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Manuscript Studies

Volume 3
Issue 1 *The Syriac Galen Palimpsest*

Article 3

5-9-2019

The Codicology and Conservation of the Syriac Galen Palimpsest

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The Codicology and Conservation of the Syriac Galen Palimpsest

Abstract
Disbinding the Syriac Galen Palimpsest to allow for more successful imaging also permitted conservators to examine the codicology and binding of the palimpsest, the quality of its parchment, and the chemistry of its inks. Both the upper and lower texts were found to have iron gall black inks. The red ink in the Galen text was identified as red lead mixed with cinnabar or vermilion, while the red ink in the liturgical text was identified as cinnabar or vermilion alone. The leaves of the manuscript were coated with chalk according to Syriac tradition. The binding, which was probably applied at St. Catherine's Monastery, retained evidence of both Syriac and Greek binding elements, including heavy endbands, reinforced headcaps, chain-stitch sewing, wide fabric spine linings, book markers, and interlaced fastening straps. During conservation treatment, conservators released leaves that were adhered in the gutter, mended edge tears and losses in the parchment, reduced adhesive residues, and consolidated flaking inks resulting from water damage. At the request of the palimpsest's owner, the book was rebound after imaging. The repaired quires were sewn over a paper concertina to protect the parchment from adhesives and to make the binding readily reversible. The volume was provided with new fabric spine linings, plain endbands, and a new leather spine that maximized visibility of the earlier binding features.

Keywords
parchment, ink, bookbinding, Syriac, palimpsest, chalk, conservation, rebinding, consolidation, coating, codicology

Manuscript Studies

A Journal of the Schoenberg Institute for Manuscript Studies

VOLUME 3, NUMBER 1
(Spring 2018)

Manuscript Studies (ISSN 2381-5329) is published semiannually
by the University of Pennsylvania Press

The Schoenberg Institute for Manuscript Studies
University *of* Pennsylvania Libraries

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VOLUME 3, NUMBER 1

Special Issue:
The Syriac Galen Palimpsest
Editors: William Noel and Ralph M. Rosen

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The Codicology and Conservation of the Syriac Galen Palimpsest

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The Codicology of the Galen Manuscript

Despite the erasure of the ninth-century Syriac copy of Galen's *On Simple Drugs*, and the loss of approximately one-third of its folios, the palimpsest derived from it retains significant evidence of the materials and techniques used in the production of the original manuscript.

The parchment's hair follicle pattern and other characteristic features have allowed it to be identified as sheepskin.[1] This is not surprising, since during this period in Mesopotamia sheep were an important source of food (milk and meat) and fiber (for wool- or hair-based textiles), and their flayed hides would have been processed into leather as well as parchment.[2] Sheep-

1 Sheepskins are thinner and spongier than the skins of goats or calves, and weak areas can spontaneously rupture and delaminate while drying under tension on the frame. This defect, unique to sheepskin parchment, is seen throughout the palimpsest.

2 The primitive breeds of sheep that would have lived in these regions were more like goats than modern sheep, and their coats were generally hairy rather than wooly; see Claire Chahine, *Cuir & Parchemin ou la Métamorphose de la Peau* (Paris: CNRS Editions, 2013), 47–50.

skin parchment was widely used in the production of early Greek and Arabic manuscripts, and it also seems to have been the predominant writing support for early Syriac manuscripts.[3]

The quality of the parchment used for the Galen manuscript is mediocre at best. There are many knife marks from flaying, natural holes and scalloped edges from the animals' legs, uneven patches of scar tissue, and horny, translucent areas throughout the entire manuscript (fig. 1). In addition, the flesh side is rough and fibrous, and the roots of brown hairs remain in the follicles on the grain side. The thickness of the parchment ranges from 0.10 to 0.36 millimeters, with an average thickness per folio of 0.21 millimeters. While other Syriac manuscripts Abigail Quandt has examined have parchment of a similar thickness, the quality of their skins is noticeably better, with relatively few defects.[4]

Recent scholarship has determined that the eleven books of the medical treatise occupied approximately 220 folios or 110 bifolia that were arranged into a minimum of twenty-two quires of ten bifolia each.[5] It is difficult to reconstruct the original dimensions of the folios, given the shrinkage of the parchment, which might have occurred during palimpsesting and also later on, as a result of water damage to the secondary manuscript. While

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3 All seven manuscripts that were recycled to make the Archimedes Palimpsest were written on sheepskin parchment; see Abigail B. Quandt, "The Making of the Euchologion," in *The Archimedes Palimpsest, Catalogue and Commentary*, ed. R. Netz, W. Noel, N. Wilson, and N. Tchernetska, 2 vols. (Baltimore: Walters Art Museum; Cambridge: Cambridge University Press, 2011), 1:81–96 at 82. For the use of sheepskin parchment for Arabic manuscripts, see Yasmeen Kahn and Sophie Lewincamp, "Characterization and Analysis of Early Qur'an Fragments at the Library of Congress," in *Contributions to the Symposium on the Care and Conservation of Middle Eastern Manuscripts, The University of Melbourne, Australia, 26–28 November 2007* (Melbourne: Centre for Cultural Materials Conservation, 2008), 55–65 at 62–63. Four Syriac codices at the Pierpont Morgan Library and Museum (M.783, M.784, M.236, and M.235), dated from the sixth to the early-thirteenth centuries, and a fifth manuscript at the Walters Art Museum (W.550), which was recently radiocarbon dated 1041 CE to 1202 CE with 95 percent confidence, all appear to be written on sheepskin parchment.

4 The five manuscripts from the Morgan Library and the Walters Art Museum are all liturgical texts, so it is likely that a superior quality of parchment was selected for their production.

5 Naima Afif, Siam Bhayro, Grigory Kessel, Peter E. Pormann, William I. Sellers, and Natalia Smelova, "The Syriac Galen Palimpsest: A Tale of Two Texts," in this issue.

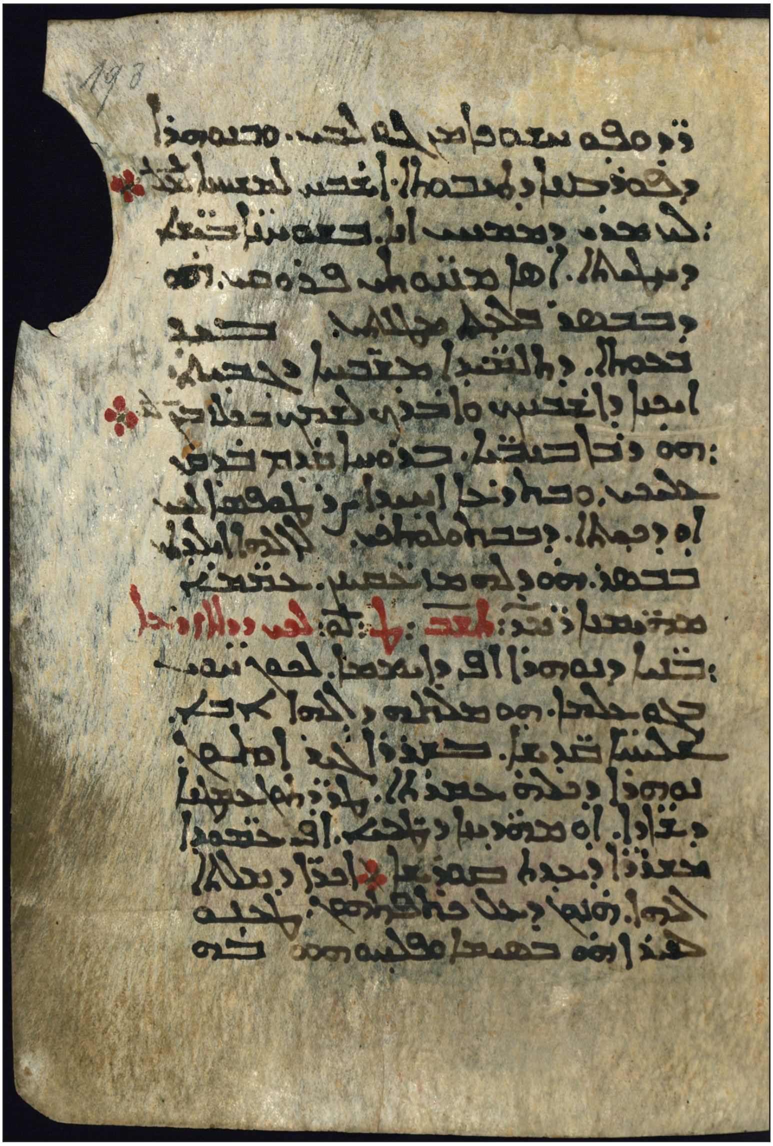

FIGURE 1. The defects in this folio include the scalloped profile of the animal's leg, areas of translucency along the fore edge, and a coarse surface texture. These would have largely been obscured by the thick chalk coating that now remains only in the upper left corner of the folio (folio 193r).

the sewing and endband stations made for the Galen codex are preserved to some extent along the bottom edges of many folios of the palimpsest, there is evidence of trimming along most of the outer three edges.[6] Assuming that three to five millimeters were trimmed off during the initial binding and later rebinding of the Syriac Galen Palimpsest (SGP), the Galen folios may have measured approximately 246 × 172 millimeters.[7] These dimensions fall within the size range of a group of 291 Syriac manuscripts dated from the fifth to the sixteenth centuries, which measure from approximately 200 × 130 millimeters to 280 × 200 millimeters.[8] If two to three bifolia were cut from a single skin, about thirty-seven to fifty-five sheepskins were used in the production of the medical manuscript.

It has been observed that the quires of Syriac manuscripts were made by cutting the bifolia individually from a single skin and not by folding the skin and then cutting it into units of two or four, a practice that was common for manuscripts produced in northwestern Europe.[9] The former system may have been necessary due to a wide variation in the sizes of skins that were available to Syriac scribes. Given the inferior quality of the parchment found in many Syriac manuscripts, it also may have been more economical to cut the bifolia out of the skins individually, so as to avoid defective areas that were unusable.[10]

The gatherings of Syriac manuscripts usually did not follow Gregory's Rule in matching like sides of the folios at every opening. This practice,

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6 Depending on the extent of trimming, the depth of the V-cuts (four for the sewing and two for the endbands) varies considerably. Many of the cuts are barely visible, but can still be identified given their location.

7 These calculations are based upon the dimensions of the largest bifolio of the SGP, which was found to be 256 × 178 mm.

8 Pier Giorgio Borbone, Françoise Briquel-Chatonnet, and Ewa Balicka-Witakowska, "Syriac Codicology," in *Comparative Oriental Manuscript Studies: An Introduction*, ed. A. Bausi (Hamburg: COMSt, 2015), 252–66 at 258.

9 Borbone, Briquel-Chatonnet, and Balicka-Witakowska, "Syriac Codicology," 255.

10 Byzantine craftsmen, limited by the availability of skins of consistent size and quality, demonstrated a similar economy in the preparation of their quires that was compelled primarily by a desire not to waste valuable parchment. Marilena Maniaci, "Greek Codicology," in *Comparative Oriental Manuscript Studies: An Introduction*, ed. A. Bausi (Hamburg: COMSt, 2015), 187–207 at 196.

which is also seen in early Arabic manuscripts on parchment, remains unexplained. However, a feature that seems to be characteristic of Syriac manuscripts is a thick, white coating applied to the parchment surface before writing.[11] This coating made the hair and flesh sides look identical and thus would eliminate the need to pair them across every opening. Specialists who study these manuscripts are aware of this coating, yet it is not mentioned in any extant Syriac recipes and has not been described in print by either scholars or scientists.[12] It was probably applied to the individual bifolia rather than to the whole animal skin before it was cut up.[13] While a coating was likely present on the parchment of the primary manuscript, it would have been removed along with the ink during the production of the SGP.

Prick marks in Syriac manuscripts were made at the four corners of the written space, whether in one column or two. Prickings for the layout of the medical text have not been found, either because they were trimmed off or because the holes were filled with the thick coating associated with the upper text and are no longer visible. It has been speculated that the horizontal and vertical bounding lines for the two columns of the medical text

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11 Parchment coated with lead white has been documented in a group of early fourteenth- to early fifteenth-century Greek manuscripts produced or repaired at the scriptorium of the Hodegon monastery in Constantinople. Despite this coating, the quires of new manuscripts were always assembled according to Gregory's Rule. E. N. Dobrynina, "The Greek illuminated New Testament with the Psalter at the State Historical Museum in Moscow, Syn. gr. 407 (Vlad. 25)," in *New Testament with the Psalter: Greek Illuminated Manuscript at the State Historical Museum in Moscow: Collected articles,* ed. E. N. Dobrynina (Scanrus: Moscow, 2014), 35–46.

12 In a technical study of four miniatures in the sixth-century Rabbula Gospels, calcium was detected with X-ray fluorescence (XRF) in the blank margins and attributed to a treatment that the parchment received during the preparation of the surface, or to the presence of residual alkalis from the dehairing of the raw skins; see Giancarlo Laterna, Marcello Picollo, and Bruno Radicati, "Le indagini scientifiche non invasive sull'evangelario," in *Il Tetravangelo di Rabbula, Firenze, Biblioteca Medicea Laurenziana, Plut. I.56, l'Illustrazione del Nuovo Testamento nella Siria del VI Secolo*, ed. M. Bernabò (Rome: Edizioni di Storia e Letteratura, 2008), 135–44 at 141.

13 There would be less waste and also less chance of damaging the thick coating if it were applied to the bifolia rather than to the entire skin.

were executed in metal point, yet they are no longer present.[14] These lines would have been drawn on top of the presumed coating, which was later erased.

Iron gall ink was the predominant writing ink used in both the east and west from at least the late antique period until the introduction of steel pens in the nineteenth century.[15] Iron gall ink was easy to prepare and use, and most importantly, it was more permanent than all other black inks.[16] The ink typically contained four main ingredients: a source of tannin (usually an extract of crushed gall nuts), a natural iron salt such as iron (II) sulfate (usually referred to as vitriol), wine or vinegar, and an adhesive such as gum arabic. Hundreds of recipes for iron gall ink survive from the medieval period, many with regional variations in the ingredients. Seventeen recipes that mention vitriol have been found in Syriac manuscripts, with the oldest dated to the ninth or tenth century.[17]

Until now, the scientific investigation of black writing inks in Syriac manuscripts has been limited to a single study from 2005, in which iron gall ink was identified in the marginal text of a miniature in the sixth-century Rabbula Gospels.[18] Recently, the analysis of both inks of the erased under-

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14 Given the absence of any bounding lines for the medical text, they are assumed to have been made with metal point rather than with a stylus, since blind ruling would still be visible even after palimpsesting. Natalia Smelova, personal communication, 2017.

15 Christoph Krekel, "The Chemistry of Historical Iron Gall Inks: Understanding the Chemistry of Writing Inks Used to Prepare Historical Documents," *International Journal of Forensic Document Examiners* 5 (1999): 54–58 at 55.

16 In a fifteenth-century recipe for iron gall ink written by Jehan le Bégue, the author states: "And note, that ink made with wine is good for writing books on the sciences, because, when books are written with it, the letters do not fade, and can hardly be scraped out or discharged from parchment or paper." See Mary P. Merrifield, *Original Treatises, Dating from the XIIth to XVIIIth Centuries on the Arts of Painting, in Oil, Miniature, Mosaic, and on Glass; of Gilding, Dyeing and the Preparation of Colours and Artificial Gems; Preceded by a General Introduction; with Translations, Prefaces, and Notes. By Mrs. Merrifield*, 2 vols. (London: J. Murray, 1949), 1:68.

17 Jimmy Daccache and Alain Desreumaux, "Les textes des recettes d'encres en syriaque et en *garshuni*," in *Manuscripta Syriaca: Des sources de prèmiere main,* Cahiers d'études syriaques 4, ed. F. Briquel Chatonnet and M. Debié (Paris: S.N. Librairie Orientaliste Paul Geuthner S.A., 2015), 195–246 at 198.

18 Iron was detected during XRF analysis of a black writing ink in the margin of a miniature in the Rabbula Gospels, indicating the presence of iron gall ink; see G. Lanterna, M. Picollo,

FIGURE 2. The black ink of both the erased medical text and the liturgical text was identified as iron gall ink. The red ink used for the section numbers of the lower text was found to be red lead, mixed with a very small amount of vermilion, while the red ink of the upper text was identified as vermilion (detail of folio 212v).

text of the SGP was carried out with X-ray fluorescence (XRF).[19] Three sites on two folios were analyzed, and although the signal was very weak, the trace amount of black ink that remained indicated that it is iron-rich, suggesting the presence of an iron gall ink (fig. 2).[20] Traces of copper seem to

and B. Radicati, "Le indagini scientifiche non invasive sull'evangelario," in *Il Tetravangelo di Rabbula. Firenze, Biblioteca Medicea Laurenziana, plut. 1.56: L'illustrazione del Nuovo Testamento nella Siria del VI secolo*, ed. Massimo Bernabò (Rome: Edizioni di Storia e Letteratura, 2008), 144.

19 The Elio XRF spectrometer, manufactured by XG Labs S.r.l. (now part of Bruker) was used, off site, at 40 kV, 80 microA, 120 seconds without purge or filters. A total of fourteen spots were analyzed, including areas of blank parchment adjacent to the black and red inks. Glenn Gates, conservation scientist at the Walters Art Museum, conducted the analysis and provided the data for this article.

20 One area of black lower text ink on folio 223v and two areas on folio 212v were analyzed.

be present as impurities in the black ink, while zinc was not reliably detected as a trace element.[21]

Medieval Syriac recipes provide no information on colored inks, and in only one case has analysis been undertaken, so there has been considerable speculation about the red inks that are so ubiquitous in Syriac manuscripts.[22] The bright red ink that was used for section numbers in the margins of the Galen manuscript is surprisingly well preserved, despite having been erased. Recent XRF analysis of the ink indicated lead as a major constituent with traces of mercury, suggesting the presence of the red lead pigment minium (Pb_3O_4), mixed with a very small amount of mercury (II) sulfide (HgS) from the mineral cinnabar or the pigment vermilion (see fig. 2).[23]

The Creation of the Palimpsest

Among the surviving Syriac manuscripts from the Black Mountain monastic community near Antioch, whose origins can be confirmed either by their colophons or on the basis of paleography, no other palimpsests have yet been identified.[24] Given its pagan origins, a Syriac translation of Galen's

21 Historic iron (II) sulfate was typically contaminated with many impurities, including copper and zinc; see Krekel, "The Chemistry of Historical Iron Gall Inks," 55. In addition to iron, copper was detected in the black writing ink on folio 14a of the Rabbula Gospels; see Lanterna, Picollo, and Radicati, "Le indagini scientifiche non invasive sull'evangelario," 144.

22 A red pigment used for the rubrics of a Byzantine-Syriac Gospel-Lectionary was identified as vermilion with Raman spectroscopy; see Robin Clark and Peter Gibbs, "Raman Microscopy of a 13th-century Illuminated Text: A Study of a Rare Manuscript Demonstrates a Promising Technique for the Non-destructive in situ Analysis of Historical Artifacts," *Analytical Chemistry* 70/3 (1998): 99A–104A at 101A. For the use of red inks in Syriac manuscripts, see Alain Desreumaux, "Des Couleurs et des Encres dans les Manuscrits Syriaques," in *Manuscripta Syriaca: Des sources de première main*, Cahiers d'études syriaques 4, ed. F. Briquel Chatonnet and M. Debié (Paris: S.N. Librairie Orientaliste Paul Geuthner S.A., 2015), 161–93 at 162–64.

23 It is less likely, but the presence of lead in the ink could be attributed to a lead-based white pigment that was mixed with cinnabar or vermilion, but the color of the areas that were analyzed seems more consistent with the use of red lead. Identical results were obtained for the red undertext ink on both folios 173v and 212v.

24 Natalia Smelova, personal communication, 2017.

On Simple Drugs would have been of little use to a community of monks. However, it would have been a ready source of parchment for a much-needed book of hymns, and it was just the right size.[25] We can only speculate on the circumstances that compelled the disassembly of the medical text, especially if this was a rare occurrence.[26]

Approximately two-thirds of the medical treatise was used to make the liturgical book. While fourteen quires were recycled, one quire from the middle of the manuscript, three from the beginning, and approximately four quires from the end were not used.[27] This evidence leads us to suggest that the Galen manuscript was defective from the outset, with a broken binding that allowed the middle quire to become detached. The folios at the front and back, as well as the remaining twenty-four unused folios from throughout the earlier codex, may have also been missing or were too damaged to be reused.

For practical reasons, it is likely that the text of the Galen manuscript was erased while the bifolia were still intact. According to a few surviving late medieval recipes, the process was relatively simple and also quite gentle, as it did not damage the parchment in any way.[28] The application of weakly acidic ingredients such as lemon juice or milk, or alkaline materials like calcium hydroxide obtained from burnt eggshells, would make the iron gall ink water-soluble and allow it to be wiped off the parchment surface.[29] To prevent the parchment from shrinking or becoming distorted, the damp

25 To preserve valuable parchment, a palimpsest was often made from a manuscript that was approximately twice the size of the new book so that, when the bifolia were divided and each folio was rotated 90 degrees, the written space of the latter would overlap that of the former and little trimming would be needed.

26 We can hypothesize that the monastery experienced a temporary interruption to its regular supply of skins, perhaps due to a period of severe weather or disease that reduced the size of the flocks and forced them to use recycled parchment for this hymn book.

27 Afif et al., "The Syriac Galen Palimpsest."

28 The Galen text was likely written on top of a surface coating, and both would have been erased. However, traces of the undertext ink survive because it penetrated the coating and the top layer of parchment when first applied.

29 Two medieval palimpsesting recipes are cited, and the chemistry of the erasing process is described in Quandt, "The Making of the Euchologion," 84–85.

sheets were put under weight or nailed to a board as they dried.[30] Additional treatments included rubbing the surface with a pumice stone or with powdered chalk.[31] After the parchment had been cleaned, the sheets were cut down the middle, and the Galen folios were rotated 90 degrees to make the bifolia for the new manuscript.

The practice of coating the bifolia with an opaque, white substance before writing, as described above, seems to be a characteristic feature of Syriac manuscripts and was not reserved for the making of palimpsests.[32] The coating on most folios of the SGP is still relatively intact despite considerable water damage and abrasion to the surface (see fig. 1). Small samples of this crusty layer were removed for analysis from the blank margins of folios 193r and 196r. Initial micro-chemical testing with sulfuric acid produced a gas, suggesting the presence of carbonates. Under polarized light magnification, high birefringence and extinction were observed, consistent with calcium carbonate. Each sample was then analyzed with Fourier transform infrared spectroscopy (FTIR) and identified as calcium carbonate or chalk.[33] Further analysis using other techniques should indicate if an adhesive such as egg white or glue was mixed with the chalk.[34] The coating appears quite shiny on many folios, and this could be due to burnishing or to the application of a thin layer of egg

30 The bifolia of two of the primary manuscripts used to make the Archimedes Palimpsest were dried under tension after the text was erased; see Quandt, "The Making of the Euchologion," 86–87.

31 Powdered chalk continues to be used used by parchmenters to draw grease from the flesh side and whiten the naturally yellow hair side. A thin, chalky substance on the Archimedes Palimpsest folios was probably used to cover residues of the erased texts; see Quandt, "The Making of the Euchologion," 88.

32 A thick, white surface coating was also observed in the five Syriac manuscripts recently examined by Quandt (see note 3).

33 FTIR analyses were performed using a Bruker Optics Tensor 20 spectrometer coupled to a Hyperion 2000 microscope, with the sample crushed between diamond, and analyzed with 256 scans in transmission at 4 $cm^{-}1$ resolution from 4000 cm to 600 cm.

34 The FTIR signal generated by the calcium overwhelmed any signal that might have been produced by an organic binder, so other analytical methods will have to be considered in an effort to identify adhesives that might be present in the chalk coating.

white over the chalk, following a practice more typical for Byzantine manuscripts (see fig. 1).[35]

The twenty-nine gatherings of the SGP are made up of four bifolia per quire. Some follow Gregory's Rule, while others have opposite sides facing at every opening, but typically the two systems are mixed within a single quire.[36] Originally conjoint folios of the medical text were not kept together, but instead were scattered throughout the liturgical book.[37] Despite this seemingly random arrangement of the gatherings, one interesting feature stands out. Most of the folios of the medical manuscript were positioned with their original gutter along the bottom edge of the new codex. Of the nine folios that were positioned with the gutter along the top edge of the palimpsest, three ended up in the same quire.[38]

Once the blank bifolia were formed into gatherings, they may have been temporarily secured with quire tackets.[39] These are loops of thin thread that pass through the centerfold and around the top or bottom of the quire, or small stitches that are sewn through the centerfold, typically in two locations. Quire tackets have been documented in Greek manuscripts, and at least two examples have been found in Syriac manuscripts.[40] Although

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35 Historically, a thin coating of egg white and flax seed mucilage is said to have been applied to the parchment folios of Byzantine manuscripts. Although egg white was confirmed and a carbohydrate, possibly from flax seed, was suggested during the analysis of parchment samples from five Byzantine manuscripts, the techniques that were used at that time are no longer considered reliable; see Vilena Kireyeva, "Examination of Parchment in Byzantine Manuscripts," *Restaurator* 20, no. 1 (1999): 39–47.

36 Afif et al., "The Syriac Galen Palimpsest."

37 The formerly conjoint folios of the original Archimedes manuscript were usually kept together as the quires of the prayer book were formed; see Quandt, "The Making of the Euchologion," 89.

38 These are fols. 102–7, 103–6, and 104–5.

39 It has been suggested that scribes working in the eastern Syriac tradition may have written on quires that were already made up but not yet sewn into a codex; see Borbone, Briquel-Chatonnet, and Balicka-Witakowska, "Syriac Codicology," 257.

40 For quire tackets in Greek manuscripts, see Guy Petherbridge, "Sewing Structures and Materials: A Study in the Examination and Documentation of Byzantine and Post-Byzantine Bookbinding," in *Paleografia e Codicologia Greca, Atti del II Colloquio Internazionale (Berlino-Wolfenbüttel, 17–21 ottobre 1983)*, ed. Dieter Harfinger and Giancarlo Prato, 2 vols. (Alexandria: Edizioni dell'Orso, 1991), 1:363–408 at 376–77, and Quandt, "The Making of the Euchologion,"

this is not yet confirmed, the quires of the SGP were most likely held together with tackets that stayed in place until the manuscript was bound.

After pricking the four corners of the writing area, the bounding lines for the single column of text were blind ruled with a stylus. When copying from his exemplar, however, the scribe did not always stay within the prescribed area and often wrote one or two lines of text above or below the horizontal bounding lines. As a result, the text varies from eighteen to twenty-three lines per page. The boundaries of the left and right margins were sometimes ignored as well, and the text extended beyond the vertical lines.[41] As was normal for Syriac manuscripts of this period, there are no horizontal ruling lines to guide the writing of the text.

The black and red inks of the upper text on three folios were analyzed with XRF.[42] The black ink was found to be iron-rich, suggesting an iron gall ink, with traces of copper and zinc (see fig. 2).[43] The red ink used for rubrication was identified as mercury (II) sulfide (HgS), which is derived from the mineral cinnabar or the pigment vermilion (see fig. 2).

The Palimpsest Binding

The palimpsest would have been bound in the Syriac style in the eleventh century, yet it is doubtful that any of those original elements survive today in the present binding. By the time the SGP arrived at St. Catherine's Monastery in the twelfth or thirteenth century, the codex was likely in poor condition from regular use and may already have been rebound. Over the course of the following seven hundred years in the Sinai, at least one and

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89–90. For quire tackets in Syriac manuscripts, see Youssef Dergham and François Vinourd, "Les reliures Syriaques: essai de caractérisation par comparaison avec les reliures Byzantines et Arméniennes," in *Manuscripta Syriaca: Des sources de prèmiere main*, Cahiers d'études syriaques 4, ed. F. Briquel Chatonnet and M. Debié (Paris: S.N. Librairie Orientaliste Paul Geuthner S.A., 2015), 271–304 at 284.

41 Afif et al., "The Syriac Galen Palimpsest."

42 The black ink on folios 220v and 223v and the red ink on folios 220v and 217v were analyzed.

43 Traces of copper and zinc were found in both areas of black ink that were analyzed.

FIGURE 3. The Syriac binding of the palimpsest was resewn and rebacked with a new leather spine in the early twentieth century. The handwritten gilt title in English was probably added more recently to the spine.

possibly two more phases of restoration took place. By the late nineteenth century, when the SGP is thought to have been brought to Europe, it had suffered from neglect and was missing many folios. It was subjected to yet another campaign of restoration using Western materials and techniques (fig. 3). Despite this modern intervention, we can reconstruct with some confidence the structural features of the Syriac binding, which was very similar to the bindings of Greek, Georgian, and other Syriac manuscripts that remain today in the library at St. Catherine's.[44]

The vertical-grain boards, made to the same dimensions as the book block, are approximately 13 millimeters thick and shaped only at the spine

44 From 2001 to 2006, under the sponsorship of Camberwell College of Arts and the direction of Nicholas Pickwoad, a condition survey was undertaken of the manuscripts at St. Catherine's Monastery. This survey, which included 266 Syriac manuscripts, recorded detailed information about the bindings and evidence of their past restoration.

edge.[45] The species of the wood has not been identified.[46] A series of holes was drilled along the inner edges of the boards to receive the sewing thread and, later, the endband sewing thread. Two sets of holes were made near the fore edge of the lower board for the leather straps, while single holes were made in the edge of the upper board for the metal pins to which the straps would be fastened. Finally, a single hole was drilled near the fore edge of each board for the leather board strap markers (fig. 4).

A vertical crack in the middle of the lower board was repaired at least two times, once with a length of cord threaded through holes made on either side of the crack and then with a strip of recycled parchment pasted to the inside of the board (see fig. 4).[47] The poor condition of the board, and its later repairs, indicates that it was reused more than once, and pre-dates the present leather cover.[48]

Three shallow V-shaped notches were made in the spine folds of the gatherings at evenly spaced positions or sewing stations.[49] The heavy two-

45 These boards are outside the average thickness of four to six millimeters that was recorded for the Syriac bindings in the Patriarchal Library of Charfet, Libya; see Dergham and Vinourd, "Les reliures Syriaques," 276.

46 The woods used for the binding of an eighteenth-century Syriac manuscript at the Bibliothèque nationale de France have been identified as walnut for the upper board and elm for the lower board; see Fabrice Belliot, "Restauration et description de la reliure du manuscript syriaque 432 (XVIIIe siècle)," in *La Restauration à la Bibliothèque nationale de France: Manuscrits, monnaies, reliures, photographies, estampes,* ed. O. Walrave (Paris: Bibliothèque nationale de France, 2003), 71–84 at 74–76.

47 While the waste parchment that was used on the inside of both the upper and lower covers of the binding contains fragments of Syriac writing, none of it has been studied or identified.

48 Wood was a precious material, especially in the Sinai, and it was common for broken boards to be repaired so they could continue to be used; see Georgios Boudalis, "The Transition from Byzantine to Post-Byzantine Bookbindings: A Statistical Analysis of Some Crucial Changes," in *Book and Paper Conservation,* vol. 2, ed. J. Vodopivec Tomažič (Ljubljana: Arhiv Republike Slovenije, 2016), 12–29 at 15. See also Andrew Honey and Athanasios Velios, "The Historic Repair and Reuse of Byzantine Wooden Bookboards in the Manuscript Collection of the Monastery of St Catherine, Sinai," in *Holding It All Together: Ancient and Modern Approaches to Joining, Repair and Consolidation,* ed. J. Ambers, C. Higgitt, L. Harrison, and D. Saunders (London: Archetype, 2009), 68–77.

49 V-notches were not observed in any Syriac bindings during a survey of American collections; see Sylvie L. Merian, "The Armenian Bookmaking Tradition in the Christian East: A

FIGURE 4. The remains of the two interlaced leather straps and central leather board strap marker, as well as Syriac manuscript waste used to repair the vertical crack, are seen inside the lower board of the binding.

ply sewing thread, which was more like a thin cord, would later be recessed in these notches and give a smooth appearance to the spine of the book. The book block was sewn with a chain stitch using one needle and a single

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Comparison with the Syriac and Greek Traditions," in *The Bible as Book: The Manuscript Tradition*, ed. J. L. Sharpe III and K. van Kampen (London: The British Library & Oak Knoll Press, 1998), 205–14 at 207. However, V-notches were seen in most Syriac manuscripts at St. Catherine's Monastery; Georgios Boudalis, personal communication, 2017.

length of thread. In this method of unsupported sewing, a sewing frame is not employed, and there are no cords or thongs that serve as sewing supports for the quires. In the case of the SGP, the thread was first looped through the holes in the upper board in a modified zigzag pattern (fig. 5).[50] The thread was then passed through the quires, which were sewn together one after another, and the lower board was finally attached by lacing the thread through the holes along its spine edge.[51]

It was typical for Syriac bindings to have anywhere from two to five fabric linings that helped to consolidate the spine and reinforce the attachment of the boards. A variety of plain-weave textiles, often brightly colored, were used. The fabric was glued to the spine of the book block and then lapped over each of the boards. Remnants of textile linings can be seen along the spine edges of the boards and felt on the outside, where they extend almost halfway across the board face (figs. 6a and 6b).

After the linings were adhered, compound endbands were sewn at the head and tail of the book, helping to consolidate the chain-stitch sewing of the book block. While nothing survives of the earlier Syriac endbands save a few fragments of plain and colored thread, they would have been made up of two components. A primary structural endband was sewn with a needle and a thick, plain thread, starting on one board and ending on the other. The thread passed through the spine linings, into the center of each quire, and then wrapped over the core at the head edge. The core consisted of a piece of cord or a rolled extension of one of the spine linings. The secondary decorative endbands appear to have been sewn with blue, white, and pink silk threads over the warps of the primary endband. Diagonal twined endbands, which created a chevron pattern, have been regularly found on Syriac bindings, and this is likely the type of secondary endband last sewn on the binding of the SGP.[52]

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50 The five methods of board attachment said to be standard for Syriac bindings are all straight-line patterns; see Dergham and Vinourd, "Les reliures Syriaques," 281 and table 2. However, the same oblique lacing pattern seen in the boards of the SGP has been recorded in at least one Syriac binding at St. Catherine's; Georgios Boudalis, personal communication, 2017.

51 The unsupported chain-stitch sewing that is typical of Syriac bindings is described and illustrated in Dergham and Vinourd, "Les reliures Syriaques," 284–85.

52 Georgios Boudalis, "Twined Endbands in the Bookbinding Traditions of the Eastern Mediterranean," postprints for the International Conference "Men and Books: from Microor-

FIGURE 5. The thick sewing thread, attached in a modified zigzag pattern, and skinned remnants of Syriac manuscript waste used for earlier pastedowns, are seen inside the upper board of the binding.

An unusual feature of both Syriac and Georgian bindings from St. Catherine's Monastery is called a preliminary headcap.[53] Its purpose was to enhance the volume of the endbands and to increase their visual impact. The preliminary headcap consisted of a wide piece of textile or leather,

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ganisms to Mega-Organisms," St. Hypollit, Austria, 28 April–1 May 2014 (forthcoming).

53 The information on preliminary headcaps, which was provided by Georgios Boudalis, is based upon his research on endbands in Eastern Mediterranean binding traditions, which will soon be published. Boudalis, personal communication, 2017.

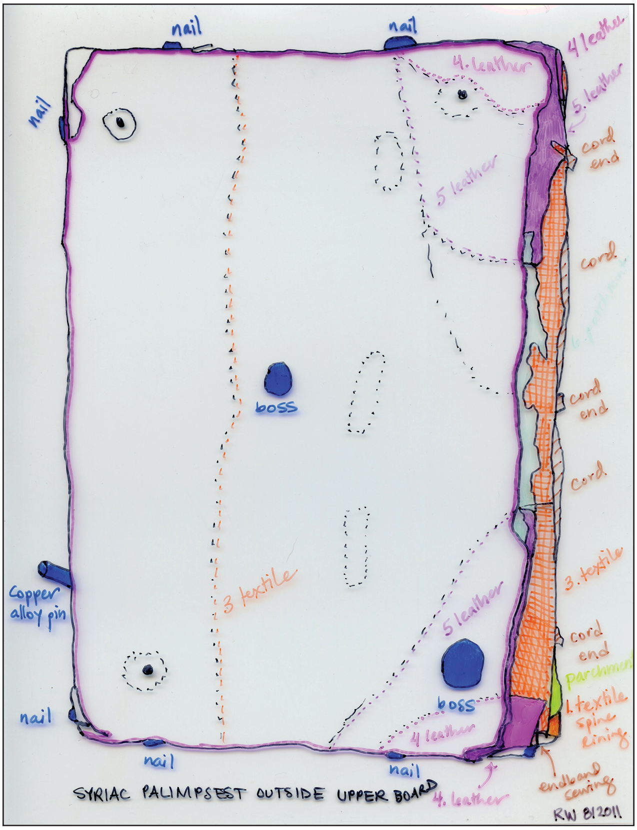

FIGURE 6A. A tracing of the exterior of the upper board shows the location of the textile spine linings that extend across the board, large remnants of preliminary leather headcaps near the spine edge, the remains of five white metal bosses and nails, and a single copper alloy pin at the fore edge.

folded around a cord core, which was positioned at the head or tail of the spine and wrapped around to the outer faces of the boards. Large pieces of leather located under the cover at the head and tail ends of both boards may be the remains of preliminary headcaps that were once a feature of the Syriac binding (see figs. 6a and 6b).[54]

54 At least four large pieces of leather probably remain from preliminary headcaps along the spine edge of each board. While one pair is likely contemporary with the present leather cover, the remnants of another pair remain in place from an earlier restoration of the binding.

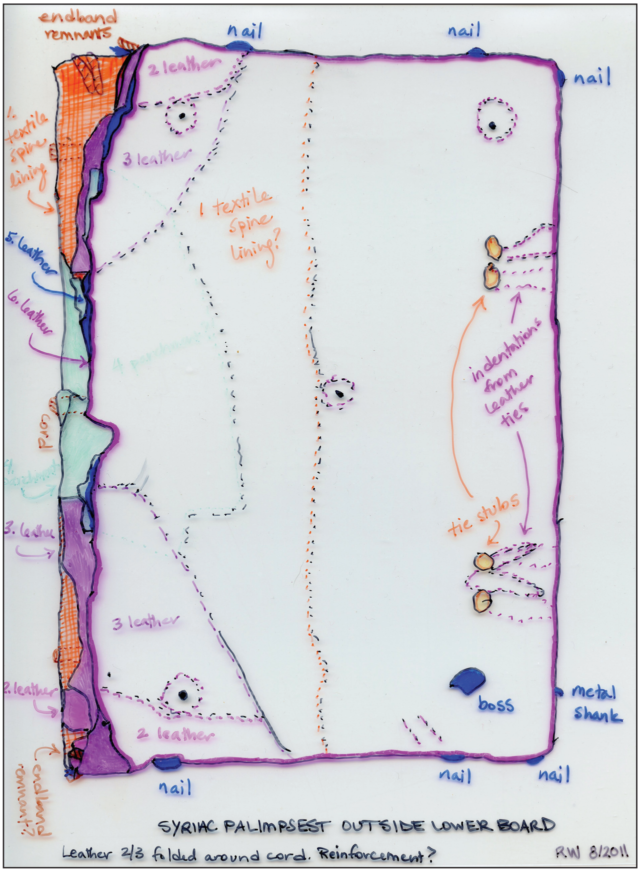

FIGURE 6B. A tracing of the exterior of the lower board shows the location of the textile spine linings, endband tie-downs at either end of the spine edge, remnants of preliminary leather headcaps on the board face near the spine, and remnants of two interlaced leather straps at the fore edge.

Once the preliminary headcaps had been worked, the binding could be covered with leather, forming heavy final headcaps at the head and tail of the spine. A common feature of both Syriac and Armenian bindings at St. Catherine's is a cap core, which served to enhance the already prominent endbands at the head and tail.[55] The cap core was a thin piece of cord that

55 Boudalis, personal communication, 2017.

was inserted into the fold of leather forming the cap as it was turned in at the head and tail of the spine. In the SGP, long pieces of tightly wound cord that protrude from the turn-ins on both boards are probably the extensions of cap cores that are now missing, along with the spine leather of the binding (see figs. 4 and 5).

In addition to the remnants of the cap cores, the lower board retains the ends of two triple interlaced leather straps, which exit through holes in the board and the leather cover at the fore edge (see fig. 4). The extensions of these straps, now missing, served to keep the book tightly closed when not in use. Metal rings at the ends of the straps would have slipped over metal pins that were once secured to the fore edge of the upper board.[56]

Both boards also retain the ends of two single leather straps that extend from beneath the fore-edge turn-ins of the leather cover (see figs. 4 and 5). These are the remains of board strap markers that readers used to mark their places in the manuscript.[57] In this binding, the flat straps passed through holes made at the board edges and then through the leather cover.

While the animal origin of the leather cover on the SGP has not been securely identified, both sheepskin and goatskin leather were commonly used.[58] There is no blind tooling on the leather, yet the binding was decorated with five white metal bosses on each board and a pair of white metal nails in each of the three board edges (see figs. 6a and 6b). These nails are a characteristic feature of the Syriac bindings produced at St. Catherine's, as is the use of white metal for the furniture.[59]

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56 The damaged copper alloy pin in the fore edge of the upper board must have been one of a pair that were used to replace earlier pins made of white metal.

57 The term "board strap marker" was introduced during the survey of manuscript codices in St. Catherine's monastery library as a way to distinguish the location and function of these page-marking devices from the leather tab page markers that are also very common in both Syriac and Byzantine codices. Georgios Boudalis, "Clarifying the Structure, Appearance and Use of the Early Codex Book Around the Mediterranean Basin: The Use of Iconographical Evidence," in *Care and Conservation of Manuscripts 15: Proceedings of the Fifteenth International Seminar Held at the University of Copenhagen, 2nd–4th April 2014*, ed. M. J. Driscoll (Copenhagen: Museum Tusculanum Press, 2016), 287–303 at 288–89.

58 Dergham and Vinourd, "Les reliures Syriaques," 289.

59 Boudalis, personal communication, 2017.

Pieces of plain-weave textile or scraps of recycled parchment were often used to line the insides of the boards of Syriac bindings after covering.[60] In the SGP, skinned remnants of Syriac manuscript waste are found on the inside of the upper board (see fig. 5). On the inside of the lower board, the St. Catherine's binder used a palimpsested but otherwise blank folio of the Galen manuscript as a pastedown.

The Restoration of the Palimpsest

Most of the damage seen today in the SGP occurred while it was at St. Catherine's Monastery. Seven loose folios, six of which were recently located, gradually become detached. After it was removed from the monastery in the late nineteenth century, Dr. Friedrich Grote may have owned the codex along with many of the loose folios.[61] In 1922, the Leipzig dealer Karl W. Hiersemann sold the palimpsest to the collector Arnold Mettler Specker. Prior to the sale, the binding was taken apart and the old spine leather and endbands were discarded. The bifolia were reinforced with guards of modern parchment, and the book block was resewn in a haphazard fashion on two wide twill tapes.[62] The boards were reattached by gluing the ends of the tapes to the inside (see fig. 5). The tape ends were then covered with a strip of wove paper on the lower board and a partial pastedown of modern parchment on the upper board. The spine was covered with a modern piece of brown leather that wrapped around to the sides of the boards (see fig. 3).

After Specker acquired the SGP, his bookplate was adhered over the palimpsest pastedown on the lower board. His heirs later transferred the book to an auction house in New York, which then sold it to an unidentified

60 Pastedowns made from manuscript waste are described and illustrated in Caroline Checkley-Scott, "The Syriac Book," in *Contributions to the Symposium on the Care and Conservation of Middle Eastern Manuscripts, The University of Melbourne, Australia, 26–28 November 2007* (Melbourne: Centre for Cultural Materials Conservation, 2008), 49–54 at 50–51.

61 G. Kessel, "Membra disjecta sinaitica I: A Reconstitution of the Syriac Galen Palimpsest," *Manuscripta Graeca et Orientalia* 243 (2016): 487–88.

62 This type of restoration has not been observed on any of the books at St. Catherine's; Boudalis, personal communication, 2017.

collector in 1948.[63] Prior to that sale, it is likely that the poor-quality restoration leather was lifting from a split along the back joint and was reattached to the book block spine with a synthetic adhesive (see fig. 3).[64] At the same time, the partial pastedown on the upper board was lifted to reveal more of an old paper label and other inscriptions that had been obscured. The gold titling that was handwritten on the modern spine is in English, which suggests that it was added around the time of the sale in New York and not before (see fig. 3).[65]

Condition of the Palimpsest

After the SGP arrived at the Walters Art Museum in 2002 for imaging and conservation treatment, contract conservator Linda Owen examined the manuscript and documented the damage resulting from centuries of use, rebinding, and exposure to water.

The thick, dark binding leather was worn, with many losses and scratches. The protruding endcaps had been cut off, and the interlaced straps and clasps that had once secured the boards at the fore edge were missing. Many of the metal bosses and nails had also been damaged or lost.

The thin modern leather used to reback the spine was severely abraded, degraded, and weak, as well as visually obtrusive. The metallic ink used to letter the spine had corroded and stained the leather (see fig. 3). Although the upper joint remained intact, a ragged tear split the lower joint entirely, exposing the spine edge of the wooden board and the twill sewing tapes. The new turn-ins over the upper board had also been cut to allow the

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63 The palimpsest was sold in New York by Parke Burnett, who listed it as number 307 in the sale.

64 Although the synthetic adhesive was not analyzed, it appeared to be a type of poly(vinyl acetate) emulsion adhesive, which became commercially available in the 1940s.

65 The title has been reconstructed as "Syriac Liturgical/11th century//Medical Palimpsest/9th century."

partial parchment pastedown to be lifted, perhaps by a twentieth-century book dealer. The detached turn-ins remained adhered to the modern paste-down, which was sewn with the rest of the book block.

The inner face of the upper board was layered with adhesive, parchment, and paper residues where the partial pastedown had been lifted. A paper label with ink and graphite inscriptions concealed some of the residual parchment, which was later identified as Syriac manuscript waste (see fig. 5). The inner face of the lower board, which retained its parchment pastedown, was almost entirely covered by Specker's bookplate.

Opening the book revealed further condition problems. The most recent rebinding campaign had employed stiff parchment guards that prevented many leaves from flexing readily, making the volume difficult to open. Glue had also seeped into the sewing notches in the bifolia, adhering the leaves together in the gutter. Several folios (particularly 39–44) were still adhered and could be opened only a few centimeters. Others had been separated by force, causing skinning of the top layers of parchment. In one case, two leaves were adhered together some distance from the gutter, perhaps where moisture had reactivated sticky ingredients in the chalk coating. Here, an elongated flap had been torn from folio 40r and remained adhered to folio 39v.

In addition, the parchment bifolia were shrunken, cockled, and stained from moisture damage. Water appears to have penetrated the book block from the front as well as the head, carrying grime with it and redistributing the chalk coating unevenly. Some folios were washed almost clean of the chalk, while others bore heavy deposits that obscured the erased lower text (see fig. 1). Folios 1–30 were tightly cockled and stained dark brown or black at the head, with occasional lesser tide lines at the tail and fore edge (fig. 7). In some cases, the tight creases hid portions of the text. Folios 39–62 displayed more gentle undulations. Lighter staining, with more water intrusion at the tail and fore edge, was present throughout the book block. In some places, the water had allowed the parchment to become horny and gelatinized. The outermost folios were brittle and split at the spine folds and edges; these edge tears sometimes extended into the text area (see fig. 7). The moisture-related damage was accompanied by a scattering of insect

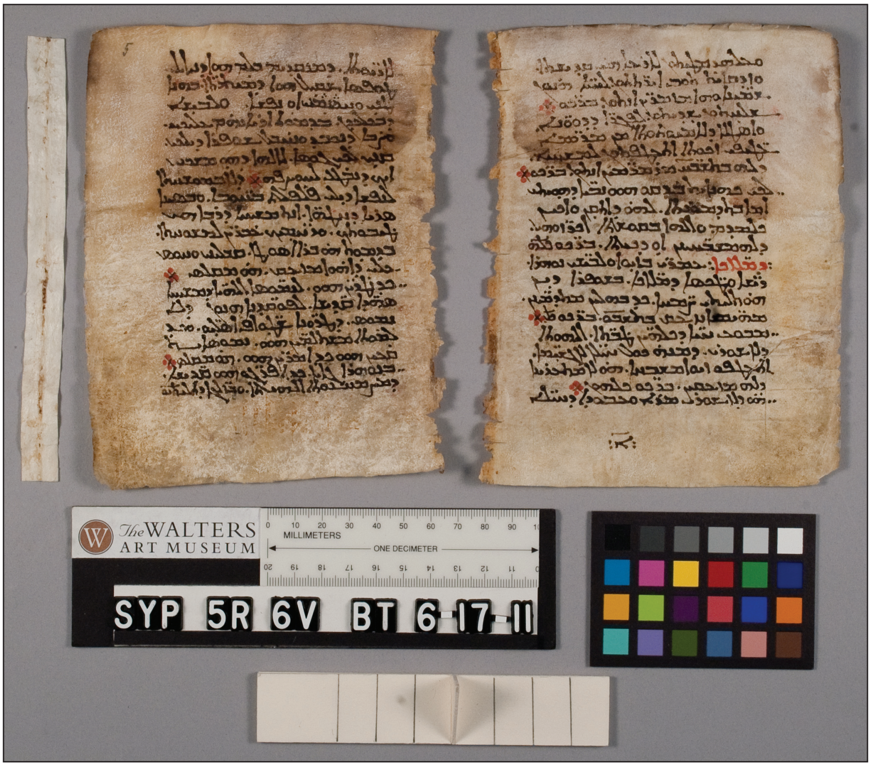

FIGURE 7. Folios 5r and 6v (an original bifolio) after removal of the parchment guard, showing moisture staining, flaking ink, shrinkage and warping of the parchment, brown adhesive staining along the split spine fold, and a long edge tear on folio 5r. Photo: Renée Wolcott.

holes throughout the manuscript. The outer edges of the book block were also very grimy from handling.

The iron gall ink of the liturgical text was flaking extensively in the areas of moisture damage, particularly in folios 1–92. In surrounding areas, it had also corroded the parchment surface, resulting in further ink loss. The moisture damage also caused the inks to bleed, especially around folio 20. The red ink was often blurred, sometimes to the point of illegibility, and had often offset onto facing folios (figs. 8a and 8b). The ink of the lower text ranged in color from light brown to very faint tan; what remained visible appeared to be stable.

FIGURE 8A. Folios 32v–37r before adhesive reduction, showing brown hide glue residues in the gutter as well as flaking and bleeding inks. Photo: Renée Wolcott.

FIGURE 8B. Folios 32v–37r after adhesive reduction. Photo: Renée Wolcott.

Conservation Treatment

Manuscripts on parchment present particular challenges for conservators.[66] Because parchment is stretched and scraped rather than tanned, it remains highly hygroscopic and sensitive to moisture and heat. The collagen fibers in the skin, which are intertwined and relaxed in a raw skin, are realigned as the lime-soaked parchment is stretched. They become fixed in a highly stressed parallel alignment as the parchment dries under tension. Any moisture introduced after the parchment has dried allows the taut collagen network to swell, relax, and return to its original entangled state.

In dry environments, parchment shrinks; in humid environments, it expands rapidly and drastically. If it is exposed to water outright and then dried, it will warp, cockle, and shrink beyond its first dry state. In extreme cases, it may become thick, tough, and transparent—more like rawhide than like a writing support.

Because parchment is so reactive to changes in humidity, inks and paints—which are not as sensitive to moisture and cannot contract and expand at the same rate as parchment—are prone to flaking and loss in environments with fluctuating humidity. Conservators therefore recommend storing manuscripts on parchment in thick-walled storage boxes of alkaline paperboard, which keep the books closed under light pressure and help buffer against changes in relative humidity.

In addition, conservation treatments for parchment manuscripts generally seek to avoid exposure to excess moisture, often by using adhesives that contain a high proportion of alcohol (which does not cause parchment to swell). When treatment requires that the parchment be relaxed and flattened, conservators select humidification techniques that rely on water vapor or mist rather than on direct application of water, as with a brush. Parchment that has been humidified is also dried under pressure or tension to keep its collagen fibers in alignment and to prevent it from shrinking.

66 Christopher Woods, "The Conservation of Parchment," in *Conservation of Leather and Related Materials*, ed. Marion Kite and Roy Thomson (Boston: Butterworth-Heinemann, 2006), 200–224.

Preparing the Manuscript for Multispectral Imaging

Conservation treatment for the SGP proceeded in several stages, beginning with disbinding the manuscript, flattening its detached bifolia, and stabilizing them in preparation for multispectral imaging. This phase of treatment sought to maximize the visibility of the undertext by opening tight creases and removing old mends that obscured the text. The spine folds of the liturgical folios were humidified and flattened to recreate the leaves of the earlier Galen manuscript. Edge tears were mended without allowing repair materials to impinge on the text area and impede the imaging process.

Conservator Linda Owen began by using compresses of isopropanol and deionized water to lift Arnold Mettler Specker's bookplate from the back parchment pastedown. She retained the plate, which was later relocated and adhered to the new front endleaves of the rebound volume. Owen used similar compresses to lift the pastedown itself from the lower board. The pastedown proved to be a palimpsest folio that had not been written on when the liturgical text was produced, and it was renumbered as the final folio of the book block.

To allow the quires to be removed from the binding, Owen cut the modern leather at the upper joint, snipped the sewing tapes at the upper and lower hinges, and carefully peeled away the leather from the spine of the book block. She then reduced hide and synthetic glue residues on the spine folds of the quires, first with a dull scalpel and then with poultices of isopropanol and deionized water adjusted to pH 8. This low-moisture, alkaline treatment helped to swell the adhesive residues and allow them to be removed.[67] Finally, Owen cut the sewing threads and removed the twill tape sewing supports.

For approximately twenty-five years, conservators have been using modified ultrasonic humidifiers to produce fine mists of alcohol and water to

67 This technique was used successfully in the treatment of the Archimedes Palimpsest. See Abigail B. Quandt, "Conserving the Archimedes Palimpsest," in *The Archimedes Palimpsest, Catalogue and Commentary*, ed. R. Netz, W. Noel, N. Wilson, and N. Tchernetska, 2 vols. (Baltimore: Walters Art Museum, and Cambridge: Cambridge University Press, 2011), 1:128–71 at 134.

humidify and soften parchment or hide-based adhesives without swelling the collagen unduly.[68] Owen used an ultrasonic mister fitted with a hose and a fine nozzle to direct a mist of isopropanol and deionized water over adhered areas between quires and bifolia, softening the hide glue residues. This allowed her to separate the disbound quires and bifolia, as well as the leaves that were still adhered together in the gutter. Owen used the same technique to remove several stiff parchment guards and a single paper guard from the manuscript leaves (see fig. 7).

Owen then used narrow compresses of isopropanol and deionized water to humidify the spine folds of the bifolia, as well as the tight creases resulting from the previous moisture damage. Once the parchment became malleable, she unfolded each bifolio, flattened any creases or cockles, and dried the parchment between felts under pressure. She used similar compresses, adjusted to pH 8, to soften the adhesives beneath the manuscript's old mends of cloth and paper, allowing them to be removed.

Owen then used remoistenable mending tissues, or Asian papers precoated with adhesive, to mend split spine folds and edge tears in the parchment.[69] The adhesive film of methyl cellulose and wheat starch paste on Owen's remoistenable mending tissues could be reactivated with a scant application of isopropanol and water, allowing her to repair the parchment without introducing excess moisture. Because even the thin, translucent paper mends would inhibit imaging of the undertext, Owen mended only the blank margins of the leaves, avoiding the lower text with its red section numbers. The mended, flattened bifolia were stored in polyester sleeves until they could be imaged.

Preparing the Manuscript for Rebinding

Although the undertext of the SGP is most accessible when the volume is disbound and the bifolia are flattened, the book's owner asked that the

68 Abigail Quandt, "Recent Developments in the Conservation of Parchment Manuscripts," *The Book and Paper Group Annual* 15 (1996): 99–115 at 101–5.

69 Andrea Pataki, "Remoistenable Tissue Preparation and Its Practical Aspects," *Restaurator* 30 (2009): 51–69.

palimpsest be returned to its bound format after multispectral imaging was complete. This necessitated several further stages of conservation treatment. The flaking ink of the upper text, which could not be addressed before imaging was undertaken, had to be consolidated to prevent further ink loss. Many of the spine folds still retained traces of adhesive residues from previous rebinding campaigns, and these had to be removed. The split spine folds and edge tears, which had been minimally reinforced before imaging, had to be mended so that they could withstand manipulation once the volume had been rebound. Finally, the flattened spine folds had to be humidified and refolded, and the bifolia had to be reassembled into quires.

The flaking ink in the moisture-damaged areas was exacerbated by iron gall ink corrosion of the underlying parchment, which made the surface of the skin uneven and rough. In order to improve the attachment between the ink and the parchment surface, conservation intern Renée Wolcott applied a mist of warm, dilute gelatin and ethanol to the text, working line by line beneath a stereomicroscope at high magnification (fig. 9). Repeated applications of gelatin were often necessary to stop the ink particles from lifting. Wolcott consolidated particularly friable areas by applying a 1 percent gelatin solution to the text with a fine brush, then applying gentle pressure through silicone-release polyester film.

Both Wolcott and Owen worked to reduce adhesive residues and mend edge tears. Most of the adhesive on the spine folds of the bifolia was the glossy or crusty brown hide glue traditionally used by bookbinders. This adhesive generally remains water soluble with aging. However, during a mid-twentieth-century repair campaign, a previous owner or book dealer had reinforced the consolidation of the book spine by applying a synthetic adhesive similar to white glue, or poly(vinyl acetate) emulsion, to the spine beneath the lifting leather. After drying, this adhesive will swell in water but does not dissolve, making it difficult to remove.[70]

Working beneath the stereomicroscope, the conservators found that both adhesives could be removed with the aid of a 70:30 mixture of isopro-

70 See Quandt, "Conserving the Archimedes Palimpsest," 133.

FIGURE 9. Consolidating flaking ink with a mist of dilute gelatin and ethanol. Photo: Abigail Quandt.

panol and deionized water, adjusted to pH 8 with calcium hydroxide.[71] When applied on a cotton swab, the alkaline solution dissolved the hide glue outright, allowing it to be removed with successive cotton swabs. The same solution softened the synthetic adhesive until it became gummy and could be picked from the parchment with tweezers (see figs. 8a and 8b).

The Mettler Specker bookplate that Owen had removed before imaging also had thick, shiny, brittle adhesive residues on the back. Owen was able

71 This treatment protocol was developed to address synthetic adhesive residues in the gutter of the Archimedes Palimpsest. See Quandt, "Conserving the Archimedes Palimpsest," 134.

to reduce this adhesive layer with deionized water alone, applied with cotton balls and swabbed from the surface. After reducing the adhesive residues, Owen dried the bookplate under pressure between sheets of spun-bonded polyester web and cotton blotter. After the manuscript had been provided with new endleaves of handmade paper to protect the book block, the bookplate was hinged to the second flyleaf.

Owen and Wolcott mended the damaged parchment using layers of thick and thin remoistenable tissue prepared from pigment-toned Asian mulberry paper. The thicker papers for mending edge tears, guarding split spine folds, and filling losses were precoated with a mixture of wheat starch paste and methyl cellulose. This adhesive blend combines strength with flexibility, and can be reactivated with a mixture of isopropanol and water. The thinner tissues used for mending tears or insect holes in areas of text were prepared with a mixture of Klucel G (hydroxypropylcellulose) and Aquazol 500, transparent adhesives that can be reactivated with alcohol alone.[72] Where the edges of tears overlapped, the conservators glued them together with sodium carboxymethylcellulose before mending on top of the tears with remoistenable tissue.

After mending, the conservators humidified the spine folds of the flattened bifolia by applying a mixture of isopropanol and deionized water with a fine brush. They could then refold the bifolia and assemble them into quires. The rebuilt quires were dried between felts under light weight, and then their spine folds were mended with remoistenable tissues to allow for resewing.

In the last steps before rebinding the SGP, Wolcott removed the vestiges of the previous rebacking from the insides and spine edges of the wooden boards. She used a dry microspatula to lift the partial white-paper pastedown on the lower board, as well as the modern leather on the spine edges

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72 This adhesive mixture was first used to mend damage within the text of the Archimedes Palimpsest. See Abigail B. Quandt, "Preserving the Brain in the Box: The Scientific Analysis and Conservation of the Archimedes Palimpsest," in *Care and Conservation of Manuscripts 14, Proceedings of the Fourteenth International Seminar Held at the University of Copenhagen, 17th–19th October 2012*, ed. R. Mósesdóttir and M. Driscoll (Copenhagen: Museum Tusculanum Press, 2014), 1–15 at 8.

of both boards. Wolcott then cleared away the adhesive and paper residues on the insides of the boards using a dull scalpel and an alkaline mixture of isopropanol and deionized water. Wolcott traced the insides and outsides of both boards onto polyester film, identifying layers of previous spine linings, leather covers, endcap materials, and board repairs (see figs. 6a and 6b). Both the parchment strip on the lower board and a skinned parchment layer on the upper board proved to retain fragments of Syriac script, which Wolcott also documented (see figs. 4 and 5).

Rebinding the Syriac Galen Palimpsest

Conservator Consuela "Chela" Metzger, who rebound the SGP, faced several challenges as she approached her task. She knew that the parchment was relatively thick and stiff, and that the folios opened poorly. She also knew that water damage had made the book block five millimeters thicker at the head of the spine than at the tail. Rebinding the volume would bury the undertext in the gutter of the book, yet the manuscript would necessarily continue to be handled, examined, and photographed by researchers. Metzger thus had three goals in rebinding the palimpsest: to keep adhesives off the spine folds, to maximize the flexibility of the manuscript opening, and to avoid obscuring elements of the historical binding materials. The owner added a fourth goal: the rebound volume had to fit into its existing box.

To accommodate the first two goals, Metzger chose to re-sew the book through a concertina guard, or an accordion of Asian paper that was pleated around the spine folds of the quires as sewing progressed (fig. 10).[73] Before beginning, she used an awl to clean out the three original V-shaped notches in the repaired spine folds of the palimpsest quires. She also made matching V-shaped notches in the spine folds of the manuscript's new handmade paper endleaves. With assistance from conservator Renée Wolcott and conservation student Carrie McNeal, Metzger then sewed the palimpsest with

73 Tom Conroy, "The Movement of the Book Spine," *Book and Paper Group Annual* 6 (1987): 1–30 at 24–25.

FIGURE 10. Chela Metzger re-sews the palimpsest with a concertina guard of Asian paper. Photo: Abigail Quandt.

linen thread through a concertina guard of medium-weight Asian paper using an extended chain link stitch. This allowed each quire of the manuscript to lie in a shallow pocket of Asian paper that would limit abrasion to the spine folds, prevent adhesive from swelling the parchment when the book was covered with leather, and allow the quires to be easily disbound in the future.

When sewing was complete, Metzger pasted strips of medium-weight Asian paper over the exposed stitches on the spine to prevent any further adhesive from penetrating the sewing holes. She then adhered extended patch linings of cotton muslin to the spine and used their overhanging edges to reattach the book boards. At the head and tail of the spine, where the original endband tie-downs were still visible on the outsides of the boards, she secured the extended fabric spine linings to the boards' inner faces. Metzger adhered two additional muslin extensions to the outsides of the boards, beneath the original textile linings and cover leather and between the original bridling stations.

FIGURE 11. Sewing a new endband after board reattachment. Photo: Abigail Quandt.

When the spine had been completely lined with muslin and wheat starch paste, Metzger reinforced the attachment of the textile spine linings by resewing the endleaf folios and one palimpsest bifolio through them with a pamphlet stitch. She also sewed new back-bead conservation endbands over thick cores of linen cord at the head and tail of the book block (fig. 11). As she worked, she tied down the linen sewing thread in every quire and packed it between the gatherings to create a firm, flexible attachment between the spine lining and the book block. When the endbands were complete, Metzger again pasted strips of Asian paper over the sewing holes to prevent adhesive from penetrating to the parchment beneath.

Before covering the spine with new leather, Metzger reduced the remaining adhesive and leather residues on the spine edges of the boards with swabs and poultices of deionized water. She then filled losses in the edges of the wooden boards with layers of mulberry paper and wheat starch paste. She protected the remnants of the old Byzantine endbands with the same materials after filling voids with linen cord. Finally, she used a tracing of the most

FIGURE 12. The rebound Syriac Galen Palimpsest, showing the spine, upper board, and tail. Photo: Consuela "Chela" Metzger.

recent rebacking leather to prepare a piece of new dark brown goatskin with the same dimensions. This leather was pared to leave as much of the inner boards exposed as possible, and then adhered over the spine with wheat starch paste, creating a new tightback binding (fig. 12).

After conservation treatment, the folios of the Syriac Galen Palimpsest open far better than they did before rebinding, although the stiff parchment leaves must be restrained for reading or photography (see fig. 13). While the manuscript retains evidence of old water damage and extensive handling, the rigid parchment guards have been removed, revealing previously hidden Galen text. The new Asian paper guards are strong but flexible, and the leaves are no longer adhered in the gutter. Adhesive residues that restricted opening and obscured the Galen text have been removed. The tears and creases that caught at readers' hands and obscured the hymn text have been mended or flattened. Conservators discovered a palimpsested folio without upper text (now folio 226) beneath a modern bookplate on the lower board, as well as red section numbers in the Galen text that were not

FIGURE 13. Natural book opening at tail after rebinding. Photo: Consuela "Chela" Metzger.

captured during multispectral imaging. One of the most satisfying and unexpected outcomes of this brief technical study and conservation treatment has been an improved understanding of the Syriac manuscript-making tradition, whose vestiges—in the form of chalk coating the leaves, endband tie-downs laced through the boards, and fabric and leather shaped over the endbands—can be seen far more readily in the rebound volume.