

Bulletin of the Asia Institute, a Non-Profit Corporation

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Source: *Bulletin of the Asia Institute*, New Series, Vol. 16 (2002), pp. 181-187

Published by: Bulletin of the Asia Institute, a Non-Profit Corporation

Stable URL: <http://www.jstor.org/stable/24049165>

Accessed: 27-12-2015 23:52 UTC

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Shorter Notices

Analysis of Writing Materials in Middle Persian Documents

Part I

The discussion of the physical characteristics of Middle Persian documents at the University of California, Berkeley, by this writer at the meeting of the 5th European Society of Iranian Studies, held in Ravenna, Italy, in 2003, left unanswered the questions of the composition and characteristics of the ink, textile, and leather as writing materials.¹ The present paper addresses these questions in light of recent scientific analyses conducted by Dr. Kathleen Martin and her associates, at McCrone Group Associates, Inc., Westmont, Illinois. The results of these analyses are presented as Part II of this paper.

Summary of Earlier Studies

The collection of Middle Persian documents at Berkeley, also referred to as the Pahlavi Archive at Berkeley, was anonymously donated to the University of California's Bancroft Library in 2001 and 2002, and comprises over 260 parchment/leather and textile manuscripts, 82 of which still bear one or more clay bullae stamped with impressions of seals. The collection is currently being classified by Philippe Gignoux and Rika Gyselen in preparation for their eventual publications and for the digitization of the documents and bullae for a Bancroft Library website.² This substantial corpus of Pahlavi manuscripts was probably even more extensive prior to its acquisition by the Bancroft Library, as evidenced in the strong similarities between manuscripts and bullae at Berkeley and those from a number of smaller collections.³ It is hoped that further paleographic studies of the documents in the col-

lection will eventually provide greater precision in our knowledge of their provenance and of their date, which is now placed on the basis of C14 tests from the seventh to the eighth (at 68 percent confidence) or the seventh to ninth century (at 95 percent confidence).⁴

The documents so far studied and read by Philippe Gignoux appear to be economic texts, written on roughly rectangular and triangular shaped manuscripts that vary in measurement from about 15" × 14" to 3" × 1".⁵ The method of preparation of the documents intended for transmission was as follows. The document was closed into a small rectangular packet after it was rolled up, folded, wrapped with a string, and knotted. A moist clay pellet, the bulla (usually 2" to 3" × 1" to 2 cm), was then pressed over the knot and stamped with one or more seals. Although all the documents in the Berkeley collection had been opened prior to their acquisition by the University of California, their method of closure and sealing is demonstrated by a similar document that had remained unopened, now in the collection of the Free University, Berlin.⁶ Notable in the documents at Berkeley is the attachment of the bulla below the bottom line, often in the center of the page.

Occasionally several documents, each bearing a bulla below the bottom line, are *bound together* at the top center of the page with an additional bulla stamped with one or more seal impressions (fig. 1-a). It is speculated that the binding and sealing of multiple documents, each with the closure seal still preserved below the bottom line, may be attributed to the archivist who thus organized and recorded original copies of documents.

Analysis of Samples

Random samples of ink and fabrics used as writing materials, and samples of other miscellaneous

fabrics acquired with the collection were submitted for analysis in 2005.⁷

Whereas samples 1, 2, 5, and 6 were taken from the documents and from unattached buliae,⁸ samples 3 and 4 were taken from a textile fragment and from a piece of unraveled yarn included in the collection. However, these and other miscellaneous items,⁹ acquired with the collection, may be unrelated to the documents.

Ink. The composition of the ink on random samples of the Middle Persian documents at Berkeley is carbon-based, specifically lamp black, rather than iron gall, according to Dr. Martin's McCrone Associates' findings.¹⁰ The most common black pigments, represented by lamp black of various sorts and a natural black earth, are not mentioned in an early Islamic treatise on bookbinding, written by Mu'zz ibn Badis (ca. A.D. 1025), presumably because their preparation was too well known to be included among the more complex ink recipes listed by that author.¹¹ Lamp soot, or lamp black, was produced by gathering soot from inside a chimney constructed over a four-wick lamp that burned linseed oil. The soot was then sieved and subjected to further treatment to produce a fine powder. Gum Arabic was commonly used as a binder, with glair as an alternative.¹²

The presence of clay minerals in the ink samples from the Middle Persian documents under study, noted by Dr. Martin's McCrone Associates' findings, may well be explained by the method of the preparation and storage of the ink.

Parchment and Leather. Although al-Nadim, a tenth-century Islamic source, observes the earlier use by Persians of sheep, buffalo, and oxen skins as writing materials, goat and sheep skins were evidently the usual materials of early Islamic parchments.¹³ Indeed, 1 of the 3 fragments used as writing material and submitted for analysis (sample 1), under magnification appears to be parchment prepared from goat or kid skin, identified by the hair fibers (fig. 2). Goatskin, which has a different fiber size and network structure from sheep and cow hides, is a superior writing material due to its softness and flexibil-

ity.¹⁴ Surviving Middle Persian documents from the Archduke Rainer's collection in Vienna also include several documents described as parchment and two of leather that are dated to A.D. 619–629, the last years of the Sasanian dynasty when it ruled over Egypt.¹⁵

Linen. The identification of the writing material in 27 of the documents at Berkeley as linen (bast fibers, the most common of which are linen and hemp), rather than silk as earlier believed, is perhaps to be expected since linen is known to have been used as a writing material in earlier times in both Egypt and China.¹⁶

The fabric in all 3 linen samples (samples #2, 5, and 6) is shown to be a 1:1 plain weave, with both warp and weft direction in a Z twist. The use of the Z-spun warp, which is notable in Persian woolen and silk weaves attributed to the Sasanian period,¹⁷ evidently continued in various weaves along the Silk Road into early Islamic times. It is found, for example, in the weaving technique of the undyed and bleached linen leggings, excavated at Moshchevaja Balka, in the northern Caucasus (between the Black and Caspian Seas), in the collection of the Hermitage Museum, St. Petersburg, and dated to the eighth to the tenth century.¹⁸

The textile documents in the collection at Berkeley are generally cut into a roughly triangular shape, with the widest part at the top of the document and the sharpest angle below the bottom line.¹⁹ Woven linen cloth, manufactured from home-grown flax, used as writing material for correspondence and record keeping in Sasanian Iran, was a readily available and economical substitute for other writing materials, such as the relatively rare Egyptian papyrus and costly parchment and leather. The discovery of specimens of linen cloth used as writing material in Sasanian Iran is of interest in that it now offers tangible evidence of the transfer of linen as a writing material by Persians to Arabs in early Islamic times. Moreover, linen rag, which was first used in papermaking in China from perhaps as early as the second century B.C.,²⁰ was the essential ingredient in the production of the earliest paper in the Islamic world. This was the renowned Samarqand or Khorasan paper, introduced there from China in the eighth century, which came into general use in the Eastern Is-

lamic lands before it spread to the Western lands.²¹

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Part II

The Pahlavi Archive, currently housed at the University of California at Berkeley, a collection of Middle Persian bullae and manuscripts dating to the early post-Sasanian period, discussed in Part I of this article, was presented as writing surfaces composed of leather and silk. However, none of the materials had been subjected to scientific testing to verify their nature. Here, we describe the analysis of a random selection of document fragments using several micro-analytical techniques.

One of the document samples consisted of three fragments of stiff, warped, tan-colored material with ink markings on one face. Examination by light microscopy revealed the presence of hair fibers, indicating an animal origin for the document (fig. 1-b). Comparison of hair fibers from the document fragment was made to fibers from a domestic U.S. goat, which were found to be very similar. Comparison was also made of collagen fiber bundles removed from the document fragment to collagen bundles from samples of modern sheep, calf, and goat parchment.²² Collagen bundles from goat parchment were found to be most similar to the collagen from the document (figs. 2-a, b). In addition, UV-fluorescence examination of the document fragment, as well as other tests, supported the identification of the material as parchment rather than leather.²³ Thus, this document material appears to be goat-based parchment.

The ink on the document fragment was examined by PLM, Raman spectroscopy, and SEM-EDS, all of which support an identification of carbon ink rather than iron gall ink. Furthermore, the ink morphology was highly suggestive of a lamp black rather than a charcoal black pigment. A higher incidence of clay minerals in the ink compared to the underlying substrate suggests the possibility that the ink was manufactured or stored in a clay pot.

An initial analysis by infrared spectroscopy of five other document fragments found them to be

cellulosic (plant-based) rather than silk, as had been expected. PLM examination identified three of these fragments to be composed of bast fibers, the most common of which are flax and hemp, and two of the fragments as cotton. The bast fiber fragments were all woven cloths in a 1:1 plain weave, with both fill and warp directions in a Z twist (figs. 3-a, b).

Accurate characterization of ancient materials is often of great importance as it can clear up misconceptions about the nature of these materials and can influence decisions regarding conservation and storage.²⁴

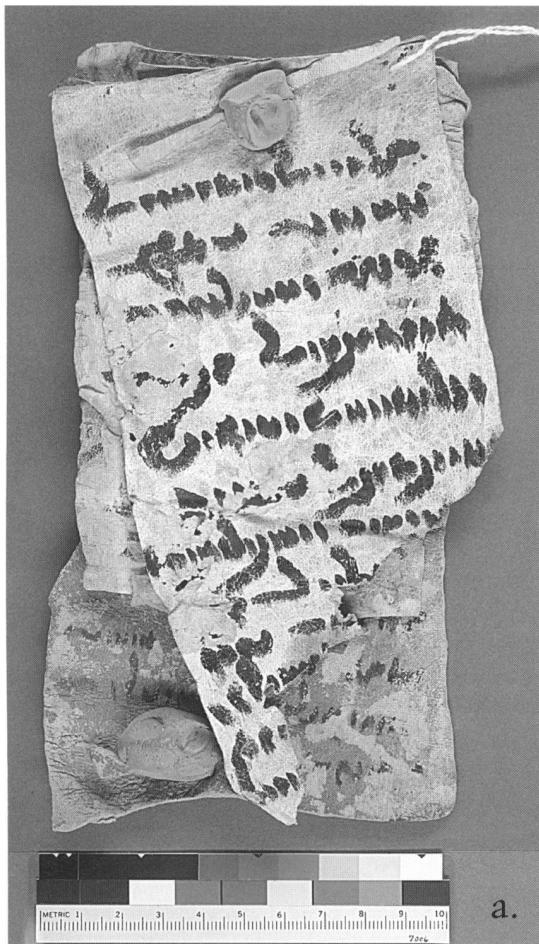
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Part III

Conclusion

The following conclusions may be drawn from the analyses of the Middle Persian writing materials in the Berkeley collection. The ink used to write the documents is carbon-based lamp black (rather than iron gall ink), a common black pigment used in ink making through Islamic times. A leather fragment, randomly selected from among the Berkeley documents, is parchment manufactured from goat or kid skin, a superior writing material due to its softness and flexibility. Finally, the textile used as a writing material in the Berkeley collection is in fact linen, rather than silk as earlier believed.

This author wishes to express deep gratitude for the cooperation and expertise of Dr. Kathleen Martin and the scientists at McCrone Group Associates, Inc., towards the resolution of a number of persistent questions about the composition of the writing material in Middle Persian documents under study. In a more detailed report of the results of their analyses, sent to this writer on August 15, 2005, Dr. Martin noted that the analysis of the fabric samples examined by McCrone Associates found white crystals on the surface of the fabric around some of the inked areas that appear to be calcium sulfate (gypsum), a common mineral. This important observation suggests the use of a sizing technique in the preparation of the linen cloth as a writing material, which was thus made relatively impermeable and resistant to the



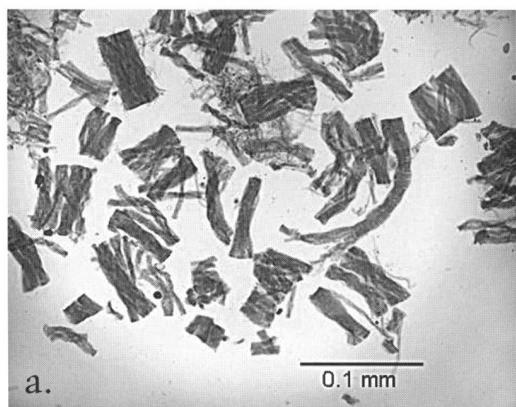
a.



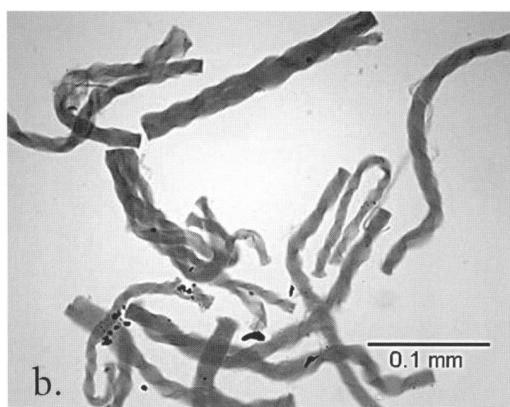
b.

Fig. 1-b. Fragment of a leather document in the collection of the Bancroft Library showing hairs. Photo: McCrone Associates, Inc.

Fig. 1-a. Leather document (Middle Persian document #43) in the collection of the Bancroft Library, University of California, Berkeley. Photo: Courtesy of the Bancroft Library.

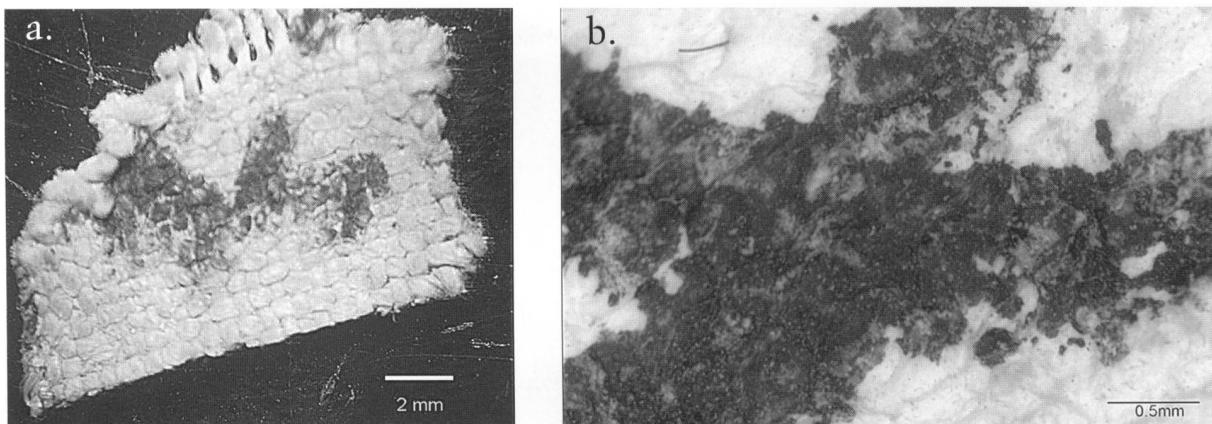


a.



b.

Figs. 2-a, b. Collagen bundles removed from document fragment (a) and modern goat parchment (b). Photo: McCrone Associates, Inc.



Figs. 3-a, b. Bast-fiber document fragments with markings. Photo: McCrone Associates, Inc.

spreading of the ink. It is hoped that future analyses of the ink samples by these scientists may reveal whether the ink was used with an admixture of a gum, which according to the early sources was a customary practice that was designed to impart an adhesive quality to the ink.

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Notes

1. G. Azarpay, "Sealed Pahlavi Manuscripts at Berkeley: Physical Characteristics," in "Proceedings of the Fifth Conference of the Societas Iranologica Europea" (Ravenna 2003), vol. 1, *Ancient and Middle Iranian Studies*, ed. A. Panaino and A. Piras, Istituto Italiano per l'Africa e l'Oriente, to appear in 2006.

2. Ibid., "Rare Pahlavi Texts Now at Bancroft," *Bancroftiana* 123, University of California, Berkeley, 2003), pp. 1, 4; P. Gignoux, "Une nouvelle collection de documents en pehlevi cursif du début du septième siècle de notre ère," *CRAI* (1991) pp. 683–700; idem, "Six documents Pehlevis sur cuir du California Museum of Ancient Art," *BAI* 10 (1996), pp. 63–72; idem, "Une liste pehlevie des noms de mois et de jours (document Berkeley no. 38)," in "Festschrift Bo Utas," Uppsala (in press); idem, "Sept documents économiques en pehlevi," "Mélanges W. Skalmowski," Leuven (in press) [re-edition of "Nouveaux documents pehlevis sur soie," in *Philologica et Linguistica, Historia, Pluralitas, Universitas, Festschrift für Helmut Humbach zum 80. Geburtstag am 4. Dezember 2001,*

ed. M. G. Schmidt and W. Bisang (Trier, 2001)]; idem, "Aspects de la vie administrative et sociale en Iran du 7ème siècle," in *Contribution à l'histoire et la géographie historique de l'empire sassanide*, Res Orientalis XVI (Leuven, 2005), pp. 37–48.

3. A manuscript reportedly from the 1960s in the 'Abbas Mazda Collection; 6 Pahlavi manuscripts and a related group of 71 complete specimens of bullae in the California Museum of Ancient Art, in Los Angeles; and over 30 specimens of manuscripts and related bullae in Berlin. For more complete references, see G. Azarpay, "The Pahlavi Archive at Berkeley," in "Egypt and Beyond: Studies in Honor of Leonard H. Lesko upon His Retirement from the Wilbur Chair at Brown University," *Egyptological Studies*, Brown University, ed. S. E. Thomson, Providence, 2006 (in press); "Bullae from the Pahlavi Archive at the University of California, Berkeley" (in press); for the electronic version see *Eran ud Aneran: Studies Presented to Boris Illich Marshak on the Occasion of His 70th Birthday*, *Webschrift Marshak 2003*, ed. M. Compareti, P. Raffetta, and G. Scarcia: www.transoxiana.com.ar/Eran/index.html.

4. Although the exact place of discovery of the Middle Persian Archive under study is still unknown, there is little question, on paleographic grounds, that the documents originated in Iran. The latest C14 tests of random samples of the Berkeley documents place them in the years A.D. 651–776 (at 68 percent confidence), and A.D. 600–888 (at 95 percent confidence), see Azarpay, "Sealed Pahlavi Manuscripts at Berkeley: Physical Characteristics." A late seventh-century date for the collection appears also to be supported by the scant evidence so far gleaned on paleographic grounds. The era referred to in these documents, earlier placed

by Gignoux in the reign of Xusro II (A.D. 590–628), is now believed by the latter to have exceeded the regnal years of that king, see Gignoux, "Nouveaux documents pehlevis sur soie," pp. 9–10. A late seventh-century date is offered by Gignoux in, "Aspects de la vie administrative et sociale en Iran du 7ème siècle," p. 37.

5. Azarpay, "Sealed Pahlavi Manuscripts at Berkeley: Physical Characteristics," p. 3.

6. D. Huff, "Technological Observations on Clay Bullae from Takht-i Suleiman," *Mesopotamia* 22 (1987), p. 390.

7. The samples of writing materials and miscellanea comprise the following:

1: ink on three leather fragments attached to clay bullae

2: ink on a fabric fragment attached to a bulla

3: a miscellaneous item, represented by an uninscribed textile fragment

4: a miscellaneous item, represented by a cluster of yarn, perhaps from a string

5: a fragment of fabric from an inscribed document (ms 25)

6: a fragment of the uninscribed section of a fabric document

8. By unattached bulla is meant a bulla that had fallen away from the document to which it was originally attached.

9. Most of these items have not been subjected to C14 testing.

10. While gallnuts are the more or less fixed ingredients of most inks, soot continues to be mentioned in later Muslim sources as useful for ink preparation, especially soot derived from sesame, walnut, hazelnut, seeds, or naphtha. The recipes for soot inks differ from each other according to the material from which the soot is prepared. Ibn Badis identifies Persian ink as a variety of soot ink prepared in the following way. "Description of Persian ink. Take the seed of the date that has been ripened in vinegar. Put it in a clay vessel. Take as much as you wish. Lute the vessel with clay of the art. The luting is done after a cloth has been put over the mouth. It is set down until it is dried a little. Then, if it is desired, the firewood is lit. It is shaken from morning to night. If desired, it is introduced into the furnace for the two kinds of glass. When it is taken out of the fire, it is set down until it is cold. Then it comes out black like charcoal. It is then made into cakes." Tannin inks, obtained from gallnut mixed with vitriol and gum, used at an early date for writing on papyrus, are a type of blue/black ink still used today, see M. Levey, "Medieval Arabic Bookmaking and Its Relation to Early Chemistry and Pharmacology," *Transactions of the American Philosophical Society*, n.s., 52.4 (1962), p. 7.

11. Levey, "Medieval Arabic Bookmaking," p. 17.

12. Although samples of pens were not included in the collection, it is most likely that the sharpened reed was used for writing Middle Persian, similar to the pens used to write Syriac, Hebrew, and Greek, but different from the brush used to write Chinese, see A. H. Hassan and D. R. Hill, *Islamic Technology: An Illustrated History* (Cambridge, 1986), p. 174.

13. *The Fihrist of al-Nadim*, p. 39; G. Bosch, J. Carswell, and G. Petheridge, *Islamic Bindings and Bookmaking* (Chicago, 1981), p. 25; J. Pedersen, *The Arabic Book*, ed. R. Hillenbrand (Princeton, 1984), p. 55.

14. R. Reed, *Ancient Skins, Parchments and Leathers* (London, 1972), pp. 119–20; H. Loveday, *Islamic Paper: A Study of the Ancient Craft* [London, ca. 2001], p. 13.

15. D. Weber, "Die Pehlevifragmente de Papyrus-sammlung der österreichischen Nationalbibliothek," in *Festschrift zum 100-Jährigen bestehen der Papyrus-sammlung der österreichischen Nationalbibliothek, Papyrus Erzherzog Rainer*, Text (Vienna, 1983), p. 25, #13:22–23 (described as leather), #13:16–20, 28–29 (described as parchment).

16. The textile used as writing material in the Berkeley collection had been identified as silk by the original owner of the collection prior to its sale and donation to the Bancroft Library.

17. For the use of the Z-spun warp and weft in Sasanian textiles, see C. M. Bier, "Textiles," in P. O. Harper, *The Royal Hunter: Art of the Sasanian Empire* (New York, 1978), pp. 119–40; A. Jeroussalimskaja, "Soieries sassanides," in *Splendeur des Sassanides: L'empire perse entre Rome et la Chine* [224–642], Musées royaux d'Art et d'Histoire (Brussels, 1993), p. 114; B. Overlaet, D. de Jonghe, and S. Daemen, "Pfister's Sasanian Cock Tapestry Reconsidered: A Rediscovery at the Biblioteca Apostolica Vaticana," *IA* 31, (1996), pp. 179–211.

18. Nobuko Kajitani, "A Man's Caftan and Leggings from the North Caucasus of the Eighth to Tenth Century: A Conservator's Report," *Metropolitan Museum Journal* 38 (2001), pp. 98–99. For the characteristics, development, and distribution of the Z-spun and S-spun yarns along the Silk Road, see also Zhao Feng, "The Evolution of Textiles along the Silk Road," in J. C. Y. Watt et al., *China: Dawn of a Golden Age, 200–750 AD* (New York, 2004), pp. 67–77. I wish to thank Dr. Prudence Harper for these two references.

19. Based on the evidence of an unopened document of this type now in the collection of the Free University in Berlin, the document was originally rolled up from the bottom into a scroll, the two ends of which were then folded over, with one end pressed over the other. The scroll packet was then tied with a string passed through a hole at the top of the docu-

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ment, and knotted around it. Finally, the knot was covered by a moist piece of clay, the bulla, on which an impression was made with a seal.

20. F. Grenet and N. Sims-Williams, "The Historical Context of the Sogdian Ancient Letters," in *Transition Periods in Iranian History: Actes du Symposium de Fribourg-en-Brisgau (22–24 Mai 1985)*, *Studia Iranica*, Cahier 5, 1987, p. 102; S. Quraishi, "A Survey of the Development of Papermaking in Islamic Countries," *Bookbinder* 3 (1989), p. 31; Tsien Tsuen-hsiun, "Paper and Printing," in J. Needham, *Science and Civilization in China*, vol. 5 (Cambridge 1985), p. 1, *passim*.

21. G. Khan, "Arabic Papyri," *The Codicology of Islamic Manuscripts*, Al-Furqan Islamic Heritage Foundation (London, 1995), p. 2.

22. Parchment samples were provided courtesy of the Newberry Library of Chicago, Illinois.

23. Reed, *Ancient Skins, Parchments and Leathers*.

24. Several colleagues who contributed to this work are gratefully acknowledged: Richard Bisbing, Kristen Skraba, and Joseph Swider.