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Learning to Conserve a Kashmiri Birch Bark Manuscript

INTRODUCTION

The AIC/CAC-ACCR Montreal 2016 meeting theme of "Confronting the Unexpected" can be explored not only in the context of disasters and emergencies, but additionally for the unexpected and unusual artifacts that sometimes cross conservators' benches. Such unusual case studies can then provide a lens for considering all of the data compilation, weighing of factors and thought processes that conservators make use of, almost subconsciously, in the decision making surrounding our more usual or "everyday" treatments: the myriad of decisions for both action and inaction that result in a treatment plan and execution.

Conservators are called by our codes of ethics to "practice within the limits of personal competence and education"[1] or are told that a "conservation professional shall recognize his or her limitations."[2] Yet we also acknowledge that each artifact is unique. As such, each treatment and examination is steadily broadening our experience, and thus increasing our limits. The question then becomes: how do we ethically expand our limits when faced with an artifact that asks for a large leap of skills or knowledge? Paper conservators usually have the luxury of really knowing our substrate (paper, primarily composed of cellulose, for which we have a relatively good understanding of degradation mechanisms, as well as historic methods of manufacture). While not the only departure from normative paper substrates, treating a birch bark substrate certainly represents something outside the "limits" of standard a paper conservator.

ENCOUNTERING THE ARTIFACT

The Special Collections of the Sheridan Libraries and Museums of Johns Hopkins University (JHU) in Baltimore, Maryland, houses a Kashmiri birch bark codex consisting of 176 leaves[3] of bark folded into nine signatures or folios (see figure 1.1). While there is evidence of former sewing, the manuscript, as examined in 2008, was unbound. Each signature was housed in archival paper folders (see figure 1.2), stacked in a card-stock four flap enclosure, inside a wooden, cloth, leather, felt and elephant paper Solander box (see figure 1.3). The media employed in the manuscript for text and diagrams is black (likely carbon) ink, which tests as insoluble in water or alcohols. A note in the Solander box stated "Birch bark MSS. From Kashmir in the Indian character called Carada [=Śāradā]. Being a ritual text of the Vedic School of the Kathas." This note dates to early 1990's, left by a researcher who expressed great interest in the contents of the manuscript; the poor condition of the manuscript at that time, however, permitted examination only of the outside of each folio.[4] The Libraries' book conservators performed some tests for treatment at this time, but were uncertain about the best treatment plan. The manuscript was set aside due to other competing priorities.

Having recently hired a paper conservator to join the conservation team, the Conservation lab was asked by the head of Special Collections to reconsider a treatment proposal in 2008. Treatment investigations began, as they often do, with a literature review to inform the writing of a condition report. Results showed that while there are a number of articles on the treatment of birch bark manuscripts (Agrawal, Gupta, and Suryavanshi 1984; Agrawal 2010; Filliozat 1947; Gilberg and Grant 1986; Gilroy 2008; Gupta and Singh 2004; Krueger 2008; Majumdar 2000; Majumdar 1957; Mikolaychuk 2005; Shah 1993; Suryawanshi 1985; Suryawanshi 2006; Suryawanshi 2000), birch bark artifacts of other forms (Anastassiades 2001; Gilberg 1986; Mason 2001), and other similar plant-based artifacts (Wright 2001; Ward et al. 1996; Teygeler and Porck 1995; Nichols 2004; Florian, Kronkright, and Norton 1990; de Poulpiquet 2012), few recommended a treatment plan that fit the JHU manuscript. Most of the manuscript artifacts addressed were treated as single sheet manuscripts or scrolls, where rigid housing could be used to permit a minimal intervention approach to any repair or stabilization of the manuscript leaves. The nested folio structure

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Fig. 1. (1) Folio 1, showing verso of detached leaf and recto of first attached leaf in the signature; (2) Stack of nine folders, housing nine folios of the birch bark manuscript; (3) Solander box housing, showing storage of the nine folios as they entered the lab in 2008.

of the JHU manuscript would not permit this sort of housing. The three dimensional artifacts of the literature rarely had to flex or move after treatment (beyond come expansion in changing relative humidity), whereas the pages of the JHU manuscript needed to be able to turn. The unknown contents and history of the manuscript also proved a troubling concern: any treatment proposal seemed very one-dimensional without knowledge of what the manuscript was, how it had come to be at JHU and what stakeholders there might be in its conservation.

DEVELOPING A TREATMENT PLAN

In the last several decades, as the conservation profession continues to mature, a number of "conservation treatises"

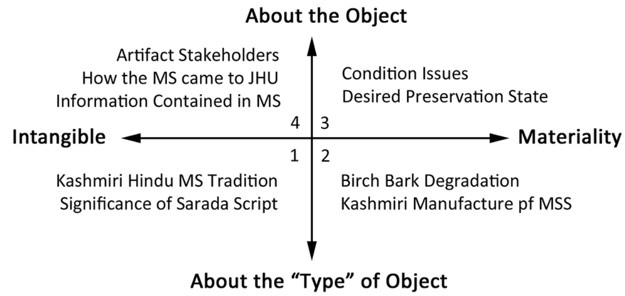

Fig. 2. Appelbaum's (2007) characterization quadrants, as used to collect information relevant to the treatment of the birch bark manuscript.

have been published that distil not only what we do in the course of treatment, but guide our collective thinking around why we make decisions in the way that we do. Clavir (2002) exhorts us to consider the values of the originators of objects. While her work was aimed particularly at First Nations artifacts, the thinking is also applicable for a Western caretaker of a religious artifact of Hindu origin. Muñoz-Viñas (2005) takes apart classical theories and then reconstructs a contemporary the theory of how we justify performing conservation treatments on cultural heritage materials. His work is useful in determining whether treatment indeed made sense in this case. Finally, Appelbaum (2007) provides a systematic framework in which to build our treatment plans. Indeed, all of the many different types of information used to build both the conservator's knowledge and a working treatment proposal for this birch bark artifact can be placed within the quadrants of Appelbaum's proposed characterization grid (see Figure 2). It is these four categories of information that guided the holistic treatment of this artifact: both the tangible and intangible history of the object, coupled with information on the broad class of Kashmiri birch bark manuscripts and on the minutia of this particular manuscript. It is these four categories of information that give the conservator confidence to treat an unfamiliar material.

BIRCH BARK AS A MANUSCRIPT SUBSTRATE IN KASHMIR

To address the first quadrant of figure 2, combining intangible information about the type of artifact, we seek information regarding the Hindu Kashmiri manuscript tradition. As geography figures largely into the use of birch bark as a manuscript substrate, we must specify that Kashmir will be used in the sense of the historic Kashmir Valley.[5] This is a small, isolated valley approximately 135km long and 32km wide located in the Himalayas, in the northern part of modern-day India.

The religious tenant of Ahisma (non-violence) shared by several Eastern religions means that while livestock was available in the valley (consider the Cashmere wool from fine-haired Himalayan goats), Hindu religious texts were unlikely to be recorded on an animal-based substrate (such as the parchment or vellum found in other manuscript traditions) (Wujastyk 2014). Prior to the introduction of papermaking in a given region, the use of plant-based manuscript substrates is dictated by availability: papyrus along the Nile and along the Mediterranean or palm leaf in the warm regions South East Asia. For the Kashmir valley, with its location in the Pir Pahjal Range of the Inner Himalayas, it is access to abundant amounts of the *Betula utilis*, or Himalayan birch growing at elevations of up to 14,800 feet according to Wikipedia that gave rise to a readily available manuscript substrate (Bühler, 1877).

Geography also plays a role in the writing system employed in the manuscript. Sanskrit, while also used for wide-ranging subjects such as philosophy, poetry, drama, and technical treatises in India and the surrounding area, is also the primary sacred language of Hinduism. The 1990's researcher identified the JHU manuscript as specifically being Sanskrit written in the Śāradā (or Sharada) script. This distinction is necessary because most written Sanskrit is found in the Devanāgarī script. Both Devanāgarī and Sharada are also used to write languages other than Sanskrit. Both writing systems are alphasyllabary and share a common historic root in the Brahmi script, but Sharada is the earlier, more conservative of the two. In a simplistic explanation, the scripts of the rest of the Indian sub-continent continued to morph and change to suit the other languages they were used to write, while the isolation of the Kashmiri Valley maintained the use of the earlier, previously more widespread, Sharada script in writing both Kashmiri and the Sanskrit used in sacred texts (Bhat, N.D.).

The practical ramifications for JHU manuscript are that many readers of Sanskrit will be unable to read this particular manuscript due to its less commonly used script. The close association of the use of Sharada script with a specific geography also permits clear identification of the manuscript as Kashmiri. Present day Sharada use/readership is very rare, with the exception of ceremonial use by the Kashmiri Pandit community. Persecution of this community in Kashmir in the late 1980's and early 1990's, notably including an ethnic cleanse of Hindus and Sikhs in the Valley on January 19, 1990,[6] caused an exodus of this community from Kashmir. This diaspora decreased the already limited transmission of the knowledge of Sharada to future generations. Kaw (2004) notes that today "there are but a handful of elderly Kashmiri Pandits that include few of their most eminent scholars who can read and write in Sharada script". The potential readers of the manuscript are therefore likely decreasing; if the manuscript were to be made available through conservation, this action arguably should happen sooner, rather than later.

MATERIALITY OF BIRCH BARK

Moving to the second quadrant of figure 2, still in the broad class of artifacts, but dealing with the tangible, we find ourselves concerned with the materiality of bark, as well as its degradation. Tree bark is comprised of the non-xylem (non-woody) tissues: the outer-most layers of cells. These layers consists of a number cell types, which broadly include the inner bark (secondary phloem), a living tissue serving primarily a vascular function for the tree in the transportation of nutrients, a middle layer called the cork cambium (phellogen), a consisting of cells capable of division to continually form the other bark layers as the diameter of the tree increases, and finally the outer bark (cork or phellem), a layer of dead tissue that performs primarily protective functions (Chang, 1954, Tsoumis 1991). The protective functions of the outer bark insulate the tree against mechanical damage, penetration of fungi and bacteria, as well as excess moisture evaporation during changes in relative humidity or temperature (Mikolaychuk 2005).

Paper conservators have some familiarity with inner bark in the form of paper making bast fibers: kozo, linen and hemp, for example are inner bark fibers. Inner bark is also used to produce bark cloth, where the fibrous bast is beaten into sheets (Wright, 2001). Birch bark manuscripts and artifacts are however made of the outer bark, specifically the inner layers of the outer bark; the weathered outermost outer bark layer is removed after harvesting.

The outer bark of birch trees in particular has an interesting structure: it forms in a manner similar to the "growth rings" of the xylem with a differentiation between early and late seasonal growth. This differentiation creates the laminar structure of the outer bark, with weak point between early and late growth. This laminate nature permits the relatively easy harvesting of the bark. Coupled with fact that the outer bark is dead tissue, harvesting occurs without killing the tree (Florian et al. 1990); birch bark therefore sees relatively frequent use as a cultural heritage material.

As mentioned above, in a single growth season early and late growth cork cells are differentiable: early thinner-walled early cells light colored and rich in betulin, thicker-walled late cells are darker in color and rich in tannins and suberin (Orsini et al. 2005). Betulin, when extracted, is a white, powdery triterpene that seems to serve an anti-fungal purpose. The extraction of betulin and numerous other triterpene compounds from birch bark has been carefully studied, as they are of much interest to the pharmaceutical industry for its anti-inflammatory and anti-viral possibilities (Abyshev et al. 2007; Chari et al. 1968; Jensen 1949). Salts of salicylic acid have also been reported, theorized to have an anti-insecticide property (Bhargava 1967). Tannins, dark red-brown in color, are antioixidants that are theorized to slow the biodeterioration of bark (Vane, et al. 2006). Suberin is a waxy, non-structural polymer composed of unsaturated fatty acids, which provides the bark with waterproofing properties (Florian et al. 1990). All of these substances have treatment ramifications, as tannins are noted as being water and alcohol soluble, while suberin, waxes and betulin and other triterpenes are soluble in organic solvents such as alcohols, ethers, aromatics and chlorinated solvents (Jensen 1949; Jensen 1971; Florian et al. 1990; Abyshev et al. 2007; Agrawal et al.1984).

The final defining characteristic of birch bark anatomy that is taken as relevant to conservation treatment is the contrast between the bark proper and the dark brown horizontal nodes, or lenticels. These lenticels provide a location for gas exchange and transpiration. The nodes also serve as a weak physical attachment point between the layers of bark, along with the various materials that cement the cells together: gums, pectin, and triterpene resins. Characterized by large intercellular spaces, the lenticels are both physically and chemically very different from the rest of the bark proper. All bark is noted to have lower proportions of cellulose and hemicellulose than wood (Tsoumis 1991), but nodes contain even less of these familiar (to paper conservators) structural substances—as such they are much more brittle. Suryawanshi (2006) finds that birch bark proper contains 12%(w/w) cellulose (of a degree of polymerization between 250-500), while the lenticels showed negligible amounts of cellulose. Lignin levels in the bark were recorded as 18%(w/w) in the bark, with 4%(w/w) in the nodes.

The consequences of this materiality for conservation are that birch bark is remarkably resistant to both fungal and insect damage, due in large part to the properties of betulin. Structurally, however, the laminate does not fair well. Becoming embrittled with time, not only does the adhesion between layers decline as the natural gums and resins desiccate, but the individual layers become less able to flex. Moisture loss and differential response of early and late cells to relative humidity changes encourages curling, and delamination, and the nodes, with less flexibility to begin with, become a fracture point. The final point of note is that if the degree of polymerization of the cellulose found in the bark proper is only 250-500, and if there is only 12%(w/w) cellulose to begin with, a paper conservator cannot rest on their knowledge of how a paper-based cellulosic responds to form a treatment plan for birch bark.

EVIDENCE OF MANUFACTURE

To complete the second quadrant of figure 2, we additionally seek information about how this sort of manuscript was made. Very little information has been recorded about the specific procedures used to harvest and process birch bark in Kashmir for the purposes of manuscript preparation. Most authors cite Al-Biruni's 11th century "History of India", an Arabic written based on his 1017 travels to the region: "They take a piece (of bark) one yard long and as broad as outstretched fingers of the hand […] and prepare it in various ways. They oil and polish it so as to make it hard and smooth and then they write on it."(Agrawal and Bhatia 1981). Agrawal (2010) further describes the technique: "The outer bark after peeling off the tree is discarded and the inner bark, which also peels off easily, is almost paper thin, very supple and flexible. It was first of all dried in the shade; an oil was applied over it and then polished with a smooth and hard stone like agate. It was then cut to the required size and written upon with pen and ink." Authors frequently cite Bühler's late 19th century report to the Royal Asiatic Society, where he describes half a dozen or more leaves as being folded and sewn together, stored between rough leather or two rough wooden boards (Witzel 1994; Kaw 2004; Suryawanshi 2000). In this report, Bühler notes that by the time of his visit, paper had superseded birch bark as the primary manuscript substrate "…and the method of preparing [birch bark] has been lost. It is at present impossible for the Kaśmîrians to produce new birch-bark MSS.…As matters now stand, there are no birch-bark MSS. much younger than two hundred years"(Buhler 1877).

Examining the JHU manuscript closely held some further clues regarding manufacture. While no direct visual evidence was found for the oil mentioned by the references above, or particularly for the burnishing techniques described, other conclusions could be drawn. For instance, the folded bark leaves appear to be a mixture of natural laminates (layers that grew together on the tree in the order in which they appear in the manuscript) and artificial laminates (layers that were trimmed separately and have been adhered together with mechanical action and the possible addition of an adhesive). The evidence for the former is found in the matching pattern of lenticels on some adjacent layers (see figure 3), while the evidence for the latter is found in a mismatch of knife trimmed edges, misaligned lenticel patterns, and evidence of pounding-type tooling marks visible in raking light (see figures 4 and 5). Some of the thinner artificial laminates exhibited a wrinkled, reticulated pattern that could indicate some sort of differential shrinking due to application of an aqueous adhesive used in lamination; this is a tentative hypothesis, as no analysis was completed to confirm the presence of an additional adhesive (see figures 4.1 and 5.2).

Further tooling marks show that each folio was folded a full 180 degrees in four places, pounded with some sort of rounded tool, and then unfolded and flattened again. These four folds served to create ruling lines that bracket the text, to guide the scribes in creating straight columns of text of uniform width (see figure 6). These folds also indicate that the bark was once much more supple than it is at present.

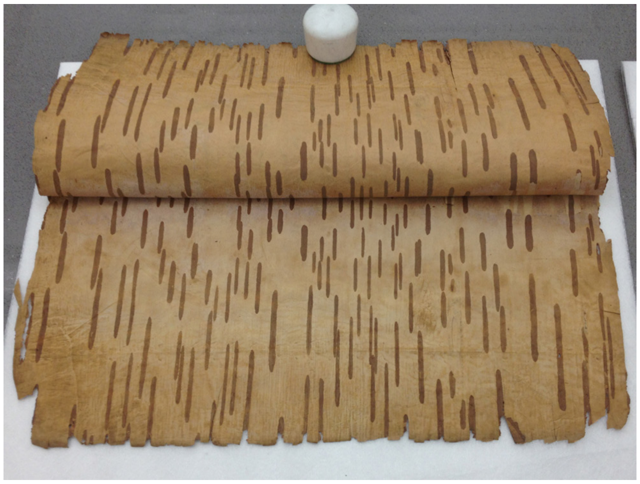

Fig. 3. Matching lenticel patterns between layers of bark, indicating these layers comprise a natural laminate.

Fig. 4. (1) Mismatched lenticels, cockling of one layer that could indicate wet adhesive use, and (2) inconsistent margin trimming of layers; evidence indicates that some laminates were constructed.

Fig. 5. Tool marks found on manuscript pages: (1) local hatch marks over a bark flaw, (2) small hatch marks to secure an area in the middle of reticulation patterns possibly indicating wet adhesive application to join layer, (3) cross-hatching in an even, fairly regular pattern overall on a leaf, and (4) more irregular cross hatching over a locally over a wide bark flaw.

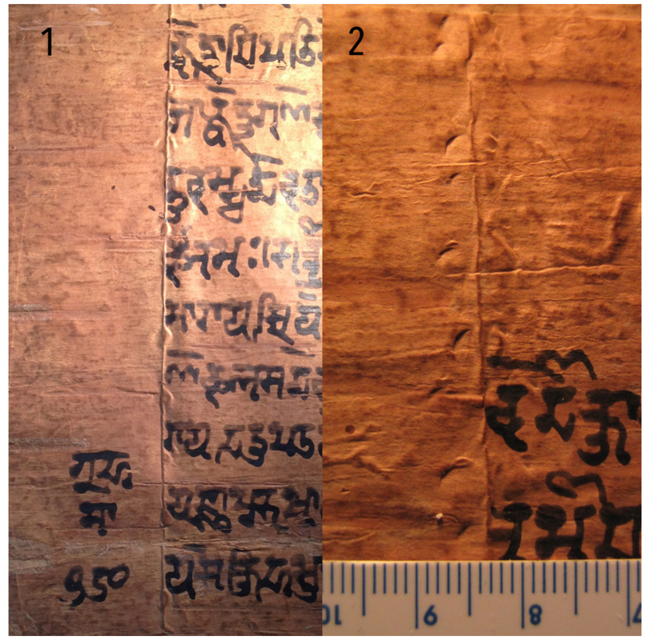

Fig. 6. (1) Ruling line verso viewed in raking light with (2) a closer detail of the recto showing rounded tool indentations and a sharp fold line. The ruler is a centimeter scale, subdivided into millimeters.

ARTIFACT CONDITION

We now move to fill in data for quadrant three of figure 2: we examine the specific physical object, its condition, and seek to determine a course of treatment to guide it toward a determined desired state of preservation. This quadrant is perhaps that most traditionally associated with the work of conservation, as its data is generally contained within a standard condition report and treatment proposal.

The manuscript as it entered the conservation lab suffered from a number of condition issues. To aid in project planning, a spreadsheet was used to track the condition of each leaf and permit extrapolations of treatment times; the overall condition issues and the number of sheets affected by each are summarized in the table below. Each bark laminate ranged from three to seven layers; most pages consisted of five layers of bark. Overall handling the manuscript was very difficult in its initial condition: curling at the edges coupled with running horizontal tears and delamination of bark layers made it non-trivial to ascertain where the layers of one page stopped and the next began. The bark, while still surprisingly supple (draping beautifully as pages were turned (see figure 7.1)), was locally very brittle. Small fragments detached easily, and over the course of the manuscript's history, friction between the nested leaves and the adjacent folios (as well as between the folios and their archival paper storage folders) had resulted in both small and quite extensive delaminations of the top, text-carrying layer of the bark. The fact that the bark had

Condition issue	Description	# of pages affected	Relevant image(s)
Delamination of bark layers	Layers of the (natural or artificial) bark laminate were in some places almost completely detached; more often local areas of detachment were found adjacent to other areas that were still firmly attached.	57 major; 28 medium; all 176 with perimeter delamination	See figures 7.1, 7.2
Splitting, cracking or tearing	The bark is anisotropic, tearing primarily in the horizontal direction. Splits may run through one, several, or all of the bark layers of a leaf. Often complex "shelves" of tears occur: the split in one layer is displaced several millimeters from that in the next layer. Fragmented nodes can be a starting point for splits.	65 with major splits; all 176 with minor splits	See figures 7.2, 7.4
Surface dirt and efflorescence	Dirt, dust and caked on mud (particularly at head and tail) or waxy efflorescence (likely betulin or suberin that migrated to the bark surface over time) presented the surface cleaning questions.	19 cases of waxy efflorescence; surface dirt on all 176	See figure 7.3
Complete detachment along spine fold	The spine fold was often weak and partially broken at head and tail, but in most cases remained intact in the inner parts of a signature. The outer leaves in any folio were the most damaged; several detached leaves accompanied each folio.	19 completely detached leaves; 3 were also torn into several pieces	See figure 7.4
Curling of bark	Most curling was located around the edges, particularly the fore-edge. Often coupled with splitting and delamination. Layers of one page could be curled around those of the next.	All 176 to varying degrees	See figures 7.7, 7.8, 7.9
Loss of text layers	Delamination of the top text-carrying layer was observed in both natural (figure 7.5) and artificial laminates (figure 7.6).	29 major text losses; many minor losses	See figures 7.5, 7.6, 7.7

Table 1. Condition issues affecting the birch bark manuscript prior to treatment.

Fig. 7. Before treatment condition Issues: (1, 2, 5, 6) full and partial delamination of layers; (3) surface dirt and waxy surface efflorescence (3); horizontal splits through (2) single layers and (4) through entire leaves; loss of text due to delamination of (5) a natural laminate and (6) an artificial laminate; partial curling of edges at the (7) spine, (8) fore-edge, and (9) entangling multiple leaves of bark together (9); former bark suppleness indicated by (10) a hard fold in localized area.

been much more supple prior to aging was evidenced in the fact that some full folds were found in the manuscript (figure 7.10); the bark could not presently stand for even a 60 degree angle without breaking. Indeed, small fragments were easily accidentally broken from the bark edges with only the slightest flexing or handling.

CASE FOR CONSERVATION

To inform the decision to perform a time-intensive conservation treatment, we now move onto the fourth and final quadrant of information for figure 2: the intangible side of this specific manuscript. Under consideration are the more curatorial aspects of this manuscript. How did the manuscript come to be at JHU in the first place? What value does the manuscript hold? What sort of information does it contain, and who are its present stakeholders (in addition to the Kashmiri Pandits discussed above)?

The manuscript's presence at JHU can be traced back to Dr. William Stratton. Stratton received his PhD studying Sanskrit and Comparative Philology at JHU in 1985, studying under renowned philologist, and then-Chair of Sanskrit Literature, Maurice Bloomfield. Stratton then moved to Lahore to become Principal of the Oriental College there, as well as Registrar to the Punjab Museum in 1899; during this time, he toured Kashmir, presumably acquiring the manuscript. He unfortunately contracted "Malta fever" shortly after moving to India, dying in 1902 (Bloomfield 1902). Upon his death, his widow left his papers, including the birch bark manuscript, as well as several other Sanskrit manuscripts on paper, to the JHU libraries.

During his 1990's manuscript survey, Dr. Christopher Minkowski identified the artifact as being a genre of manuscripts called rcaka or the "text that has verses in it." In Dr. Minkowski's words such a manuscript "usually begins with passages copied from the […] Vedas, but then proceeds with a collection of various ritual manuals. Each [manuscript] is different, because each one is prepared by a Kashmiri pandit/priest for his own use. Therefore various things may be copied into it that are not preserved elsewhere, and it cannot be predicted all that will be found in any individual [manuscript]." After noting that it is rare to find in an American collection, Dr. Minkowski stated that the manuscript seemed to contain some rather unusual and interesting ritual practices (Minkowski, 1996). Dr. Minkowski examined the outside of each signature only, but was unable to find a colophon. He dated the manuscript as 18th century or earlier, as this was the latest date that he knew of such manuscripts on birch bark being produced (Minkowski, 1999).

Dr. Alexis Sanderson of the Oriental Institute at All Souls College, Oxford examined digital images of some of the manuscript and further identified the manuscript as "'A Guide to the Rituals of the Kashmirian [Brahmins]'. In such texts we find the procedures for and Mantras to be recited in the various rituals that are performed by Kashmirian priests for the families they serve." Sanderson viewed several early pages of the before treatment documentation images of the manuscript, digitized and among other observations stated that "the manuscript seems to me to be likely to reward close study, being rather older than most that I have seen" (Sanderson, 2013).

Acknowledging that the manuscript was likely to contain unique information, that the constituents who could read the script in the manuscript were unlikely to be getting larger (both within the Kashmiri Pandit community (see the discussion of the Sharada script, above), and within the scholarly academy)[7] and that the stakeholders in the manuscript were unlikely to be geographically located near Baltimore, MD, the logical conservation path was deemed to be stabilization of the manuscript sufficiently to permit access to the manuscript through digitization. "Sufficiently" in this case was to include surface cleaning, stabilization of layers (including uncurling the edges, re-adhering delaminations and repairing splits and tears), and rehousing in a manner to prevent further future loss of text layers due to friction either between the manuscript pages or with the housing materials.

TREATMENT STEPS

Only several of the treatment steps (surface cleaning and uncurling bark edges), will be discussed in depth in this article. Adhesive and repair material choice will be touched on more globally. Together, these treatment "vignettes" will be used to illustrate the process by which treatment decisions were made.

For surface cleaning, the literature indicated that organic solvents could not be brought in contact with the bark, due to the possible extraction of up to 20%(w/w) of bark components, causing color changes as well. Likewise, hot water could leach from 1-4%(w/w) of bark extractives; alkalis and acids similarly need to be avoided (Agrawal 1984; Agrawal and Suryawanshi 1987; Anastassiades 2001). Cold water, however, was demonstrated in the same studies to have little to no solvent effect on any bark components, though one author (Yamuachi 2009) did note some removal of color with water; in the case in question it was theorized to be a colorant added to the bark (orpiment). Monitoring test cleaning of the JHU manuscript under the microscope, natural rubber sponges (Absorene® soot sponges) and DI-water moistened cotton swabs proved viable methods to removed caked on dirt and mud and to reduce the waxy surface efflorescence without altering the bark surface (see figure 8). Purchased sterile cotton swabs proved more cohesive and less likely to catch on brittle bark fragments than self-rolled swabs. It was established that the surface efflorescence was an original bark material, however, its surface deposition was deemed to decrease the contrast of the text sufficiently to warrant some reduction prior to digitization.

When the conservation labs looked at treating the JHU manuscript in the 1990's, one leaf was humidified with water vapor. At the time, they found that any relaxation of the bark was insufficient to flatten the curled edges. By 2008, the treated leaf was more completely delaminated around the edges than the majority of the other leaves. As such, relaxing the curled bark relied heavily on the work investigating the use of solvent fumes to plasticize bark (Gilberg 1986; Gilberg and Grant 1986). Methanol was shown to be the most promising solvent in this work, but as the research to date had primarily been performed on a North American species of birch, and due to the greater toxicity of methanol, simple in-lab trials were used to compare ethanol and methanol vapors.

Using a compound microscope with a motorized stage and an integrated digital camera, it was possible to secure a

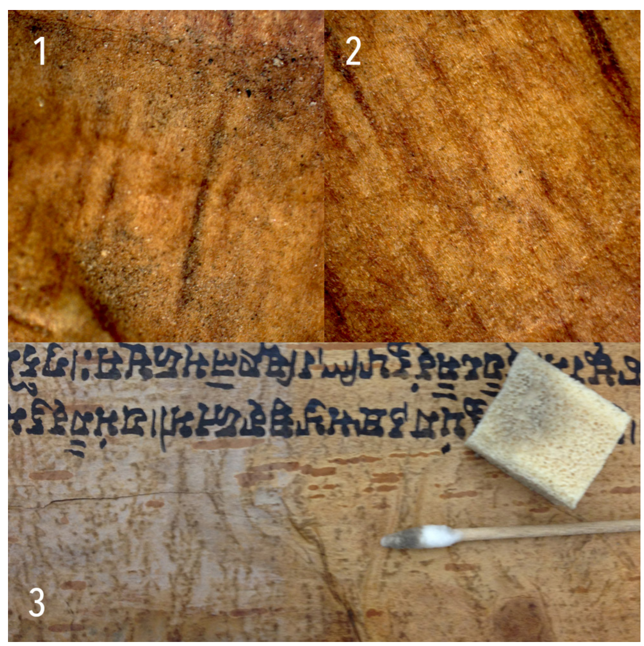

Fig. 8. 100X magnification (1) before and (2) after cleaning with a DI water-dampened swab. (3) An area of waxy surface efflorescence and light grime, shown before (left) and after (right) cleaning with a smoke sponge and a damp cotton swab.

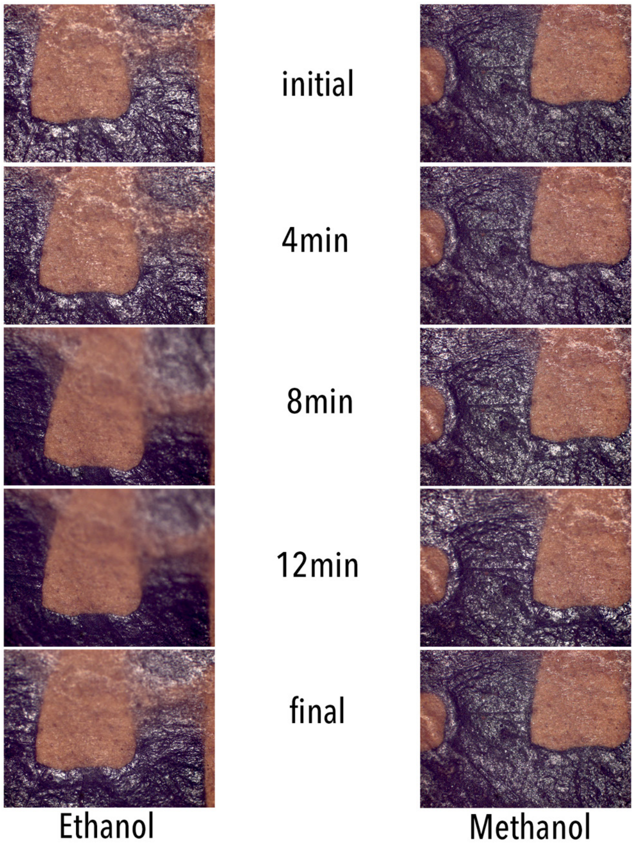

Fig. 9. Solvent vapor tests, under 50X magnification with timed exposure to ethanol (left column) and methanol (right column) solvent vapors. The initial image is recorded before any solvent vapor is applied; the final image is recorded after several minute of evaporation. More movement of bark components is visible with the ethanol vapor.

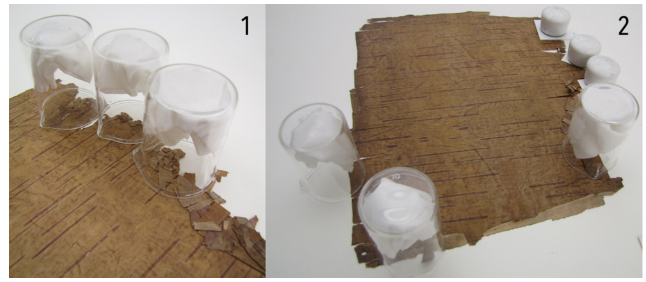

Fig. 10. (1) Solvent chambers made of inverted beakers with lightly methanol-dampened tek-wipe wadded inside and (2) the light weights and blotters used to plasticize and re-align bark layers while the solvent chambers worked elsewhere on the leaf. Full alignment often required multiple solvent vapor applications.

Fig. 11. Bark before and after realignment by methanol vapor plasticization: (1) effective through many layers with multiple application of vapor, and (2) useful on very fragmentary pieces of bark.

bark sample to the stage, record an image at 50X magnification, drop the stage and expose the sample to a solvent vapor for a set period of time and then raise the stage to exactly the same location to record another image. In such a manner, two bark fragments containing ink lines were imaged after exposure in four-minute intervals to a cumulative twelve minutes of either ethanol or methanol vapor. The final image was recorded after an additional twelve minutes of wait time, to allow most, if not all of the solvent to evaporate from the bark. More perceptible change in the surface, including possible re-deposition of a waxy surface efflorescence, was visible with the ethanol-exposed sample than the methanol-exposed sample (see figure 9).

A system of small inverted beakers with wadded absorbent materials (cotton or tekwipe) lightly dampened with methanol kept solvents use to a minimum. After plasticization, very light weight over blotters kept the bark in its new alignment (see figure 10). The same area of bark could be exposed to solvents several times in order to slowly align all of the individual layers. The plasticization was effective even on very small, brittle-looking areas of bark (see figure 11).

Adhesive and repair material choice presented another interesting challenge. The literature speaks of cellulose ethers (Agrawal 2010; Anastassiades 2001; Shah 1993; Gilroy 2008; Yamuachi 2009; Suryawanshi 2000), starch pastes (Nichols 2004; Teygeler and Porck 1995; Majumdar 2000; Anastassiades 2001; Agrawal and Suryawanshi 1987), or combinations of the two (Ubbink 2011; Nichols 2004). Other authors have tried animal glues, gelatin or isinglass (Bentchev 2003; Agrawal and Suryawanshi 1987; Anastassiades 2001) or have experimented with synthetic adhesives (Anastassiades 2001; Agrawal and Suryawanshi 1987; Bentchev 2003; Gilberg and Grant 1986). In the case of the JHU manuscript, sensitivity to Hindu nature of the manuscript precludes use of animal-based adhesives, and synthetic adhesives seemed likely to be far too strong and tacky. Both methyl cellulose (A4M, 1%) and mixtures of wheat starch paste and methyl cellulose (1:1) seemed to perform well. However, in the end the author's greater familiarity with the working properties of wheat starch paste, as well as its great versatility at different concentrations seemed to produce the best and most consistent repair results. Very dilute paste worked well for re-laminating separated layers; slightly more concentrated paste served for local repairs with various Kozo fibred Japanese papers. The matte quality of paste also served the project well. The choice of a single adhesive, rather than switching between methyl cellulose and paste for different types of repairs, also worked best for consistency in treatment when two project conservators, Vania Assis and Cristina Morilla, began also working on the manuscript.[8]

CONCLUSIONS

There is nothing particularly unique about the approach taken to treat this manuscript. Each treatment requires the conservator to fill in many of the spaces in a mental grid like the one found in figure 2; we often just fill in the data without explicitly contemplating each component. Information from literature surveys, conversations with colleagues in either conservation and in allied professions (curators, scholars or researchers, industry etc.), examinations of the construction and condition of the artifact in question, and testing of treatment options directly allows conservators to map a course of treatment (or non-treatment) appropriate to the artifact at hand. As such, we are constantly expanding our limits: often it is just a bit at a time, with artifacts close to our comfort zones. Then, every so often in the course of a career, we confront the unexpected: we stretch our capacities, and take on an unusual artifact or problem that not only broadens our limits, but causes reflection on how and why we do what we do.

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NOTES

1. This is the fourth item in the 1994 AIC list of "principles that guide conservation professionals and others who are involved in the care of cultural property", which goes on to conclude "as well as within the limits of the available facilities".
http://www.conservation-us.org/docs/default-source/governance/code-of-ethics-and-guidelines-for-practice.pdf?sfvrsn=7 (accessed June 17, 2016)
2. This is the fifth principle of ethical behavior listed in the third edition of the CAC/CAPC code of ethics, 2000 (reprinted 2009). https://www.cac-accr.ca/files/pdf/ecode.pdf (accessed June 17, 2016)
3. Note that the term "leaves" is used throughout this article in the anatomy of a book sense (each leaf of a book is two pages, a recto and verso), rather than in a plant biology sense.
4. Professor Christopher Minkowski, then of Cornell University, now the Boden Professor of Sanskrit at Balliol College of Oxford University, performed a survey of Sanskrit manuscripts in several University Library Collections in the United States.
5. As opposed to the modern administrative division of the same name inside the Indian state of Jammu and Kashmir.
6. The history of people groups in the Kashmiri valley is very complex and still very politically fraught (as are the modern borders of Kashmir). Some further insights can be gained into the referenced events by reading the various articles linked through the "Kashmiri Pandit" Wikipedia article, but to fully examine the nuance of this subject is beyond the scope of this paper. https://en.wikipedia.org/wiki/Kashmiri_Pandit (accessed June 27, 2016)
7. Scholarship of area of Indology is not as wide spread as during the 19th and early 20th century; for instance, there is no longer a Chair of Sanskrit Literature at JHU, a position that was quite renowned. The author was quite encouraged to see, however, while preparing for the talk on which this paper is based, that there has been resurgence in interest inside India in reviving Sharada. A New Delhi-based NGO (Millennium India Education Foundation) is partnering with the Special Centre for Sanskrit Studies, Jawaharlal Nehru University to continue education of the script. See "Reviving the dying Kashmiri script" http://www.dawn.com/news/1205725 (accessed June 28, 2016)
8. Funding was secured to bring in two project conservators. Vania Assis and Cristina Morilla worked intensively on the project for several months, each treating close to a third of the manuscript pages. Their contribution was invaluable as each brought treatment knowledge of palm leaf, papyrus or tapa bark cloth materials.

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