine the number of columns according to visible information, and the ratio of Column Height to Column Width. In the case of a front-toback measurement of inside columns of a two-column leaf (or middle columns of a three-column leaf), Lines per Page and Column Height will be three times too large; for the inside column of a three-column leaf, lines per page and column height should be divided by five.
- 11. Locate a comparison leaf similar to the one being measured in content, place and date of origin. Use that to estimate missing layout details, such as intercolumnar space.

²³ See, e.g., N.R. Ker, "From 'Above Top Line' to 'Below Top Line': A Change in Scribal Practice", *Celtica* 5 (1960), 13–16.

- 12. Estimate, on the basis of the comparison leaf, the precision. As a ballpark figure, use 5% for fragments produced in the tenth century and later, and 10% for earlier fragments with uneven line width.
- 13. When indicating the estimate, state the procedure used, the edition, and the comparison leaf.

The results of the test show the general reliability of its method, but that the suitability of any given edition cannot be taken for granted. Calculation errors occur with some frequency as well, and therefore, if the fragment and the time available allow, multiple estimates should be used.

Calculating Missing Leaves

A similar method can be used to calculate the distance between any two fragmentary leaves. Larger measurements reduce the need to strip out punctuation from digital texts, and permit words instead of characters, and even just the calculation of a correspondence of columns of texts between manuscript witnesses can produce good results. For example, [F-70dh] Brugge, Stads- en O.C.M.W. archief, reeks 538: Fragmenten van handschriften, nr. 34 [Figure 24, 25] (Henceforth, the "Bruges Fragment"), consists of two leaves of the Commentary on Book I of the Sentences by Peter of Tarantaise, OP (later Innocent V).²⁴ From the running titles, "D" (distinctio), on one side, and "v" (first leaf) or "vII" (second leaf) on the other, we can determine recto and verso: the verso has "D", and the recto has the number. On both leaves, the recto is the hair side, and the verso is the flesh side. Therefore, these two leaves cannot have made a bifolium, since the recto of a bifolium's prior leaf shares the same side (flesh or hair) as the verso of its posterior leaf. Moreover, as mentioned above, Gregory's Rule specifies that bifolia are bound together so that hair side faces hair side and flesh side faces flesh side; thus there will be an odd number of leaves between the two fragments [Figure 17].

²⁴ The Bruges Fragment was digitized as part of the *Comites Latentes: Hidden Manuscripts Revealed* project led by Godfried Croenen and focusing on fragments in Flemish collections: <u>https://fragmentarium.ms/partner-projects/comites_latentes</u>.

or an anofte and deto with Stand pa אינר בור האו אל אתר בור אם ירוואה וה. been phoreior Srabelojm mi moi fuente hust a fine can to Po in Monte fig Di onfernie 49 12 sand piklums + 19 te לווווב אשותותות אושףו מושיה ול משי לוויי רא יה לוול ווי וכל יה נולאי ווייי וכל לא לי atur ala mot fig di figite at bath forme Addy arudir of nor filitin is noie hele THE Dar & Buperto + 0, Pully Bate to tollin pin futo ofta no anti. Ou o ar rinte Prapin unt li noia plati fin + g ++-In figtua a tian. Ou o ardimuz, fu, ce fun i pole in car p i ai a i and the p a bar in a i in a content pol nut a co bar in a i in a content pol nupore rap p i p f fine apre pol fue Supti spint was would have annous ur men port alth arropugina fell'un up apre Bi-na miniurle. 0. ille gene non warer perroy & rollie winne V Himne ca tor ampli guane or uch genan no cor ש שהסוב אל וא לבוויםל שום כמו או אפווים roller pinin fign fa no tollio flinne vi finn for ramoui puegom & magios Drofigun grione . Fr Bil . 1922 12 111 cought ton de if grant for to hive tim dial. p. tal Sillietum print filu. altin & q a dend an aluf ut airin mi q alirin q mias. S. am and far nat figin thi diff mod fig di quibe בי וז מצח בעודי כי יל מי אותו כב העום לחוו vnonois figer auto a sit va ami unit tune unit now if no duine vi sultuple הוומיוסט לכוומ אל אווו זכנהו אל אווות Henni Sona Arm of. Propro quilit actu fugoin foi fi untaple Por 17 fin li teme mart fu fi pioni Por 17 fin li teme mart fu fi pioni for 17 fin guiar fi noit ab fino A pino far for m an an gaiar I panar to an ta un fir mo or de la fina pre pino or a can onn no gnar fo q no giat . F. tropor o fa. 20. rone fa no ingonan of q ho plate terias fimt qu'il aug-plac. ano ourir ad to go it histary tour S. jug pre p puepelle tin 4-parnorauti fou fipni quab terite vara fo while of har אות זה שוור אור יוור אות האסווב שועי אות ומוודים בוד של. ב מווסדר למווו א נאווודים אייייי. white an anona " their mine in a light the air . un I 1, 5 quean us gian aini minplemi fir minple for fignare ga una וונון זו ל העודיות למוותנו זונה לסוות. ל היור בסווה שמור במור מוולבר מופי למר המור מנויות 23 1 והו נהופוותו או. ferde. of ar to fund as fuine of for form Tintan & Duitant Postation or Dui B & oppen avatuints bolante fo totur. finat fuppin fi duista i no et poir duige מווד ההותה מי המה א מוס והר מ גולה כיוו הר אום אישיוט ק אטוור אעולבן ק אווי q'fili as fin par nad for to file ame file ה ביותר אה הי הואום - עו או או והי איל אים אים gour guale S. bur bler. F. Gale aufer fin ett på Betnar seller f g f f nu bar radom glen að taga bar fagnar phúr fin vað vir Fathri uð f a far fagn finst að fein lapsin vi bie. S fissi קומן מראור א מקטותר. כוובמיל אין ל החול i pme veri ant bins for ginne foan for geurnaf un az işi fir gilen f t om frit bue fran grebb' for or and smar . Po an and obmmer. gen Stri bhe mage bilm mur h tutte citter rat bes tanta cine ie greed mus en pl. agin lic tre guing in Sing ? Mang? for relow fie and and attre

Figure 24: [F-70dh] Brugge, Stads- en O.C.M.W. archief, reeks 538: Fragmenten van handschriften, nr. 34, first leaf, recto

Duba

ñ cen sina difingur qu vua en iplib; वीले भार्ने कि का मार्ग राजे के कि कि कि कि B no stiar. If fi cen stiar & no ne molmr. B. P thin + 10 to Pm thim of 1 Sena of ad do fi go salar ad do de se na grine and of n go ad do fi go salar ad do de se na guiar aff inchife anter fugiones as we tay fi ad dene of thuannest guiar fi fid go attil + de fi fi Aliq one of the qui fat win + atti cen 14 to 19 18 a fi achur guanor i att & tan 4 can. Ar ann an ver genant ann n הונס . g cal' tone fi Brian figratie g שלי זב קבוואות איב קבוווזה איב איבול te alt iuenne foint te va i gentne אות הב בא אל הבי אי אב אב אל אב בבי אי אות and adul atilet-up due i te etil polt pour atur plar ur geriare. He nat to se da tor luttone & the to en f די ל דיד היד האוניות לי וווט ש הד על מד לי מואד זה גלי ל לכו מרוור איס וואלי הי מוא טוא איל טווונים אליות טוואס n taritar atin fa pen hrue an gratur i iponite at bi afarde figficanter no Porant a sel to a f to bane o to fir nz cell + & na durfune tone t chier duz וף אשות אוודיות יבווי ככה אוועש כות מ ווס בתי שונותו ה בול ום קי שב אל מרטוום חום אל שוואים וו אולב מי לי מחוור ול העוציו וושי א כמוו וו כעוו ווליוו אי אותוויוור מקור E 175 + Imanite 18 Actur artbuite funt no sent il alle fa to no cen " fuge" no differir in Gibne az cal d'enrabio tuni & dentiti + retari vi wat no obunar dentr" G to & tone or grannt qui andoute alle they & go is at dige beates matur center qui do arrbui nur for sigfur no ur actur gler fie לב האולו לו לחת וף מוזילות ומו לי האולים וליים וליים וייים מינו וייים th as during tone of and unif q' out o abo - 1.9 tom no atebum

אוליותל אולי ש מיוט בוד קמום ייף יד אולי burt att un en te. Ou & fi alia duo 18 nil qui anthuno for p qu 18 02 8 aur elt Butur S. pi. fi te f gilaur ne fur unan tur ghenn gnonit i a fin odude i acq call & CD Fil animer fir fi dunt inte an me narty ally of an ally I' the an toll oman air of an ton. Or & te a to and ad ושוב של השל וום מד מב ושווב משא שו קבו at & daude en no an is to ton a fon an arthun cal no es l'& grandum ב הש קטומוד מב כבל הר ה מב ל גלו מולווו בו בביני קו יק אותר עלים ובל עי אוודיותר ום חב הר המושול איב אר בבה שה חוף שב או למל על יה ווה ול מ מה לו ליאל למיף ל Unit no a a gratto th thi ul' & gritit que fat ous adome no duige quo offe ad imam זכוב אי מש אי עי לי כלו כור אבווד ח כלו en pe aus wine & all i far to g dramar toma אים מש איש לאורה לאורה לאורה לאוני לא איש שור לא ती निर्मा मंद्र के कि कोई ता मंद्र प्रता का मंद्र निर्मा के genur filui. He ar dos & tom & al Hemi f ad mond Hanr + tom & Hern part .ge name wind ab an of + 42 (Fringer ab הו זהו של הו שומות לי מעל שוף שוי ויש או ביו יושי וויש In the work of the second seco Winn ul'ad fune & in 190 The lettin fund ta au fait saunar vi no te ut no to sam tar va no to lee edu for un va oplar for

Figure 25: [F-70dh]Brugge, Stads- en O.C.M.W. archief, reeks 538: Fragmenten van handschriften, nr. 34, first leaf, verso

The Toulouse 1652 edition of Peter of Tarantaise's commentary on book I was reprinted by the Gregg Press in 1964; it was later scanned by Google, and Jeffrey Witt has encoded the machine transcription at LombardPress.org.²⁵ Assuming that the machine transcription errors and paratext will have a negligeable effect on the overall word, it is therefore trivial to copy-paste the text into a document, and measure the words, which will be referred to as 'Witt Words' in what follows. The text on the first leaf runs from the end of d. 4, q. 4 to the middle of d. 5, q. 5; the second leaf starts near the beginning of d. 7, q. 1, and includes the first part of q. 2. To validate our data, we will use the witness in Paris, Bibliothèque nationale de France, latin 14556,²⁶ which has book I on ff. 1r–85r, and book II on ff. 86r–163v.

The Paris manuscript has 56 lines per page on two columns on the leaves corresponding to the Bruges fragment. The passage witnessed by the first leaf begins on f. 11ra, l. 35/56 (*unde non potest habere plurale*) and ends on f. 11vb, l. 9/56 (*unde copulat for*[*mam*]); the passage parallel to the second leaf begins on f. 13va, l. 53/56 (*prius est in potentia*) and ends on f. 14rb, l. 41/56 (hoc vero in Deo non contingit).

Bruges Fragment	Witt Words	Paris Passage	Paris Lines
Leaf 1	1809	f. 11ra, l. 35 – f. 11vb, l. 9	142
Leaf 2	1959	f. 13va, l. 53 - f. 14rb, l. 41	152
Between 1 and 2	5725	f. 11vb, l. 10 – f. 13va, l. 52	434

Table 3: Passages in and between the Bruges Fragment, expressed in terms of Witt Words and Paris Lines

On these calculations, one leaf of the fragment has, on average, 1884 Witt Words, and 147 Paris lines [Table 3]. We therefore divide the measurements of the missing text between Leaves 1 and 2 by these figures.

²⁵ Innocentii Quinti [...] In IV Libros Sententiarum Commentaria [...], Toulouse 1652, Repr. Gregg Press 1964 (https://www.google.com/books/edition/ Innocentii_Quinti_pontificis_maximi_ex_o/qbo-AQAAMAAJ); Petrus de Tarantasia, Commentarius in libros Sententiarum, ed. J. Witt, https://reader. lombardpress.org/text/pdt7y6.

²⁶ Digitization at: https://gallica.bnf.fr/view3if/ga/ark:/12148/btv1b9066640d/ f30.

 $\frac{434 \text{ Paris Lines}}{147 \text{ Paris Lines per leaf}} = 2.95 \text{ leaves}$

Both methods of calculation come within 2% of three leaves. Therefore, we can conclude with confidence that there were exactly three leaves between Leaf 1 and Leaf 2. The text in question contains Scholastic theology, a genre known for its highly abbreviated manuscripts. The results show that, at least for this manuscript, the rate of abbreviation is quite consistent.

Reconstructing the Gathering/Codex

A bifolium can be situated within a quire by identifying the number of intermediate leaves. In some cases, the entire codex can be reconstructed in this way.²⁷ An example will demonstrate the viability of this approach.

The fragment [F-44mw] Leeds, University of Leeds Libraries, Special Collections, MS Ripon Cathedral Fragments/20 [Figure 26], is a bifolium from Brunetto Latini's *Trésor*, a thirteenth-century encyclopedia written in French. The fourteenth-century fragment was published on *Fragmentarium* as part of the UK Research and Innovation *Digital Explorations* Project at the University of Leeds.²⁸ In her description, Laura Albiero identifies the bifolium as having non-consecutive leaves, and containing passages found on pp. 33–34 and 52–55, respectively, of Chabaille's 1863 edition, and pp 36–38, pp. 50–51 of Carmody's 1948 critical edition, corresponding to book

²⁷ For an example of such a reconstruction, see W. Duba, "Fragments of Francesco d'Appignano's Improbatio", *Picenum Seraphicum* 36 (2022), 101–121, at 105–107 (https://riviste.unimc.it/index.php/pi_ser/article/view/3215), where a single-bifolium fragment is reunited with two sexternions that precede it, and its own gathering, a quinion, is reconstructed.

²⁸ Digital Explorations: Opening the Medieval Manuscript Fragments from the Ripon Cathedral Library, Dr N.K. Yavuz, Principal Investigator, Prof. E. Cayley, J. Double, R. Fitzgerald, Co-investigators, February–July 2023.



Figure 26: [F-44mw] Leeds University Library, Special Collections, MS Ripon Cathedral Fragments/20

Image Rights: https://bit.ly/44BrxgX

I, part 1.²⁹ In addition, the current edition of reference is that of Beltrami, Squillacioti, Torri, and Vatteroni; unlike Chabaille and Carmody, it is available only in print and not in digital form.³⁰ To determine the situation of the bifolium in the original gathering, and the constitution of the original codex, I counted the lines of text of the first 55 pages of Chabaille's edition, skipping the chapter titles, and marked where the bifolium's passages began and ended. I performed a similar operation using words and characters against

²⁹ L. Albiero for *Fragmentarium*, Description of [F-44mw] Leeds, University of Leeds Libraries, Special Collections, MS Ripon Cathedral Fragments/20 (https://fragmentarium.ms/description/F-44mw/6009); Li livres dou tresor par Brunetto Latini, ed. P. Chabaille, Paris 1863; Li Livres dou trésor de Brunetto Latini, ed. F.J. Carmody, Berkeley 1948, text online at: http://www.florin.ms/ tresor1.html.

³⁰ Brunetto Latini, Tresor: testo a fronte, ed. P.G. Beltrami, P. Squillacioti, P. Torri, and S. Vatteroni, Turin 2007.

an electronic copy of Carmody's text. For the sake of completeness, I digitized the beginning of the Beltrami et al. edition, using optical character recognition (in Adobe Acrobat) to produce a digital text, and compared the passages on the fragment to it as well. I then solved for the number of bifolia between the prior and posterior leaf of the Ripon Fragment, by indexing the leaves against lines from the Chabaille edition, and words and characters from both the Carmody edition and from the automated recognition of the Beltrami et al. edition (including the text of chapter titles, which are rendered in rubric in the manuscript) [Table 4].

 Table 4: The Ripon Trésor Fragment measured against the Chabaille, Carmodi, and Beltrami et al. editions

Ripon Fragment	Chabaille Lines	Carmody Words	Carmody Chars.	Beltrami Words	Beltrami Chars
Prior leaf	46	550	2,961	585	3152
Posterior leaf	48	595	3,105	617	3233
Total bifolium	94	1,145	6,066	1,202	6,385
Gap between leaves	371	4,706	24,724	4,846	25,720
Bifolia in gap (est.)	3.95	4.11	4.08	4.03	4.03

All measurement schemes produce results within three percent of exactly 4 bifolia; the hasty uncorrected scan of the latest critical edition produces results within one percent. Almost certainly, when bound in the original volume, the fragment here had four bifolia inside it. The total text covered from the beginning of the prior leaf to the end of the posterior leaf corresponds to ten leaves, and therefore we can estimate per leaf: 46.5 Chabaille Lines, 585 Carmody Words, 3,079 Carmody Characters, 605 Beltrami words and 3211 Beltrami characters.

These figures provide a consistent projection for the number of leaves from the incipit of the *Trésor* to the beginning of the fragment. From the beginning of edition to the beginning of the passage on the prior leaf, there are 679 Chabaille Lines, 8,132 Carmody Words, 43,524 Carmody Characters, 8,379 Beltrami words, and 45,123 Beltrami characters. If we divide these figures by the average amount of text per leaf contained in the ten leaves between the beginning of the prior leaf and the end of the posterior leaf of the Ripon Fragment, we get: 14.4 leaves (from Chabaille Lines), 13.9 leaves (from Carmody Words), and 14.14 leaves (from Carmody Characters), 13.8 leaves (from Beltrami words), and 14.05 leaves (from Beltrami characters). In other words, if the prior text resembled the previous three major editions of the work, exactly fourteen leaves preceded the prior leaf of the fragment, assuming a complete original.

The information provided by the bifolium can also be used to support a hypothesis about the codex's original collation, assuming that this professionally-copied manuscript was originally bound in gatherings of the same size. Since, on the surviving bifolium, the gap between prior and posterior leaf corresponds to four bifolia, the gatherings were at least quinions. If there were quinions, then the fourteen leaves would account for a preceding quinion and the last four leaves of the first quinion. On the other hand, on a senion hypothesis, one leaf would belong to the outermost bifolium of the current gathering, twelve would find themselves in the preceding senion, and the first leaf of the *Trésor* would be the last leaf of the first senion. One could also calculate for the rare case of a septenion-binding (7 bifolia) [Figures 27–29].

That the text of the *Trésor* would not begin at the start of a gathering seems odd, but a quick survey of available digitizations through Gallica shows that most copies of the *Trésor* were preceded by a table of the rubrics of the individual chapters. In some cases (e.g., Paris, Bibliothèque nationale de France, français 570), the text begins (f. 5r) with a gathering (a senion), and is preceded by a bifolium with the chapter titles; in other cases (français 569, 571 and français 110, for example), the table of titles appears on the same quire as the beginning of the text, sometimes (français 571 and 1110) with a blank leaf between the tables and the text.

While measuring the tables of rubrics in the original manuscript is difficult, since they could have been done by a different hand or according to a different layout, the appearance of the beginning of the text in the same gathering favors the hypothesis of the same layout, namely, 2 columns, 31 lines per column. While many of the rubrics are long, extending to two or three lines in some manuscripts, most









Figure 28

Figures 27-29: hypothetical collations of the original Trésor codex, assuming quinions (27), senions (28), or septions (29). These visualizations were created using VCEditor on 4 December 2023. Dotted lines indicate missing bifolia, the solid line situates the surviving bifolium, and the light blue dotted line stands for the incipit of the text.

are of the single-line variety. Thus, there will be less variation in total lines used for the tables of rubrics than there will be for the text.

Manuscript	lines for book I rubrics	lines for book I–III rubrics
BnF, français 569	254	-
BnF, français 570	259	-
BnF, français 571	224	509
BnF, français 1110	271	455
Rouen, B.M., O 23	227	

Table 5: Trésor manuscripts, number of lines used for tables of rubrics

At 31 lines per column, the Ripon original would require 7–9 columns, or between 2 leaves and 2 leaves and a page for the rubrics for book I. On the other hand, for the rubrics for all the books of the *Trésor*, between 4 leaves and 4 leaves and a page would be required. Neither solution fits the senion hypothesis, which would have 11 leaves preceding the incipit. If the codex had gatherings of seven bifolia, then the two leaves at the beginning would be close fit for a table of contents of just book I. On the quinion model, however, it is likely that the first gathering resembled that of français 1110, formerly of the Visconti family: f. 1r–b: Blank/*ex libris*, f. 2ra–5rb: table of rubrics, f. 6: blank, f. 7ra: beginning of the text. Since the Ripon original had fewer lines per column than 1110 (31 instead of 38), the rubrics likely continued on to f. 5v.³¹

The Visconti Trésor can also be used to validate the measurements and pro-31 jections of the Ripon original. The Visconti manuscript (Paris, BnF, francais 1110) is ruled at 38 and 39 lines per page. As noted, the text begins on f. 7r. The passage corresponding to the Ripon prior leaf is on 14ra, l. 34/39 – 14va, 1. 25/39 (=69 lines); the one matching the posterior leaf (including a 10-line illumination) runs from f. 18ra, l. 33/39 to 18vb, l. 39/39 (85 lines), giving a measure of 154 Visconti lines for the Ripon Bifolium. Between the prior and posterior leaf-passages, there are 593 Visconti lines, and thus the estimate of 3.85 bifolia holds. Adding the lines together, we get an average of 74.7 Visconti lines per Ripon leaf. Now we reverse the calculation. We have estimated that the Ripon Original had 14 leaves preceding the Prior Leaf. That corresponds to $14 \times 74.7 = 1046$ lines in the Visconti manuscript. The first quire has 39 lines per column, so 156 lines per leaf. Divide the total estimated Visconti lines by lines per leaf: $1046 \div 156 = 6.7$ leaves estimated in the Visconti manuscript. The actual distance from f. 14ra 33/39 to the first line of f. 7ra is 6.22 leaves (969

Duba

The original manuscript from which came the Ripon bifolium was likely composed of quinions and contained, or was planned to contain, the entirety of the *Trésor*. In the original codex, assuming that it began with the *Trésor*, the Ripon fragment's prior leaf would have been f. 21, and the posterior one, f. 30.

This example also provides an opportunity to examine the relative accuracy of counting lines, words, and characters: on the final measurement (with a sample of 10 leaves), the Chabaille Line method overestimated the text needed by about 3%, counting Carmody Characters overestimated by 1%, and Carmody Words underestimated by 0.7%. Given a sample of 10 leaves, all three methods are relatively accurate, and should the text afterwards be homogeneous, free of major disruptions, changes in layout, scribe or major changes in illumination density, these methods will provide a reliable estimate for the original text.

Using the corrected average of 583 Carmody Words per leaf, we can project the size of the rest of the manuscript [Table 6].

Section	Carmody Words	Leaves
Book I-Posterior Leaf	13,983	24
Rest of Book I	49,899	85.6
Book II	61,157	104.9
Book III	47,000	80.6
Total	172,039	295.1

Table 6: Ripon Trésor, projection of the size of the original manuscript

Assuming 2% error, the total work would have covered 289–301 leaves bound in 29–30 quinions. Someone inspired by a drawing of a temple derived from a piece of pediment, or an amphora from a handle sherd, might make a diagram of the collation: 30 groups of

Visconti lines, an error of one page). To estimate the extension of the *Trésor* in the other direction, we first estimate total lines in the remainder of the Visconti manuscript, from f. 19ra, l. 1 to f. 155vb, l. 15 (assuming an even split between 38- and 39-line columns): 20,919 Visconti-lines, which correspond to 280 leaves in the Ripon Original; adding the three prior quinions produces a 310-leaf codex.

five bifolia, all missing, except for one, the outer bifolium of the third gathering.32

Obviously, such an extrapolation needs qualification. The Trésor, like the Historia Scholastica in Latin, accumulated interpolations and significant accidents from manuscript to manuscript.³³ Moreover, several manuscripts have illuminations, and there are diagrams, particularly astronomical ones in book I, part 3, and the *mappamundi* in book I, part 4; we have no idea how much space these would take, or how it would influence the relationship between the Carmody edition and the gatherings. The same scribe would have had to copy the entire codex with the same density of script. Very rarely does such a "perfect" manuscript exist in nature. By compounding hypotheses, we are moving from the solid basis of the script on the bifolium to an increasingly conjectural original. Finally, a bifolium-normative approach to medieval quire structures has been rightly challenged by descriptive codicologists; at the very least, we cannot distinguish between two non-existent singletons and a single missing bifolium.³⁴

On the other hand, the power and accuracy of this method rewards detailed investigation. For example, one could use this method to estimate the number and type of illuminations in the written area in the non-present leaves. If a critical edition has an extensive apparatus, one might be able to not only align the text with a family tradition, but also to determine whether any major textual perturbations (large additions and omissions) were present in the missing sections, which would further situate the fragment as a witness to the text. With fragments of large books, we might expect to find another leaf or bifolium in the future, and this form of conjecture can specify some of the criteria that will make the

55

³² On such visualization techniques, see A. Dorofeeva, "Visualizing Codicologically and Textually Complex Manuscripts", Manuscript Studies 4 (2019), 334-360.

See the discussion in Beltrami's "Nota al testo e alla tradizione", in Brunetto 33 Latini, Tresor, ed. Beltrami et al., XXVII-XXXIII.

Dorofeeva, "Visualizing Codicologically and Textually Complex Manuscripts", 34 350-351, summarizes the discussion, with major contributions from Gumbert, in the context of the prejudice introduced by presuming the bifolium.

search easier. The identification of such future fragments will, in turn, allow us to confirm and refine the reconstruction.

This example also shows the importance of a suitable edition. The term "critical edition" has many meanings, depending on the discipline within which the edition is produced, national traditions, and the goals of the editors. At times, as in the example, a more modern edition is available, but not in digital form, as was the case here.³⁵ A pre-digital approach would specify without hesitation using the more reliable edition. When working with digital sources, however, the availability of older texts plays strongly in their favor. While the Beltrami edition features an apparatus with variants, and could be used to form a more detailed assessment, the facing-page translation requires significant variation in text density, so that pages and even lines on a page are not reliable measures. Scanning the text, applying optical character recognition, and then using Adobe Acrobat's text editing feature to copy-and-paste the French text on the first part of the work took forty minutes (thanks to the need to scan less than ten percent of the work); including borrowing and returning the book, this calculation took approximately two hours to perform. That time in itself may seem short, but it is unacceptably long for many projects with thousands of fragments and only a fraction of the time available. Moreover, Latini's Trésor is an ideal situation: we have multiple modern editions to choose from, and they all are relatively good.

As a corollary, these textual methods underscore the need for critical editions that are available in digital form and in Open Access. Print editions and digital ones copyrighted or in limited-access databases lack the utility of the previous editions, hasty transcriptions, and manuscript sources that they propose to replace.

Conclusion

The extrapolative method is not particularly complicated and has been practiced, explicitly or implicitly, by scholars for centuries. Similarly, cataloguers have made an art of identifying the

³⁵ Brunetto Latini, Tresor, ed. Beltrami et al.

orientation of manuscript leaves and bifolia from textual, paratextual, and material cues. By documenting these techniques, my hope is to engender discussion on how to approach fragments, to provoke criticism and hopefully refinement of these techniques. How far can we take these methods, and to what degree are they useful for understanding this facet of fragments?

In working with fragments, we seem to cite them in two ways: as they currently are and as they were. In referring to them as they currently are, it seems that we should avoid applying a schema that makes sense only for intact, bound books. We cite an in situ fragment according to its location in a host volume, and a loose fragment according to its shelfmark, *Fragmentarium* ID, or other identifying feature. To refer to the intellectual content, however, requires some level of reconstruction, if only the determination of the orientation. For a leaf has two sides, recto and verso, and a bifolium has two sides, inwards and outwards. Unless the leaves of a bifolium still have their original foliation, the act of giving them numbers, such as f. 1 and f. 2, A and B, makes less sense than to refer to them as prior and posterior. A bifolium has conjoined leaves that are relative to each other.

Reconstructions never rebuild the original, but they can provide a way to place the fragment in its original context, and establish a framework for future investigation. Even a quick perusal of the *Fragmentarium* database shows that different projects vary considerably in the level of precision used for identifying and orienting. Such variability lies in the heterogeneous vicissitudes of fragment work, with variable goals and times to achieve them. Thus, some scholars work on reconstructions over decades, curating them as new fragments appear, and adjusting them to fit their hypotheses.³⁶ Some researchers focus their attention on working with pieces of the same manuscript in the same collection, and recreate the leaves with attention and care.³⁷ In other cases, reconstructive work becomes

³⁶ See, notably, [F-75ud] the Gottschalk Antiphonal that Lisa Fagin Davis maintains on *Fragmentarium*; L. Fagin Davis, *The Gottschalk Antiphonary: Music and Liturgy in Twelfth-Century Lambach*, Cambridge 2000.

³⁷ E.g., A. Manfredi, *"Fragmenta disiecta et recollecta* da un codice giuridico ora Vat. lat. 15518", *The Vatican Library Review* 2 (2023), 75–86.

part of project workflow aimed at the publication of a large number of fragments in a short period.³⁸

The documentation of these methods aims to help build experience and competence with fragments, reducing the time needed for the initial work of identifying, orienting, and situating the fragments, while producing more accurate results in envisioning the prior whole. The reliability of the extrapolative method can be confirmed by reference to multiple texts of reference, such as editions or other manuscripts, and by using such a method on more complete witnesses.

The investigation of a fragment begins with the material object, and asking the question "what is it?" If it is part of a book, and is a single piece, one must determine whether it is part of a leaf or a bifolium. Then reconstruction begins with the orientation, assigning recto and verso to a leaf, inwards and outwards to a bifolium. Then we can relate fragments from the same manuscript together. A part of a leaf can be used to rebuild the rest; a bifolium can lead to a quire, and even to a model of the original codex. The expression 'finding the prior leaf' has therefore a dual meaning: it can refer to determining the orientation of the bifolium and, by synecdoche, it signifies discovering the previous codex, the one that has left meager remnants, but remnants that can speak a volume about the whole.

Obviously, this discussion has its limitations. Fragments of written material are not limited to manuscript books. Documents, notably charters and letters, often are reused in bindings.³⁹ We also encounter ephemera, printed fragments, and illuminations. These will require their own methods. Moreover, reconstruction of the text only provides one of the contexts for the fragment. For, it should be underscored that, assertions to the contrary notwithstanding, manuscript fragments almost never arise from natural causes.

³⁸ I. Dobcheva and C. Mackert, "Manuscript Fragments in the University Library, Leipzig: Types and Cataloguing Patterns", *Fragmentology* 1 (2018), 83–110, at 90–91, for example, describes a methodology for a summary description of fragments that averaged about four hours per fragment.

³⁹ See most recently, G. De Gregorio, M.L. Mangini, and M. Modesti (eds.), Documenti scartati, documenti reimpiegati. Forme, linguaggi, metodi per nuove prospettive de ricerca, Genova 2023, for a statement of mission and recent studies on documentary fragments.

The circumstances of fragmentation, if known, provide invaluable insight, most obviously on the death of the original object. The knowledge of when and where a binding was made identifies when the recycling of written or printed material occurred, when the work became, in the eyes of its owner, more valuable for its material properties than for the text it transmitted.⁴⁰ The traffic in cuttings,⁴¹ the sales of individual leaves,⁴² or even the last sale of an intact codex prior to its breaking provide likewise an indication when and where the book's value became less than that of the illuminations subsequently cut from their context,⁴³ or of its leaves, sold off as individual examples of calligraphy,⁴⁴ or even as totemic representations of medievalism.⁴⁵ Similarly, the sack of a church,⁴⁶

⁴⁰ Most famously, N.R. Ker, Fragments of medieval manuscripts used as pastedowns in Oxford bindings, with a survey of Oxford binding c. 1515–1620, Oxford 1954, repr. 2000 [2004]; now online as part of the Lost Manuscripts project: https://www.lostmss.org.uk/pastedowns-oxford-bindings-online-poxbo.

⁴¹ R. Wieck, *"Folia Fugitiva*: The Pursuit of the Illuminated Manuscript Leaf", *The Journal of the Walters Art Gallery* 54 (1996), 233–254; A.-M. Eze, "Abbé Luigi Celotti and the Sistine Chapel Manuscripts", *Rivista di storia della miniatura* 20 (2016), 139–54.

⁴² E.g., S. Gwara, "Collections, Compilations, and Convolutes of Medieval and Renaissance Manuscripts in North America before ca. 1900", *Fragmentology* 3 (2020), 73–139.

S. Hindman, M. Camille, N. Rowe, and R. Watson, *Manuscript Illumination in the Modern Age: Recovery and Reconstruction*, Evanston, Il, 2001, 3–45;
 M. Connolly, "The album and the scrapbook", *Florilegium* 35 (2018), 31–51.

⁴⁴ See, e.g., the literature on the biblioclastic work of Otto Ege, especially L. Fagin Davis, "The Beauvais Missal: Otto Ege's Scattered Leaves and Digital Surrogacy", Florilegium 33 (2016), 143–166; and S. Gwara, Otto Ege's Manuscripts: A Study of Ege's Manuscript Collections, Portfolios, and Retail Trade, with a Comprehensive Handlist of Manuscripts Collected or Sold, Cacy, SC, 2013.

⁴⁵ C. De Hamel, *Cutting Up Manuscripts for Pleasure and Profit*, Charlottesville 1996.

⁴⁶ P. Chambert-Protat, "A Seventeenth-Century Treasure Hunter in the Rubble of a Ninth-Century Library. Gathering Fragments and the History of Libraries", *Fragmentology* 1 (2018), 65–81.

Duba

the bombing of a library,⁴⁷ or the visit of a humanist⁴⁸ dates precisely when the surviving written work's context altered permanently. This crucial information provides the point of departure for much of the exciting work in fragmentology, allowing us to use a concrete point of transition to document the changing contexts of human written artifacts over the centuries.

These circumstances also provide important leads for the recovery of other parts of the fragmented objects, their books, their bindings, and even the other works in the libraries and archives they came from. When the binder is known, other leaves from the same book can be recovered.⁴⁹ By tracing down sales records, broken books can be reassembled. Post-fragmentation inscriptions, such as information related to a host volume or the sale of a leaf or cutting, can similarly be used to put the pieces back together.

In short, fragments witness more than books, and provide vast opportunities for exploration. Reconstruction is nothing more than the first step.

⁴⁷ V. Drescher, Chartres – eine fragmentierte Bibliothek. Rekonstruktion des mittelalterlichen Buchbestandes des Klosters Saint-Père-en-Vallée, unpublished Ph.D. thesis, Université de Fribourg, 2022. See also the studies on "Restorations and Investigations on the Burned Manuscripts of the Bibliothèque Municipale de Chartres and of the Biblioteca Nazionale Universitaria di Torino" in the special issue: Scrineum Rivista 17:1 (2020) (https://oajournals.fupress.net/ index.php/scrineum/issue/view/513);

⁴⁸ J. Frońska, "Les Dupuy à Chartres et le plus ancien inventaire des manuscrits à la bibliothèque du chapitre cathédral", Scriptorium 74 (2021), 223–250, at 249; E. Pellegrin, "Membra disiecta floriacensia", Bibliothèque de l'École des chartes 117 (1959), 5–56, reprinted in Bibliothèques Retrouvées. Manuscrits, Bibliothèques et Bibliophiles du Moyen Age et de la Renaissance, Paris 1988, 159–210 (and the literature cited there), documenting fragments from Pierre Daniel's sixteenth-century depredations.

⁴⁹ Or even the lutemaker; see J.-P. Échard and L. Albiero, "Identifying Medieval Fragments in Three Musical Instruments Made by Antonio Stradivari", *Fragmentology* 4 (2021), 3–28.

Appendix: Working with Fragments Digitally: Photogrammetry, Scaling, and Reconstructing leaves

While digitization has revolutionized manuscript studies, digital surrogates only partially communicate the materiality of the objects themselves. In a viewer that automatically displays static images to fit a screen, the relative size of objects disappears along with their feel, the context of their storage, and their dynamic relation to the world. Therefore, it is critical that manuscript material be digitized under controlled conditions that can be repeated, and that every digitization series include reference images, if not reference objects in each image.

These references to the physical world enable the identification of geographically dispersed fragments as coming from the same manuscript and their reunion in virtual reconstructions. In order to put the pieces back together, we need to establish the relation between the physical object and the surrogate, which will allow us to use images to obtain details about the dimensions of the object.

Simple Photogrammetry

Photogrammetry is a sophisticated discipline that has developed over a century and a half and focuses on using photography in the measurement of three-dimensional objects.⁵⁰ While medieval written artefacts are three-dimensional, our representations and discussions often treat them as two-dimensional, and thus makes using photographs to measure these objects much easier than is the case for the more classic uses of photogrammetry, hence the qualification 'simple' photogrammetry.

Using digital images to measure fragments (or manuscripts) involves image viewing or editing software and suitable images. After establishing the suitability of the images, the researcher determines the scale of the image, validates the scale, and then uses the proceeds

⁵⁰ For a commonly-available history of the discipline, see the lecture notes, "Center for Photogrammetric Training", *History of Photogrammetry*, 2008 (<u>https://assets.documentcloud.org/documents/3235835/History-of-Photogrammetry.pdf</u>).

to make measurements using the scale. If the measurements are published, the researcher should specify the method by which they were obtained, and document the precise choices made in obtaining them.

Software

Image viewing or editing software must be capable of measuring the distance in pixels between two points in an image. This basic functionality exists in numerous image suites, including Adobe Photoshop (ruler tool) and the Open-Source GNU Image Manipulation Program (G.I.M.P.) (measurement tool).⁵¹

Suitable images

Not all fragment images are equally suitable for photogrammetry. Either the image should have a reference object in it, such as a ruler, or there should be a reference object in the same series of images. The reference object and the object to be photographed should be flat in the plane of focus, at the same distance from the imaging equipment (camera or scanner). Often, the angle from the surface to be photographed to the camera is not quite 90 degrees, and the result is a distortion in the measurement. With images in a series, attention should be paid to the focal distance. A pastedown in the front of the book, for example, could be significantly closer to the camera than a pastedown in the back. If the ruler used is then photographed at the front of the book, the back pastedown will return a smaller measurement than the front. Finally, camera lenses can distort the image.

Many sub-ideal images can still produce decent measurements. If no proper reference image is at hand, something with known dimensions (such as a standard hole punch for being placed in a binder, or a library stamp) can be used; even the fragment itself, if it was previously measured, can be used as a reference object (as with the example using [Figure 22], above). Any such adaptations, however, should be noted, as well as any mitigating measures.

⁵¹ The distance between a pair of x,y coordinates on a grid can be obtained by applying the Pythagorean theorem: $\sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$.

Determining Scale

The scale is the number of pixels per physical millimeter (px/mm). To arrive at an accurate measurement, take a large measurement and divide. Magnify the image to at least 100% (1 pixel on the screen = 1 pixel on the image) and measure a large part of the reference object. If using a ruler, measure, for example, 10 cm.⁵² Record the number of pixels, then divide that number by the length of the measurement, in our case, by 100 (mm). Record this result as the scale, expressed as:

scale = S pixels per mm

Validate the scale and the image

To the degree possible, measure in pixels reference objects in different parts of the image, divide the results by the scale (S) and compare to the physical measurements. Note any variation.

Measure

Use the ruler or measurement tool to make measurements in pixels on the image, and divide the result by the scale (S) to get the size in millimeters. Record the measurement, along with the method taken, and the likely degree of precision.

Scaling Images

The simple photogrammetry method above derives a scale for each image. Comparison of manuscripts requires images at the same scale. For virtual reconstructions of pages and bifolia, being to scale constitutes a necessary condition.

For any set of images, in suitable image editing software (e.g., G.I.M.P. or Photoshop):

- 1. Establish the scale, as above, for all images (as S1, S2, S3, etc.).
- 2. Note the image with the lowest px/mm value, and record that as Smin. This is the lowest-resolution image, and we will be scaling down all other images to that resolution.
- 3. For each other image

⁵² Not all rulers are equally accurate; Famously, the ruler indications on one of the versions of the popular Digital Colorchecker SG feature a first "centimeter" that is only 9 mm long (see, e.g., the colorchecker on [F-r237])!

Duba

- a. Go to Change Image Size, and select image size by pixels, being sure that "scaled" is selected, so that height and width are changed together.
- b. To determine the target width, multiply the current width in pixels by the ratio of the lowest-resolution image (Smin) to the current scale (Sn):

scaled width = width in pixels × (Sn/Smin)

- c. Enter the scaled width in the width box.
- d. Resize, ensuring that both height and width change. The image is now to scale.

Reconstructing leaves

Occasionally, pieces from the same leaf or bifolium surface. A digital reconstruction of the image becomes desirable. Digital images of the fragments, when taken against a neutral background, allow for them to be removed from the background and placed on the same canvas. These fragments can fall under the same shelfmark, such as [F-f72y] Wien, Österreichische Nationalbibliothek, Cod. 3820 [Figure 30], or they can come from different parts of the world (see, for example, Elizabeth Mullins' contribution to this issue).

- 1. Create a master canvas, either by extending the canvas of a scaled image that already exists, or by creating a new blank canvas. Make it at least twice as big as you think it needs to be. Save it with a unique name.
- 2. Select, cut and paste the fragments onto the master canvas.
 - a. Using the Magnetic Lasso Tool or Magic Wand (Photoshop) or the Fuzzy Select Tool (Gimp), carefully select the fragment, and copy the selection.
 - b. Go to the master canvas, paste in the fragment, move it into place, using rotation and transform (and free transform/distort if necessary) until it fits well.
- 3. When everything is in place, flatten the image/merge the layers. For IIIF viewers such as Fragmentarium, save the reconstruction as a .jp2 JPEG-2000 (Photoshop), or as an uncompressed PNG (G.I.M.P.), which will then require conversion.

mant udean er wafinant an ce popule og mshous tuos ancher. O ome da s pler nibi meme open ma opars esob e very Maurer erte n no em anon racan 01 10 01 ou 11 manaonauaen imer plagae moula 1 in uermente f adarosu 011 oaic la o et u un puere muter anniata nhe nandi; etlaceros aer nun nun Puens al collina igna ueu umc auto onunana esta manana mn nar auh taur nulla 6 Ginns. ro tam Date soun n. raams ea ns onoum dan aun aresmist mpu eca uni w. nor un nro gun 1111411 n Dun T ler un.ne ansit ean n urin

Figure 30: [<u>F-f72y</u>] Wien, Österreichische Nationalbibliothek, Cod. 3820, f. Bv. Digital Reconstruction by V. Drescher.



DOI: 10.24446/j9en