# Moisture and mending: A method for doing local repairs on iron-gall ink

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## Introduction

The relationship between moisture and mending is a tense one. On the one hand, we need moisture as a basic component of frequently used adhesives. On the other hand, moisture is our enemy, because it often has a detrimental effect on the objects with which we work. Fortunately, the relationship between moisture and mending is also evolving. It evolves because, gradually, our knowledge of the effect of moisture on particular materials, objects and repairs increases, and because we use this knowledge to improve our techniques.[1]

This article discusses the use of a method for doing local repairs on iron-gall ink, first outlining the three different techniques of which the method consists: the use of remoistenable tissue, the use of the 'Dutch Fe-Migration Mending Test' (DMT) and the so-called sponge-blotter system, followed by an explanation of the requirements that need to be met for making a good repair on an iron-gall ink object. The second part of the article discusses examples of recent projects in which the use of remoistenable tissue proved useful, including some cases in which iron-gall ink was *not* the major problem.

**1** One of the best examples is a recent book by G. Banik and I. Brückle, *Paper and Water: A Guide for Conservators* (Oxford: Butterworth-Heinemann, 2011).

## Local repairs on iron-gall ink

The method discussed in this article was first described in a 2011 article in the *Journal of Paper Conservation*, under the title 'Rendering the Invisible Visible: Preventing Solvent-Induced Migration During Local Repairs on Iron-gall Ink'.[2] This title already explains the main problem of the conservator carrying out repairs on iron-gall ink. The use of an aqueous adhesive, like wheat-starch paste, MC or gelatine, causes detrimental products from the ink-line, such as iron-(II)-ions and acids, to migrate into the surrounding paper, causing the ink corrosion to spread and discolour areas around the ink line. These consequences are invisible at first. It takes years before the migration becomes visible (Fig. 1).

**2** Eliza Jacobi, Birgit Reissland, Claire Phan Tan Luu, Bas van Velzen and Frank Ligterink, 'Rendering the Invisible Visible', *Journal of Paper Conservation* 12 (2011): 25–34. In this article all three elements of the method are described in detail.

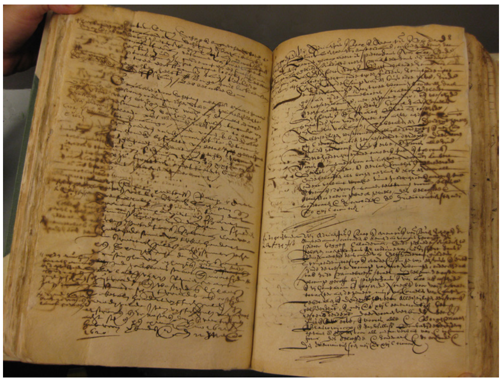

**Fig 1** Migration of soluble components. This object was repaired around 1974–76 with Japanese paper and an industrial wheat-starch paste. Collection of the City Archive, Amsterdam. Photo: B. Reissland.

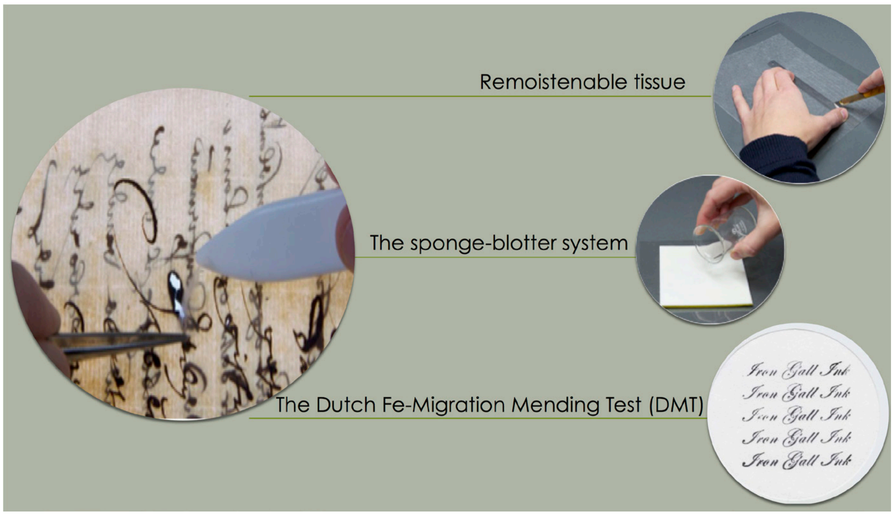


**Fig. 2** Local repairs on iron-gall ink: three elements.

In the 2011 article, we concluded that the best possible result is achieved by using remoistenable tissue coated with gelatine. The most satisfying use of this method requires—besides practice—making visible (and thereby gaining some control over) the not immediately visible problem, the migration of detrimental elements. It is for this reason that we developed the so-called 'Dutch Fe-Migration Mending Test' and the sponge-blotter system. A combination of these techniques, we found, enables the conservator to control the moisture content of a repair, and thus the migration. I will proceed by explaining the three different elements of this method (Fig. 2).

**Remoistenable tissue**

The use of remoistenable tissue is important, because it gives the conservator maximum control over the amount of adhesive applied while using a minimum amount of moisture needed for sufficient sticking power. It is made as described by Brückle in 1996 in the *Book and Paper Group Annual* of the AIC, by applying adhesive through a screen onto a piece of Melinex® and then adding Japanese paper.[3] I use two different screens: one with a fine mesh for the 2 to 6 g Japanese papers and a thicker screen for Japanese papers with a weight of 9 g or higher to get a thicker adhesive layer necessary for the heavier papers. I always prepare in advance different kinds of remoistenable tissue with a variety of Japanese papers from 2 to 18 g and different adhesives, including gelatine, a mix of gelatine and MC, a mix of wheat-starch paste and MC, and Klucel™ G.

3 Irene Brückle, 'Update: Remoistenable Lining with Methylcellulose Adhesive Preparation', *The Book and Paper Group Annual* 15 (1996): 25–26. See also the illustrated guide to making remoistenable tissue in: Bas van Velzen and Eliza Jacobi, 'Remoistenable Tissue', *Journal of Paper Conservation* 12, no. 1 (2011): 36.

**Choices of material: Japanese paper and adhesives**

Repairs on iron-gall ink are almost always made in areas of high information. Therefore, the repair paper needs to be as thin as possible. One of the great advantages of the use of remoistenable tissue is that it allows for the application of very thin Japanese paper. One of the thinnest available Japanese papers, the 2 g Berlin Tissue, can easily be used with this method and is highly transparent when applied in areas of high contrast. The Berlin Tissue is most suitable for small areas of iron-gall ink damage or cracked border lines in manuscripts. In cases that require more strength, two layers may be applied rather than one layer of 4 g paper. The two layers of 2 g tissue are still more transparent than one layer of a thicker tissue. The fact that two layers of adhesive are applied gives extra strength. Japanese papers of up to 9 g may be used. Papers of 9 g and above give problems with transparency, but in some cases may be used if maximum strength takes priority.

One may wonder about the use of alternative adhesives—particularly those that do not require the use of moisture. This is an important question, worth discussing briefly before proceeding to the second element of our method. Recently I have started to produce, by way of experiment, a pre-coated tissue with the thermoplastic acrylic adhesive Lascaux 498. My reasoning was that this might be a possible alternative to moisture-based adhesives. But, as yet, I have not used these adhesives for local repairs on iron-gall ink. Although the acrylic adhesives have been extensively tested for long-term ageing, they are still quite new and have not yet stood the test of time. Also, we do not know the exact composition of these adhesives, because of the large amount of filling and stabilizing products they contain. There are other reasons for my hesitation in using these adhesives. One of them has to do with a coincidence. Due to my general interest in adhesives, I occasionally walk around with dried films of adhesives in my backpack. I make these films to investigate what different adhesives look like and how they behave. One day, when unpacking my backpack, I noticed that the film I had made of Lascaux 498 was stuck between the pages of my notebook. I was absolutely certain that the film was dry at the time I put it in my bag, so I became suspicious. I asked a chemist who specialized in adhesives how this was possible. He told me that, when put under pressure, the Glass Transition Temperature can be significantly lowered, even to room temperature, and this may explain why the film had become sticky. The consequences are clear. The books and papers that require mending often lie in stack, which means that the repairs are constantly under a certain pressure. This could cause a problem when using acrylic adhesives. Additional reasons why not to use Lascaux 498, which I will not discuss here, have to do with possible future treatments (not reversible in water) and the heat required (sometimes twice, firstly to make the adhesive adhere and secondly to remove it).

**The Dutch Fe-Migration Mending Test (DMT)**

The second element of the method is the Dutch Fe-Migration Mending Test (DMT), which was developed in cooperation with Birgit Reissland, Frank Ligterink and Han Neevel (all affiliated with RCE in Amsterdam), Bas van Velzen (University of Amsterdam), and Claire Phan Tan Luu (Practice in Conservation).[4] The creation of the test was inspired by the iron(II) test, developed by Han Neevel and Birgit Reissland to detect iron-gall ink.[5] The DMT is a Whatman™ filter paper impregnated with Bathophenanthroline—an indicator for iron-(II)-ions that turns magenta when forming a complex—and stamped with iron-gall ink (Fig. 3).


**Fig. 3** The Dutch Fe-migration mending test (DMT).

**4** See http://cultureelerfgoed.nl; inkcorrosion.org; http://uva.nl/en/disciplines/conservation-and-restoration; http://practice-in-conservation.com.

**5** Johan G. Neevel and Birgit Reissland, 'Bathophenanthroline Indicator Paper', *PapierRestaurierung* 6, no. 4 (2005): 28–35.


**Fig. 4** An example of how the DMT can be used to perform different tests with different adhesives and methods of application. Photo: Eliza Jacobi.

The DMT was developed to allow for a quick and effective assessment of the risk of ink migration taking place before making a repair on the original. By doing a repair on the indicator paper first, it is possible to trace the migration of the ink stamped on it. If no excess water is used in the repair, the DMT should remain unchanged. It can be concluded that the repair did not cause a significant migration of iron-(II)-ions. However, if a pink halo appears around and on the verso of the ink line, indicating the migration of iron-(II)-ions, it means that too much solvent was applied during the treatment. The DMT is thus a tool for practice, that is, for perfecting a particular repair, making sure that one is able to carry out the necessary treatment while using a minimum of moisture. The DMT paper can be used multiple times (it is large enough) for checking your repair, especially after a new sponge-blotter system has been set up (Fig. 4).

**The sponge-blotter system**

The goal of the third element, the sponge-blotter system, is to manage the amount of solvent used in a repair. It is simply a piece of 10x10 sponge cloth with two layers of blotting paper, also cut to 10x10 cm, on top. The sponge is filled with about 32 ml of water. The exact amount of water is not so important (anything between 30–34 ml would work). It is important that enough water is used to make the remoistenable tissue repair stick. The DMT test, described above, is used to check whether too much water is used in a repair (Fig. 5).

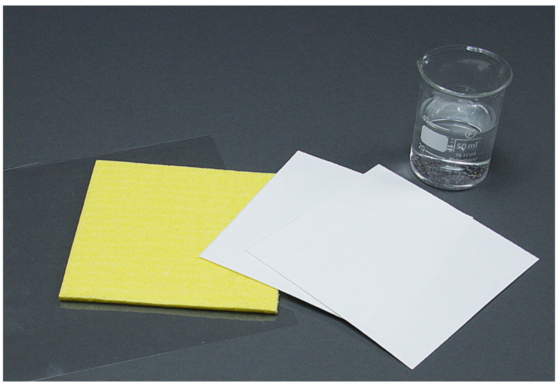

**Fig. 5** The sponge blotter system: sponge cloth, two layers of blotting paper and water on a piece of Melinex. Photo: Eliza Jacobi.

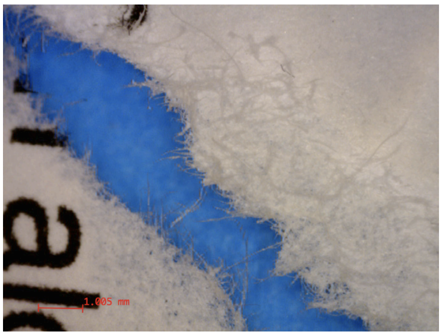

**Fig. 6** Detail of a regular tear in paper. Photo: Eliza Jacobi.

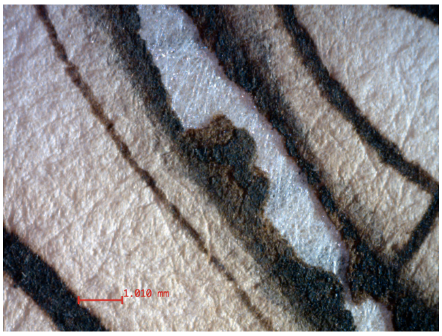

**Fig. 7** Detail of a tear in iron-gall ink. Photo: Eliza Jacobi.

In sum, the combination of these three elements—the remoistenable tissue, the Fe-migration mending test and the sponge-blotter system—makes it possible to do a repair on iron-gall ink with different kinds of Japanese paper and a range of commonly used adhesives, while at the same time controlling the amount of moisture by testing the treatment on the DMT. Our method is, in other words, a self-monitoring or -control system. It is a way of testing, objectively, that one is carrying out the repair with sufficient adhesive power, while at the same time using a minimum of moisture.

**Tear repair on iron-gall ink**

Carrying out a repair on iron-gall ink is different from doing repairs on 'regular' tears in paper. Regular tears usually have soft and fibrous edges, maybe even a beard, making repairs relatively easy. In contrast, tears or breaks in areas affected by iron-gall ink corrosion have sharp edges. Often, material is missing. The break is surrounded by brittle material (iron-gall ink areas) and flexible material (paper areas), making it a non-homogenous area. Moreover, since the tears or breaks are caused by the ink, they are always located in areas of information and high contrast (Figs. 6 and 7).

Because of the special characteristics of a break in areas of iron-gall ink corrosion, a repair involves a number of specific requirements and considerations:

1. The repair has to be bigger than the iron-gall ink area, so it covers the break as well as some non-iron-gall ink degraded paper. If not, the repair could literally drop out of the paper together with the brittle ink.
2. The best result is achieved when the broken area is 'encapsulated' by repairing both from the verso and recto side. If the break is not repaired on both sides, the edges can easily let go of the repair paper and stand up because they are inflexible and brittle.
3. It is aesthetically pleasing when the repair follows the form of the inked area. Giving the repair rounded edges helps to achieve this.
4. A combination of different grammages of the repair paper may be used, especially if the verso side is blank. It is advisable to apply the thickest repair paper first. One should, however, be aware that the pressure used in applying the repair may cause a transfer of iron-gall ink colour into the opposite paper.
5. A high paper grammage requires a thicker adhesive layer. This, however, also increases the risk of distortion of the repair.
6. Loose bits and pieces of iron-gall ink must be removed, if they cannot be placed back, before starting the repair.
7. It is important to check carefully where, exactly, the ink corrosion is located. Margins and folding points (particularly in books) are the areas that are most at risk.

8. One should watch out for hidden cracks. Quite often, the breaks are already there in the iron-gall ink area but not clearly visible because none of the brittle edges has gone missing (yet).
9. Sometimes preventive repairing can be necessary, even if no crack is evident yet. In some cases, it is possible to anticipate that handling the paper once or twice more will cause breaks and tears in the most brittle and inflexible (iron-gall ink affected) areas.

In the second half of this article, I will give a few examples of repairs in which the use of the method described above—and especially the use of remoistenable tissue—proved to be very useful.

**Machabeu, manuscript book**

This book by Machabeu (Fig. 8) was the last in a large conservation project of over 30,000 books carried out for the Ets Haim Library in Amsterdam. The project took more than 10 years to complete and consisted of damage assessments, condition reports, the creation of a conservation plan, and the implementation of this plan by Elizabet Nijhoff Asser, owner of RNA in Amsterdam, together with a group of 30 freelance conservators. The Ets Haim Library is the oldest still functioning Jewish library in the world. It was founded in 1639 and has been housed in the historical complex of the Portuguese Jewish community of Amsterdam since 1675. The library's holdings consist of some 560 manuscripts and 30,000 printed works. The library holds a large and rich collection on the subject of seventeenth- and eighteenth-century Judaism. The manuscript by Judah Machabeu is a Spanish translation of Hebrew prayers according to Sephardic rites. He made this copy during his stay in Brazil in 1650.

The pages of the book are written within a frame of iron-gall ink lines (Fig. 9). Most of these lines were brittle and broken. In the past, these broken lines had been beautifully repaired with perfectly cut pieces of Filmoplast® tape. However, as a result of creeping adhesive, dust and iron-gall ink particles had accumulated along the edges of the tape. In addition, the binding of the book was in bad condition and the complete book had to be sewn again. While treatment was badly required, it was stalled for years, even when the larger project had already ended. A phytate treatment was thought to be too invasive, yet it was not clear what the proper alternative should be. At the same time, between 2000 and 2010, a lot of new information was becoming available about iron-gall ink treatments.

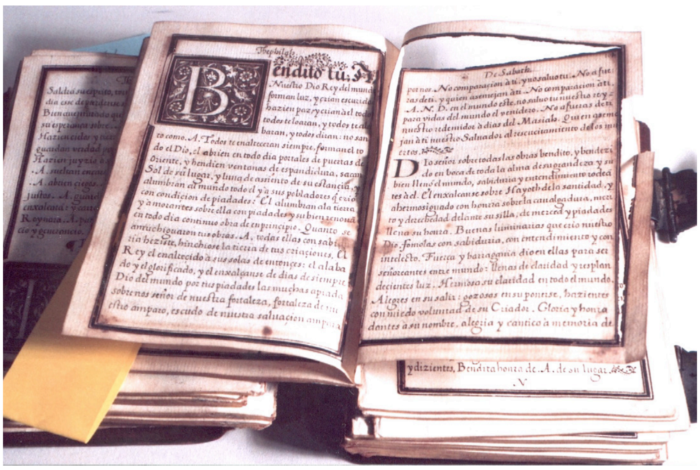

**Fig. 8** Judah Machabeu, *Spanish Translation of Hebrew Prayers*, 1650 [EH 48 E 61], approx. 17 x 10 x 5 cm. Manuscript from Ets Haim, Livraria Montezinos Library, Amsterdam. Photo: RNA.

**Fig. 9** In the past, all iron-gall ink lines were repaired with Filmoplast. Because of creeping adhesive, dust and ink particles became stuck to the sides of the tape. Photo: RNA

**Fig. 10** Removing the Filmoplast with solvents. Photo: RNA.

**Fig. 11** After removing tape: some pages are completely loose. To be able to do the repairs, the sections were placed at a 90 degree angle. Photo: RNA.

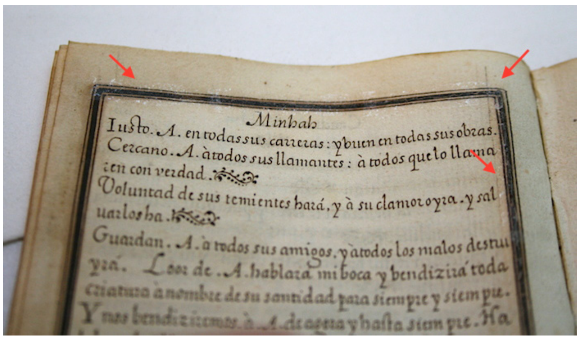

**Fig. 12** Repair with 2 g Berlin tissue coated with a 3% gelatin solution. Photo: RNA.

Treatment was started, eventually, in 2009 (Fig. 10). The Filmoplast® was removed with xylene, which was the only solvent swelling the adhesive layers, so the carrier and adhesive could be removed using tweezers and a spatula. Page by page, the Filmoplast® was removed from the ink lines, a process that took some 70 hours. The next step was to repair the individual pages. Some of them had come completely loose along all edges of the frame (Figs. 11 and 12). The pages were repaired with remoistenable tissue made of 2 g Berlin Tissue and coated with 3% gelatine. The remoistenable tissue was pre-cut unto the Melinex® in strips of approximately 5 mm wide. Because in some of the ink lines parts of the paper were missing, it was necessary to apply two layers of remoistenable tissue. This gave the paper sufficient strength to enable the turning of the pages. This part of the repair took about 30 hours of work. During the repair of individual pages, the book was


**Fig. 13** After conservation: the bookblock has been repaired, sewn and put back in the original cover. Photo: RNA.

placed in a position that caused minimal stress on the rest of the pages. The pages were placed at a 90 degree angle, held in position by magnets to create a flat working surface. Thus, the invasive treatment of the book could not do further damage to the brittle iron-gall ink lines. After all pages had been repaired, my colleague Saskia Mertens rebound the book and put it back in the original leather binding, which is not contemporary (Fig. 13).

**Leaf from a missal**

The next example concerns a leaf from a missal in private ownership. The text and notes are written on parchment, both recto and verso, with iron-gall ink. As becomes clear from the photo, many parts of the letters are missing. The owner requested that the parchment leaf be framed. We decided to consolidate the broken and brittle parts from verso, before framing the parchment leaf. For the repairs we used 6 g Japanese paper coated with 3% gelatine. Quite large areas needed repair. The remoistenable tissue was moistened on the sponge blotter and the paper was put into the right position with a dry brush. The brush was also very useful for applying gentle pressure on the repair paper, enabling good contact with the cockled parchment (Fig. 14). After repairing all areas, the parchment was hinged onto a museum board on which a darker coloured paper had been adhered. The

**Fig. 14** Leaf from a missal. Pre-coated tissue is moistened and ready for application. A dry brush is used for careful application and light pressure. Photo: RNA.

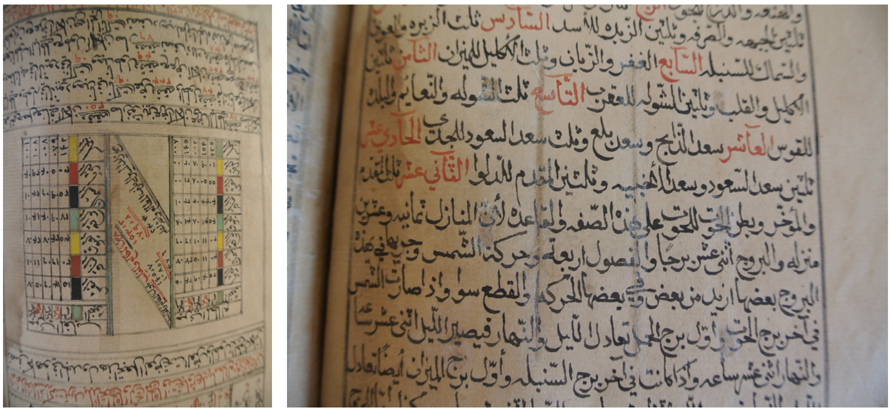

**Fig. 15** Recto and verso of the same page: repairs along the margin of verdigris deterioration. Japanese tissue (*tengujo* 3.7 g) coated with 2% gelatin. Manuscript 2012.265 (1822), Ministry of Culture and Heritage Collection, Muscat (Sultanate of Oman), 330 x 450 x 20 mm. Manuscript in marine science. Photo: Gaia Petrella.

darker coloured paper was used in order to visually blend in all the missing ink parts from the text. Also, because parchment is quite translucent and the object was written on both sides, the darker paper helped to make the text on the verso side seem less conspicuous.

I would like to end this article by providing a few examples of the use of remoistenable tissue on objects without iron-gall ink. Two of the examples were generously provided by colleagues who, while working abroad, corresponded with me about the method discussed above.

**Islamic manuscripts**

In 2012, my colleague at RNA, Herre de Vries, worked with Gaia Petrella on the conservation of 48 Islamic manuscripts in the Vatican Library. In a few of the treatments they used remoistenable tissue to repair tears and copper corrosion damage, and to strengthen frayed edges. Today, Gaia Petrella continues to use remoistenable tissue in her work on Islamic manuscripts in the collection of the Ministry of Culture and Heritage of the Sultanate of Oman.

Figure 15 shows an example of a repair of copper corrosion damage. Here, remoistenable tissue was used to minimize or prevent the migration of copper ions. Unfortunately, a verdigris-stamped copper indicator paper—analogous to the Dutch Fe-Migration Mending Test—has not been developed yet. Thus, for copper corrosion the method cannot (yet) be applied with the same level of control as with iron-gall ink.

For Islamic manuscripts, copper corrosion can be a major problem. Gaia Petrella and Herre de Vries regularly encountered cases of typical copper corrosion damages in Islamic manuscripts noted in the conservation literature. Copper containing pigments, used to paint the greens in the miniatures or to fully dye the sheets of paper,[6] can lead to a local or total deterioration of the paper, with the deteriorated areas showing a brown discoloration and brittleness similar to heavily acidified nineteenth- and twentieth-century machine-made papers. Gold was used for sprinkling the paper or to gild the frames around the text area.[7] This can actually have a copper content high enough to eventually result in corrosion damage similar to that of the Judah Machabeu manuscript. Further improvement of the control system of the remoistenable tissue method in regard to copper migration in paper could increase the possibilities for repair of this type of damage.

6 Nil Baydar, ‘Structural Features and Conservation Problems of Turkish Manuscripts and Suggestions for Solutions’, in *Works of Art on Paper: Books, Documents and Photographs: Techniques and Conservation; Contributions to the Baltimore Congress, 2–6 September 2002*, ed. Vincent Daniels, Alan Donnithorne and Perry Smith, (London: International Institute for Conservation 2002), 2.

7 Baydar, ‘Conservation Problems of Turkish Manuscripts’, 4–5.

**Fig. 16** Papyri (ninth century) from the Louvre Museum, Islamic art department, part of the Jean David Weill collection. Photo: Aurelia Streri.

Gaia Petrella has also found the minimal and controlled introduction of moisture beneficial in another aspect of the repair of Islamic paper. Depending on the amount of sizing and the presence of fillers, the paper can be very hygroscopic. In the more hygroscopic and heavily burnished papers, the use of water tends to cause serious deformation, which is difficult to control during the drying process and which can leave residual tensions in the paper. In her experience, particularly with the thinner, more delicate papers, remoistenable tissue can ensure sufficiently strong repairs while using a minimum amount of water, thus implying less deformation risk for the object.

**Papyri from the Louvre**

These papyri are found in the collection of the Louvre Museum (Islamic art department), Paris. They are part of the Jean David Weill collection, which consists of about 800 items, 90% of which are papyri. These were discovered during excavations in Edfu in the 1920s. They date from the ninth century and comprise both government-related matters and family letters.

Aurelia Streri, a book and paper conservator in private practice based in Paris, restored the papyri. For the work on this collection, which she started in 2009, Streri used remoistenable tissue pre-coated with gelatine. For remoistening the tissue she used the method as described by Andrea Pataki.[8] The paper was humidified by spraying water with ethanol on blotting paper in a sandwich of Gore-Tex®. Streri's choice for using gelatine was prompted by its adhesive strength, as well as the fact that gelatine dries fast with no distortions. The application of the remoistenable tissue was used as a lining and for attaching the papyrus to the margin paper (Fig. 16).

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

**Russian newspapers**

Of late, RNA has worked on a collection of Russian newspapers held at the International Institute of Social History in Amsterdam.[9] Minimal repairs were needed, mostly on small tears on the edges. The use of wheat-starch paste was not possible because it caused local discoloration of the paper. The use of remoistenable tissue was a good choice for this object because it caused no discoloration, no distortions to the paper and because it was a quick and effective method of repair (Fig. 17).

**9** http://socialhistory.org.


**Fig. 17, a** The use of wheat starch paste and remoistenable tissue on Russian newspapers, 1916–18, Collection of the International Institute of Social History, Amsterdam. Photo: RNA.

**Acknowledgements**
I would like to thank the following people: Aurelia Streri in Paris, Gaia Petrella in Milan, my colleagues Herre de Vries, Saskia Mertens and Elizabet Nijhoff Asser at Restauratie Nijhoff Asser (RNA) in Amsterdam, Makiko Tsunodo (Oxford) and Jana Rasch (Weimar) for their feedback on the method and Claire Phan Tan Luu and Birgit Reissland (both in Amsterdam).

**Abstract**
This article describes a repair method for local repairs on iron-gall ink. The method consists of the 'Dutch Fe-Migration Mending Test (DMT)', the use of remoistenable tissue and the use of the so-called 'sponge-blotter system'. The main objective of this method is to provide the conservator with control over the amount of moisture involved in the repair during mending. I begin by introducing and explaining each of the three elements. I then proceed by outlining the requirements for doing a repair, taking as a point of departure the fact that tears and cracks in iron-gall ink have different characteristics than 'regular' tears in paper. To illustrate, I provide several examples of repairs made on different objects and materials, using the remoistenable tissue method: a small manuscript book, a collection of Islamic manuscripts, a parchment leaf from a missal and a set of papyri.

**Biography**
Eliza Jacobi is a paper conservator with a studio in Leiden, The Netherlands. She holds an MA in Modern Art History, with a minor in Museum Studies, from the University of Amsterdam. After her graduation in 2004 she worked for a period of three months in the library of the Dutch University Institute for Art History in Florence. In 2009 she completed a four year book and paper conservation training at The Netherlands Institute for Cultural Heritage (now RCE). As part of these studies, she completed two internships, at Lingbeek Papierrestauratie in Haarlem, The Netherlands (2008) and at the Book and Paper Conservation Studio in Dundee, Scotland (2008). In 2009 she worked voluntarily in Yogyakarta, Indonesia, directing a conservation and digitization project in the library of the Kraton (the Sultan's palace). Between 2010–2016 she worked as a paper conservator in the private conservation studio, RNA, in Amsterdam (www.restauratie-na.nl). In 2011 Eliza worked briefly as a paper conservator in the National Gallery of Australia (Canberra). In 2012–13 she worked as a paper conservator at the Stedelijk Museum, Amsterdam. In 2016–2017 she held a position as a paper conservator at the Islamic Arts Museum Malaysia in Kuala Lumpur. Since 2011 Eliza has worked together with Claire Phan Tan Luu under the name 'Practice-in-Conservation'. Together they offer workshops on mending ink-corroded manuscripts and they produce (for sale) the 'Dutch Fe-Migration Mending Test' (DMT).

**Materials and suppliers**

Japanese paper: RK-38 (16 g/m$^2$; *kōzo*, handmade); RK-0 (5 g/m$^2$, *kōzo*, machine-made); RK-00 (3,6 g/m2; *kōzo*, machine-made):
Paper Nao, via Conservation by Design
2 Wolseley Road
Kempston
Bedford
MK42 7AD

Blotting paper (235 g/m$^2$); Melinexâ (Type O, 100 Micron, 140 g/m$^2$); TST (100% Polyester, 110 Micron)
Jansen & Weismuller & Beuns b.v.
Postbus 166
1530 AD Wormer
The Netherlands

Berliner Gossamer Tissue (2 g/m$^2$), Gelatine (Type Restoration 1, pH 5.1 Bloom 274):
Gabi Kleindorfer
Aster Straße 9
D 84186 Vilsheim
Germany

Lascaux 498
Peter van Ginkel
Dennenlaan 28
1161 CR Zwanenburg
Postbus 33
The Netherlands

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