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Local Strengthening of Mould-Damaged Manuscripts

A Case Study on Logbooks of Early French Expeditions in Louisiana (1684-1722)*

The National Archives in Paris house the logbooks of early French expeditions in Louisiana, preserved in their original binding. They raise current conservation issues specific to archival materials: iron gall inks are relatively well preserved but the paper is extremely weak on the edges, as a result of old water damages and micro-organisms growth. Using local consolidation techniques to strengthen the paper of these documents would prevent us from removing the bindings, hence allowing for minimal interference. But these methods generate a substantial number of risks: formation of tide lines more likely to turn brown over time, local distortion of the paper, and iron gall ink migration. Often underestimated, the latter aspect should prevail in the decision-making process. Indeed, the formation of halos around and on the verso of the ink lines is often barely noticeable to the naked eye, but always comes with a migration of iron-ions, which is particularly detrimental to the manuscripts. We therefore sought the parameters of a local re-sizing technique that would limit, as much as possible, tide lines, distortions and ink migrations. We finally opted for a 2 % Klucel G® in ethanol as adhesive and re-sizing agent. The solution was applied directly with a brush on damaged areas, in a local procedure combining re-sizing, lining with Berlin tissue, and infilling. This study provides an alternative to existing treatments that usually employ water based adhesives. It allows a satisfactory local consolidation and preserves the original feature of the ink, the paper, and the binding.

Lokale Verstärkung schimmelgeschädigter Manuskripte: ein Fallbeispiel von Logbüchern früher französischer Expeditionen nach Louisiana (1684–1722)

Das Nationalarchiv in Paris beherbergt die original gebundenen Logbücher früher französischer Expeditionen nach Louisiana. Während die Eisengallustinten relativ gut erhalten sind, ist das Papier an den Kanten durch alte Wasserschäden und Mikroorganismen-Befall extrem geschädigt. Eine lokale Konsolidierung würde den Erhalt der originalen Bindung erlauben, birgt jedoch auch Risiken: das Entstehen von Wasserrändern, die sich im Laufe der Zeit verfärben, lokale Verformung des Papiers, Migration von Eisengallustinten. Oft unterschätzt, könnte Letztere den Entscheidungsprozeß entscheidend beeinflussen. Die Bildung verfärbter Bereiche neben und unter den Tintenbereichen ist für das bloße Auge meist kaum sichtbar, jedoch führt diese immer zu einer Migration von Eisenionen, welche besonders schädlich für Manuskripte ist. Die lokale Nachkleimung sollte die Bildung von Wasserrändern, Verformungen oder Tintenmigration verhindern. Zum Nachkleimen wurde dabei Klucel G® in Ethanol (2 %) gewählt, welches direkt mit einem Pinsel auf die geschädigten Bereiche aufgetragen wurde. Diese Methode kombiniert Nachkleimung, Kaschieren mit Berlin Tissue und Fehlstellenergänzung und bietet eine Alternative zu existierenden Behandlungen, die normalerweise wasserhaltige Klebstoffe verwenden. Es erlaubt eine erfolgreiche lokale Konsolidierung und bewahrt die originalen Merkmale der Tinte, des Papiers und der Bindung.

The National Archives in Paris houses one of the most precious collections of French expedition logbooks. Inherited from the 'Service hydrographique', previously 'Dépôt des Cartes Plans et Journaux de la Marine', the so called '4JJ'-series consists of 477 documents mainly identified as everyday logbooks, exploration reports and their abstracts. These abstracts were prepared between 1736 and 1742 by the 'Dépôt des Cartes Plans et Journaux de la Marine' whose mission was, among others, to collect logbooks in order to produce nautical maps. The Conservation Centre of the National Archives is currently working on this collection as part of a larger project [1].

This article reports a one year graduation project focused on the conservation of the box 4JJ14, containing the documents of the very early voyages trips to Louisiana (1684-1722). These documents, sixteen logbooks, were chosen because their condition was deemed quite representative of the whole collection (4JJ).

Condition of the Documents

The manuscripts, written with iron gall ink [2], are bound with more or less developed book binding structures, made before or shortly after the journey. As the bindings are contemporaneous with the expeditions, they convey information about the prac-

tices in use at that time by the writers, the bookbinders and the persons in charge of collecting this type of record. The structures are also specific to the logbooks (Fig 1): simple quires covered with white or marbled papers and stationary vellum bindings, generally stiff board with laced-in sewing supports. This 'original state', combined with its specificity, led us to consider minimal intervention preserving all aspects of the physical object as well as the text for the information they provide on the document's history and use.



1 The 16 logbooks of early French expeditions in Louisiana (Service hydrographique, Marine 4JJ14, National Archives). © G. Vanneste/INP.

The text block condition was problematic, raising current issues specific to archival materials. First, the inks are in different conditions: in some cases, they became very pale in the course of writing, as if the author was running out of ink and diluted it during the expedition (Fig 2a). In other cases, the leaves show evidence of damage from moisture, which has generated a significant migration of ink through the paper (Fig 2b). Furthermore, a characteristic deterioration of the paper by the ink is sometimes visible, causing few tears and small losses. These remain fortunately very local (Fig 2c). However, the writing is generally fairly well preserved and the text remains easily legible.

The major problem emerging from these documents does not come from the ink as much as the paper itself. Some of the logbooks have suffered from significant water damage on the edges combined with rodents and micro-organisms attacks (Fig 3). The paper has lost its strength and has become soft and spongy with areas of loss, fragmentation, and thinning clearly visible. This weakening is localized but often repeated on every sheet, preventing from proper handling and threatening the physical integrity of the documents.

Background

A Local Approach: Relevance of Partial Re-Sizing

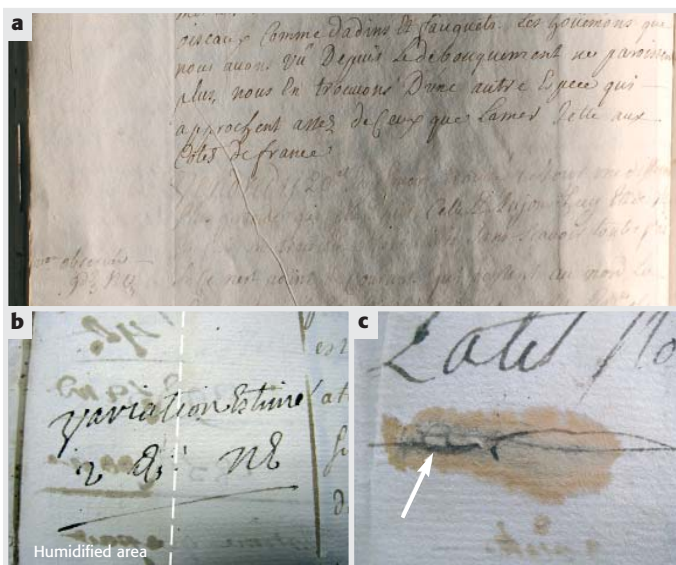
One concern was to avoid the removal of the bindings in order to respect the historical value of the documents. A local approach was therefore adopted, since the degradation of the paper was localized along the edges. Local strengthening techniques that would consolidate the deteriorated areas only were investigated. This approach presents the added advantage of preserving the original properties of undamaged areas, especially those containing iron gall inks in good condition. Two consolidation techniques were then considered: partial re-sizing and localized lining.

In the paper industry, sizing aims to make the paper less permeable to water. In conservation practice, the rationale is different. The main purpose is to enhance the mechanical properties of the paper. It is generally applied on papers that were weakened by micro-organisms, or that supported immersion treatments, like washing, bleaching or deacidification (Baker 1992; Henry 1986; Seki et al 2005, 2009; Strnadová and Durovic 1994). It then aims to impart strength, improve the 'feel' of the sheet and reintroduce characteristics lost through degradative influences or conservation treatments (Henry 1986).

Overall re-sizing treatments are often mentioned in the literature, but localized interventions are rarely studied because they are hardly practiced. This reluctance of conservators is partly due to the risks that are inherent to local interventions. The application of an adhesive, often aqueous, on a portion of dry paper can cause distortion, discolouration, and tide lines at the wet/dry interface. Partial re-sizing has been first explored (Ribbans 2006) to compare the effect of methylcellulose and gelatine on the appearance, brightness, and pH of modern laboratory paper (Whatman no1) previously boiled in order to reproduce degradation. Yet, it appeared necessary to further this work by studying other adhesives and papers and assessing, among others, the risk of halos formation.

Risks Related to the Presence of Iron Gall Inks

Aqueous treatments are likely to cause a migration of brown products coming from the ink and/or from the paper. A previous work was undertaken on this subject (Rouchon et al 2009), and showed that most of the brown halos formed around the ink lines are hardly visible in a context of conservation practice. However, these colourations come with a significant migration of iron in the paper, known to be detrimental to its proper conservation.



2 Ink deterioration (the Durance logbook, no 13: **(a)** fading of the ink (dilution issue); **(b)** ink migration through the paper (humidity/water); **(c)** ink corrosion on paper (oxidative and hydrolytic degradation of cellulose). © G. Vanneste/INP.



3 Paper degradations (the Durance logbook, no 13): **(a)** Water stains and tide lines along the edges (UV light); **(b)** Micro-organism damages (upper corner of the text block). © G. Vanneste/INP.

Tab 1 Adhesives selected.

Name	Product name	Composition	Supplier	Manufacturer	Solution	Brookfield viscosity (mPa.s)*
<i>zin shofu</i>	Zin Shofu®	Wheat starch	Atlantis (Fr)	Paper Nao (Japan)	Distilled water	–
<i>gelatine</i>	Gelatine B 225	Type B bovine gelatine with medium bloom degree (225) (reference: 225LH30)	Rousselot (Vion Cy, The Netherlands)	Rousselot (Vion Cy, The Netherlands)	Distilled water	–
<i>methocel</i>	Methocel® A4C	Methylcellulose	Dow Chemicals (USA)	Dow Chemicals (USA)	Distilled water	350-550
<i>tylose</i>	Tylose MH300P®	Methylhydroxyethyl-cellulose	Stouls (Fr)	Shin Etsu (Japan)	Distilled water	180-300
<i>klucel</i>	Klucel G®	Hydroxypropylcellulose	Stouls (Fr)	Hercules (USA)	Ethanol (> 99 %)	125-450

* Brookfield viscosity is measured at 20 °C for 2 % solutions prepared in water (fabricant information).

Paradoxically, humidification treatments considered to be the less invasive ones, such as those using Gore-Tex®, are precisely causing the most obvious migrations: when soluble compounds are not extracted in the solvent, they migrate into the paper (Reissland 2001: 111). To prevent such migrations, there are two recommended approaches. One is to keep the documents at a relative humidity below 80 %. The other is to immerse the documents in water in order to wash out most of the soluble detrimental products. In this case, water must not be mixed with alcohol and the immersion should last for a sufficient amount of time (about 30 minutes). However, this method can appear drastic, since the manuscript composition undergoes significant chemical changes during this type of treatment. Moreover, both, the paper and the ink, especially when the latter has already faded, can become lighter, thus making the text less legible.

Only simple aqueous treatments were investigated in order to ensure a satisfactory reproducibility of the experiments. These treatments do not fully represent more sophisticated techniques usually used in a conservation workshop. In particular, different methods of re-sizing, using various adhesives at different concentrations, were not investigated. Gelatine is often recommended and sometimes used to treat iron gall ink manuscripts (Kolbe 2004; Smith 2007). This adhesive, as a re-sizing agent, presents the advantage of making paper less permeable to water (Duplat et al 2008). Therefore, it provides a better protection in high humidity and is generally recommended for re-sizing paper after immersion treatments. In these cases, if the immersion time is long enough, the soluble compounds are extracted, thus limiting the risks of migration. On the contrary, choosing a local approach on untreated documents involves risks of ink migration. Those risks prevail over other criteria when selecting an adhesive and thus must be estimated in conditions as close as possible to those of a workshop.

Research Purpose

The aim of this study is to evaluate the possibility to use partial re-sizing techniques on iron gall ink manuscripts that suffered from mould damage on the edges and were never treated before. Two directions were investigated. The first deals with the choice of a local re-sizing technique and its side effects on paper. The

second deals with the risk of ink migration compared with other re-sizing procedures that are currently in use in conservation centres.

Choosing a Local Re-Sizing Technique Suitable for Paper

Adhesives and Procedures

Five widely used adhesives were selected for this study: Tylose MH300P®, Methocel® A4C [3], Gelatine B225, Klucel G® (soluble in ethanol) and Wheat starch paste (Zin Shofu®). Their specifications are summarized in Tab 1. Among the various methods of re-sizing, the most commonly cited by conservators are immersion and brush application (Henry 1986). Immersion is not suitable for local application, because it increases the risk of tide-line formation. Thus, preliminary tests were conducted in order to select an application technique that would, a priori, be appropriate for mould damaged paper containing iron gall ink, in the context of a conservation studio.

Several methods were tested: reactivation of a dry gelatine film placed on the paper surface, spray of a gelatine solution, and application with a brush directly on the paper or through a non-woven polyester fabric. Finally, a direct application with a brush proved to be the most suitable in terms of ease, handling and aesthetic results [4].

Which Concentration Strengthens the Paper?

The ability of adhesives to strengthen papers that are mechanically damaged by micro-organisms was evaluated empirically on original documents. The samples come from blank leaves, deteriorated by mould through all their thickness. The five adhesives (Tab 1) were prepared at concentrations ranging from 1 to 5 % and applied on the weakened areas, using the brushing method described above [4].

After drying, the samples were manipulated by three paper conservators to evaluate how re-sizing improved the strength of damaged areas. A consensus was quickly reached regarding the concentration at which each adhesive sufficiently strengthens the paper without stiffening it: 1 % for *gelatine*, 3 % for *klucel*, and 2 % for *zin shofu*, *tylose* and *methocel*.

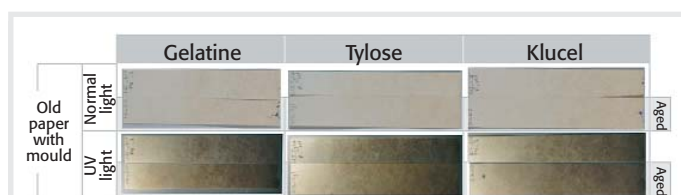
Risks of Tide-Line Formation and Paper Distortion

The re-sizing treatment, when applied locally, is likely to induce paper distortion, tide-lines and a change in paper surface appearance. These side effects, although minor compared to those related to ink migration, were evaluated in the first instance on an old mould damaged paper, submitted to artificial ageing [5]. All adhesives were applied with the concentrations selected above. These preliminary tests gave very encouraging results: no colour change between blank and treated areas was visible (Fig 4); no tide lines could be observed under UV or visible light (Fig 4); no change in surface appearance (gloss, texture of the paper) could be noticed (not shown). However, water-based adhesives tended to cause dimensional changes, which were limited when the paper was dried under weights.

These effects were further evaluated on another original paper and on a laboratory paper (Whatman no 1). The latter appeared relevant to us despite the fact that its chemical composition consistently differs from that of an 18th century handmade paper. In fact, its colour is close to white, making subtle colour changes more likely to be detected. Whatman paper is also extremely hydrophilic and warps easily. Finally the formation of tide lines can be recreated on this paper (Dupont 1996).

One millilitre of each adhesive was dropped off with a pipette on the two types of paper. Samples were then dried stretched, with their edges clipped between two cardboard frames. The sandwiched samples were held horizontally raised from the table surface during the air drying process to avoid any contact. Some of them were artificially aged for three months [5]. The pictures taken with grazing light (Fig 5) confirm that all aqueous treatments created distortions. Only *klucel* in a 2% ethanol (> 99.5%) solution does not cause dimensional changes. Tide lines and discolourations of the paper are generally better visible under ultraviolet light, although the reasons of their formation are not fully understood yet (Dupont 1996). These fluorescent compounds are known to disappear during the natural ageing of paper, replaced by visible yellow brown discolouration specific to water stains. Tide lines are observed on every sample, including on the un-aged Whatman paper only submitted to a drop of pure water (Fig 5). These tide lines are more pronounced on the original paper, probably because size and degradation products are dissolved in the drop and get more concentrated along the migration front, as watercolour pigments would do.

Among all adhesives, *klucel* generates the least-noticeable halos on both original and laboratory papers (Fig 5), under



4 Partial re-sizing (brush method) of old damaged paper through artificial ageing tests. Only the right part of the samples (with mould) has been re-sized. No tide lines or colour changes are visible before and after ageing.

daylight and UV light. *Zin shofu* also presents satisfactory results, because it seems to cause halos quite similar to those of pure water. *Gelatine* remains hardly visible under daylight, but fluoresces significantly on Whatman paper after ageing. Finally, *methocel* and *tylose* cause both the most obvious changes on both papers, with fluorescent tide lines under UV light, and a yellow-brown halo appearing under visible light.

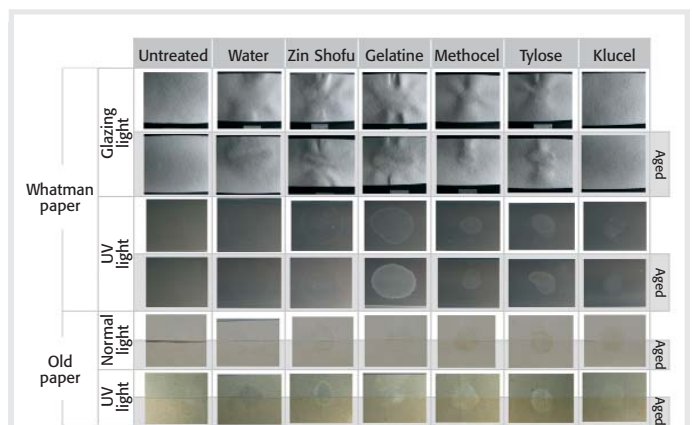
In Search for a Re-Sizing Procedure Suitable for Iron Gall Inks

The main objective of this work is to assess the risk of ink migration resulting from re-sizing treatments. It was elaborated within a larger project undertaken at the CRCC (Centre de Recherche sur la Conservation des Collections) and in collaboration with the French National Library. Four types of re-sizing application were investigated: immersion was first considered as a reference method because it is the most reproducible. Then three different types of brush application were selected (Tab 2). The first (brush 1) corresponds to the application method, described above [4]. The two others (brush 2 and brush 3) are adapted from a cleaning/strengthening procedure that is used to remove soluble products by mopping up the wet document with blotting paper.

Fifty original iron gall ink manuscripts were chosen specifically for this study. They have various origins and no initial value. On each manuscript, small pieces were sampled then re-sized using the different methods listed in Tab 2. The methodology, described extensively elsewhere (Rouchon et al 2009) consists of a comparison of macro photographs taken on original samples before and after treatment in order to identify visible migrations.

Visual Observation Using Macro Photographs

Macro photographs were taken of the recto and verso of each sample under similar lighting conditions provided by an illuminating box built with daylight. The pictures were then compared to assess visual changes: 'Lateral migrations' refer to halos which are formed on the recto of the document, around the writing lines, while 'transverse migrations' describe the



5 Partial re-sizing (drop method) of new and old papers through artificial ageing tests.

Tab 2 Adhesives selected. Klucel was prepared in > 99 % ethanol. The other adhesives were prepared in distilled water. All adhesives were used at room temperature, between 20 and 22 °C. 'Direct application with a brush' means that the brush is applied three times (left to right, then top to bottom, then bottom to top) on the recto and the verso of the sample.

Method	Description	Solution/adhesive
<i>immersion</i>	Immersion for 5 minutes. The excess of adhesive is removed by placing the edge of the sample perpendicular to a blotting paper. Air drying on a non-woven polyester film.	distilled water <i>zin shofu</i> (2 %) <i>gelatine</i> (1 %) <i>methocel</i> (2 %) <i>tylose</i> (0,5 %) <i>tylose</i> (2 %) <i>klucel</i> (3 %)
<i>brush 1</i>	Direct application with a brush. No removal of the excess of adhesive. Drying between wool felts, non-woven fabrics and under woodenboards and weights (pressure 20 g.cm ⁻²).	distilled water <i>zin shofu</i> (2 %) <i>gelatine</i> (1 %) <i>methocel</i> (2 %) <i>tylose</i> (2 %) <i>klucel</i> (3 %)
<i>brush 2</i>	Direct application with a brush. Immediately after, the excess of adhesive is removed manually by pressing the sample with the thumb between two blotting papers. Drying in a press with interleaving wool felts.	<i>tylose</i> (0.5 %)
<i>brush 3</i>	Direct application with a brush. Immediately after, the excess of adhesive is removed by pressing the sample for 2 seconds between two blotting papers with a pressure of approximately 0.4 kg.cm ⁻² . Drying in an un-clamped press with interleaving wool felts.	<i>tylose</i> (0.5 %) <i>tylose</i> (2 %)

coloured compounds, which migrated through the paper, onto the verso of the sample. Two migration levels are then identified (Fig 6): 'subtle' migrations which cannot be identified in a conservation practice context where a large number of documents has to be treated at the same time, and 'obvious' migrations which can easily be observed by naked eye.

The visual examination was made by three professionals separately to obtain consistent results. After homogenization of all the observations, the results were summarized in two histograms representing the number of subtle and obvious migrations for each treatment (Fig 7).

Results

Whatever the method of application, all aqueous adhesives cause ink migration. The great majority of the migrations are subtle, which means hardly noticeable during regular conservation practice. However, they are no less detrimental. As previously observed (Rouchon et al 2009), the inks are more likely to migrate through the paper than around the writing lines. This observation is probably related to the fact that inked areas are generally more hydrophilic than blank ones.

Considering aqueous sizing, the number of migrations differs somehow from one method to another. However, none of the aqueous treatments appears suitable, as they all cause transverse migrations on at least half of the samples.

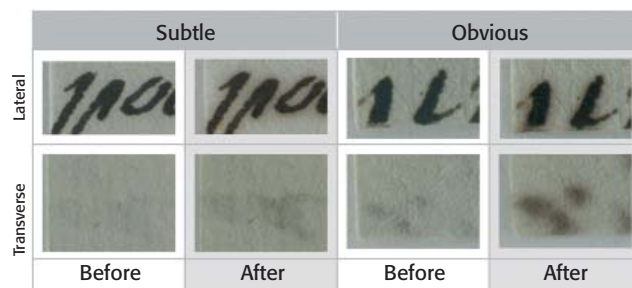
The water uptake was estimated by weighting paper samples before and after the sizing application. No correlation was found between this water uptake and the observed migrations: the samples treated with brush 2 and brush 3 methods gain about 25 times their weight in water. However, Fig 7 shows that lateral migrations were more numerous on these samples than on those treated with the brush 1 method in which samples absorbed 50 times their weight in water. In all treatments, the water uptake during the re-sizing process is probably largely above the minimum that would cause migration of soluble compounds.

Finally, no migration was observed on the samples treated with *klucel* in ethanol (> 99 %). This result corroborates previous tests which showed that no visible components of iron gall inks dissolve in ethanol. The addition of 3 % hydroxypropylcellulose does not change this property [6].

Conservation Treatments: A Local Consolidation Procedure Combining Re-Sizing, Infilling, and Lining

The Choice of an Adhesive

The work described above shows that it was not possible to find an aqueous technique of partial re-sizing that minimizes the risk of ink migration. From this point of view, the *klucel* prepared in ethanol offers the most reliable alternative. It does not induce any visible migration of iron gall inks, it significantly strengthens the damaged paper without creating distortion, and it involves less visual side effects (tide lines, discolouration, etc.) than other tested adhesives. Therefore, we chose to consolidate the text block of the logbook 4JJ14 using *klucel* not only as a sizing agent but also as an adhesive.



6 Samples with subtle and obvious ink migrations after re-sizing.

From Re-Sizing to Lining

The weakened fluffy areas of the paper were first cleaned with a micro-vacuum [7], and then re-sized with *klucel* prepared at 3 % w/v in ethanol (> 99.5 %). These areas were mainly located along the centre folds and the edges of the text block. On the most damaged areas, and especially on the upper corners (Fig 3), the re-sizing treatment did not sufficiently strengthen the paper. A consolidation procedure was hence developed combining re-sizing, infilling, and lining of damaged areas. This should be easy to carry out in a relatively short time for a large-scale application, in particular with the other logbooks of the collection.

Selecting a Lining Material

Prior to treatment, some tests were carried out to select a lining material. Three papers were compared: two Japanese machine-made papers, RK1 (kozo, 8 g.m⁻²) and RK00 (kozo, 3.6 g.m⁻²), and a handmade paper, the Berlin tissue[®] (mixture of kozo and mitsumata fibres, 2 g.m⁻²: Gangolf Ulbricht). This latter is already mentioned in several articles about the consolidation of manuscripts with iron gall ink deterioration (Pataki 2009, Titus et al 2009). The tests led us to choose the two thinnest materials (RK00 and Berlin tissue[®]) since they impart sufficient mechanical strength to the paper without affecting the legibility of the

writing. However, although the RK00 performance is satisfactory, the Berlin tissue[®], nearly invisible, provides much better aesthetic results with a great ease of application. Indeed, RK00 has to be water torn and slightly pre-toned with watercolours to be less visible, which involves a more time-consuming procedure. The Berlin tissue[®] can, on the contrary, be cut with a scalpel and used as such, which actually reduces the treatment time and largely compensates its high purchase cost.

Choosing a Local Lining Method

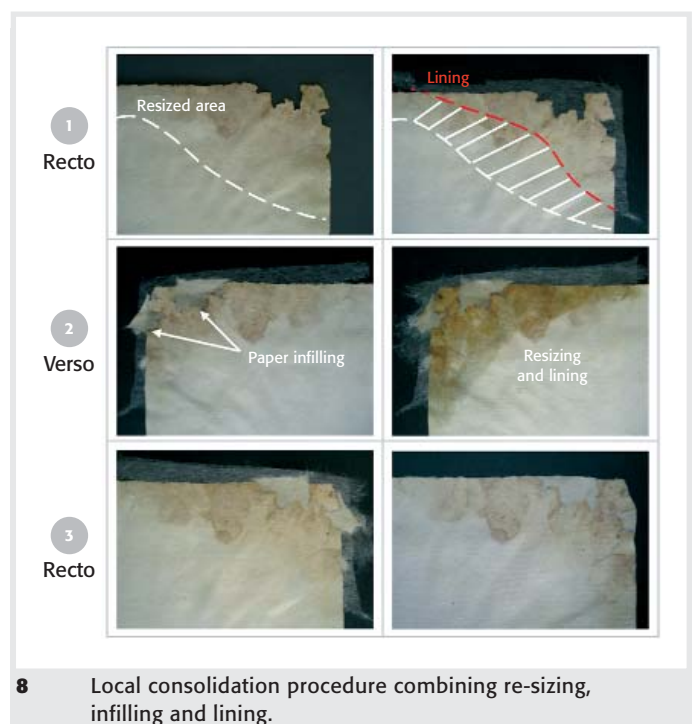
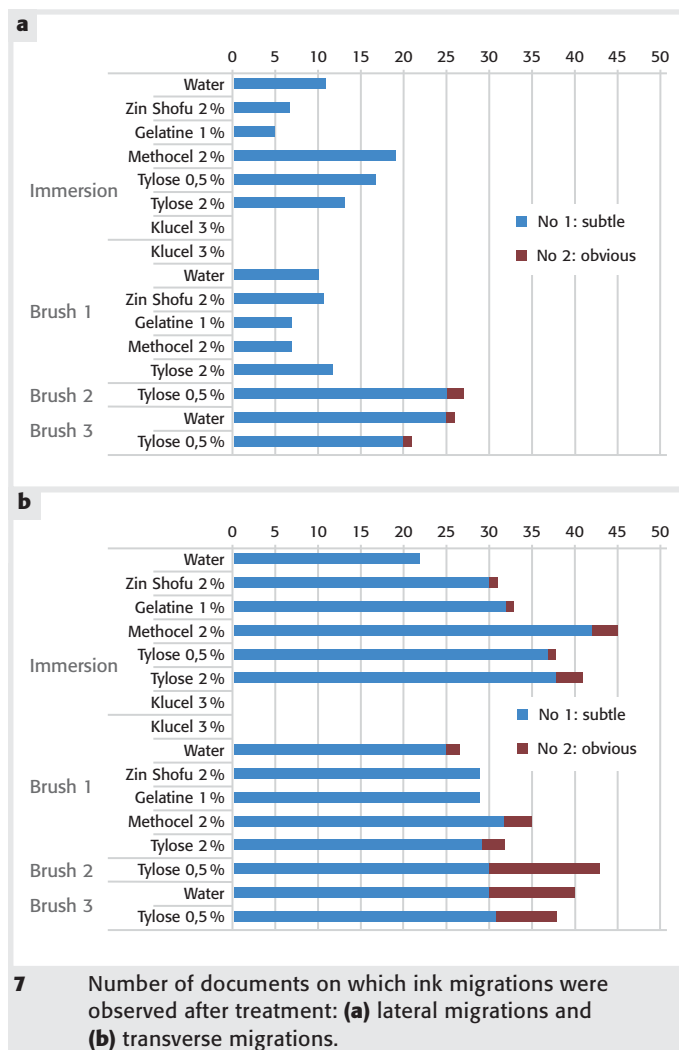
Several lining techniques were compared on old mould damaged papers. The tested methods were: brushing the adhesive directly through the lining paper, adhesives pasted out over an absorbent surface (blotter) prior to lining, and reactivation of pre-coated papers. The latter technique, often used with gelatine when iron gall ink is concerned, is also mentioned because it allows a good control of the gesture (Pataki 2009, Duplat et al 2009, Anderson and Reidell 2009). At the end, the brushing-through method proved to be the easiest, and fastest option with the best aesthetic results in comparison with the other methods.

Consolidation Procedure for the Upper Corner

Every step of this procedure was carried out using a synthetic hair brush and 2 % w/v *klucel* diluted in 99.5 % ethanol. This concentration is lower than the one used in the tests, because re-sizing is here followed by lining. It involves the application of a second layer of adhesive and we wanted to prevent the treated area from being stiffened by it.

The procedure is organized in three steps (Fig 8):

- > The damaged area is re-sized. Then a piece of Berlin tissue[®] or RK00 is pasted using a very soft synthetic brush with nylon filaments (Fig 9). The viscosity of the *klucel* solution and its dilution in ethanol allow a good application without damaging the fibre structure of the thin paper. The lining does not cover all the



re-sized part, but it slightly exceeds the outer edges of the document.

- > The page is turned and partially re-sized. Losses are then in-filled with pre-toned Japanese paper ($\sim 30 \text{ g.m}^{-2}$, with water-colours), using the lining paper on the recto to support the in-fill. The area is finally lined, thus immobilizing the in-fill paper in a sandwich of thin lining papers.
- > After drying, the excess paper is cut with a scalpel along the outer edges of the document.

Upon reflection, and for ethical and mechanical reasons, it was decided not to reconstruct the missing corner of the sheets up to the original format. We only filled the losses up to the outer edges of the paper. On the one hand, a complete filling of a corner would go far beyond the theoretical aim of this intervention, namely mechanical stabilization of the sheets. On the other hand, pasting a large piece of new material on an old mouldy paper increases the risk of fold formation along the graft area.

Conclusion

The consolidation procedure proposed in this study provides a satisfactory solution to the specific problem of manuscripts that present well-preserved iron gall inks on mould damaged paper. This technique preserves all the original structural parts of the

binding and the initial composition of both papers and inks in the undamaged areas (Fig 10).

The use of extremely thin but strong enough papers (Berlin tissue[®] or RK00) provides a lining that significantly reduces the prevalent problems concerning the opacification of the writing lines. Furthermore, the use of 2 % w/v Klucel G[®] in ethanol, both as re-sizing and lining agent, highly limits the risk of visible ink migration, of paper distortion and tide-lines formation.

Re-sizing prepares the paper prior to lining. Far from being dispensable, this step presents the additional benefit of increasing the adherence of the lining paper onto the damaged area. The Klucel G[®] that was impregnated in the damaged areas is probably reactivated during the lining process. Finally, considering the application itself, the direct brushing technique appears to be fast, convenient and also easy to implement on a large scale collection within reasonable treatment times. Close to half an hour per page, this procedure can be widely adapted and used for the treatment of archival collections with similar issues.

Acknowledgements

This work was conducted in the context of a master degree in Book Conservation at the National Institute for Heritage in Paris (France <www.inp.fr>). It also took part in a larger project funded by the National Library of France. We would like to express our gratitude to the Library of Arsenal which allowed us to perform experiments in their conservation studio and the National Archives who entrusted us with the logbooks for a year and made this project happen in the best conditions. We especially thank Ms Delmas, chief curator and head of the Conservation Department at the National Archives and all members of the Conservation Centre with whom we maintained regular exchanges throughout this year. We would like to thank Marie Christine Danielle for her help in examining the macro-photographs.

Endnotes

- * A French version of this peer-reviewed article was published in 'Support Tracé', no 10 (2010): Martin, A., et al.: 'La consolidation locale de manuscrits altérés par des microorganismes: Le cas des journaux de bord des premières expéditions françaises en Louisiane'.
- [1] The National Archives have recently decided to collect within the Marine 4JJ series every logbook produced in the context of slave trade expeditions conducted by the French East India Company between 1721 and 1757. The project involves the production of a digital edition of these documents in order to promote French archives related to slavery and increase the circulation of information on this subject. Prior to digitization, one-fourth of the documents underwent conservation treatments and the totality was re-housed.
- [2] The presence of iron(II) ions was identified on the sixteen manuscripts with the bathophenanthroline indicator paper test, pointing to iron gall inks applied as writing fluid.
- [3] Although hardly used in France, the Methocel[®] A4C was chosen because it is often mentioned in the literature as a methylcellulose (Evetts et al 1989; Ravines et al 1989; Baker 1992; Biggs 1997). We found it interesting to compare this adhesive with the Tylose MH 300P[®], widely used in France, and frequently presented as a methylcellulose although it is, from a chemical standpoint, methylhydroxyethylcellulose. The only reference found on this adhesive (Strnadova and Durovic 1994) compares its performance to another methylcellulose (Glutofix 100[®]).



9 Lining with Berlin tissue, the brushing-through method.
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10 The Durance logbook (no 13), before (on the left) and after treatment (on the right).

- [4] The sample is re-sized on both the recto and the verso, brushing first horizontally and then vertically in order to create a smooth intermediate area with no clear demarcation between treated and untreated paper. The sample is then dried under weights between wool felts and non-woven polyester fabrics (Reemay, 17 g.m⁻²) with a soft pressure of approximately 20 g.cm⁻².
- [5] The conditions of artificial ageing are based on the standard of sealed tubes ageing (ASTM D 6819-02). All samples were pre-conditioned at 80 % RH prior to ageing. Each tube (210 mL) contains 4 g of paper. It is then hermetically closed and aged for three months at 50 °C. This specific temperature was chosen to avoid the gelatine denaturation that takes place beyond 60 °C. The relative humidity measured in the tubes remained close to 70 % during ageing.
- [6] *Klucel* must be prepared in pure ethanol (> 99.5 %) and not in technical grade ethanol (95 %) as sometimes used in conservation studios. Indeed, the 5 % residual water may cause ink migration, as observed during previous tests.
- [7] Micro-organisms, no longer active, have left small coloured deposits on the paper surface, probably with residual spores. To prevent a possible risk of recontamination, each page has been dry cleaned with a micro-vacuum HEPA filter (High Efficiency Particulate Air). A protective framework with textile muslin was placed on the documents to immobilize the paper fragments during aspiration.

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Suppliers

Atlantis France, 35, rue du Ballon, 93160 Noisy-le-grand, France, Tel +1-48-15-51-51, Fax +1-48-15-51-50, www.atlantis-france.com (Bathophenanthroline paper test, Japanese paper Nao RK00, RK1, *Zin Shofu*).

The Dow Chemical Company, 2030 Dow Center, Midland, MI Michigan 48674, U.S.A., Tel. +1-989-636-1463, Fax +1-989-636-1830, www.dow.com (Methocel® A4C)

Gangolf Ulbricht, Mariannenplatz 2, 10997 Berlin Germany, Tel/Fax +49-30-6158155, www.gangolfulbrichtpapier.com (Berlin Tissue®).

Rousselot, Vion Company, Kanaaldijk Noord 20-21, 5691 NM SON, The Netherlands, Tel +31-499-364100, Fax +31-499-373873, www.rousselot.com (Gelatine B 225 LH 30).

Stouls, 9/11 Rue de l'orme Saint Germain, 91165, Champlan cedex, France, Tel +33-1-69101070, Fax +33-1-69101079, www.stouls.com (Klucel G®, Tylose MH300P®; non woven polyester Reemay 17 g.m⁻²).

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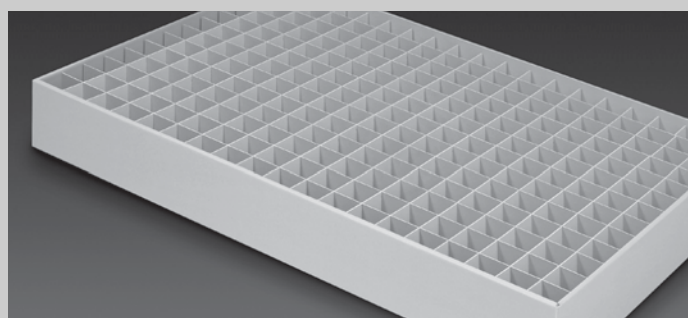
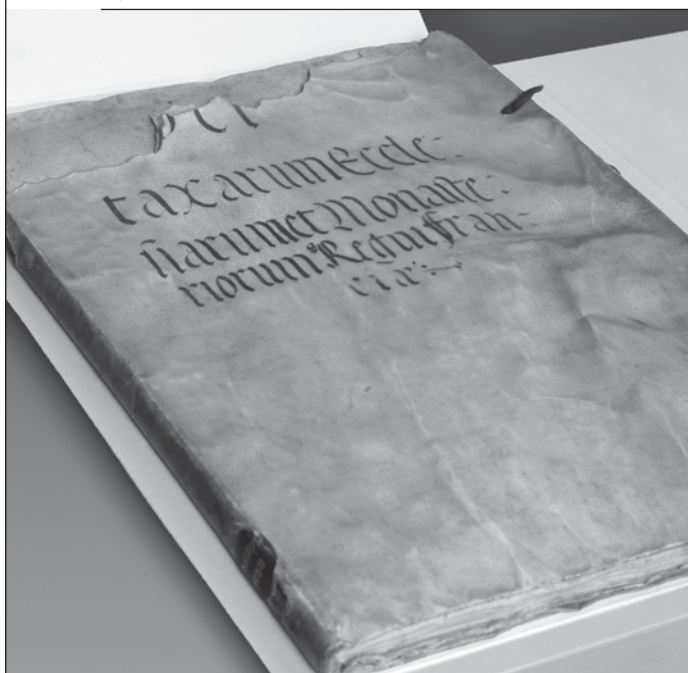
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