Adapt & Evolve 2015: East Asian Materials and Techniques in Western Conservation. Proceedings from the International Conference of the Icon Book & Paper Group, London 8–10 April 2015

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The conservation of a modern Mongolian mandala on paper: A conservation approach applying an adapted dry stretching method

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To cite this article: Ann-Kathrin Eisenbach, 'The conservation of a modern Mongolian mandala on paper: A conservation approach applying an adapted dry stretching method' in *Adapt & Evolve 2015: East Asian Materials and Techniques in Western Conservation. Proceedings from the International Conference of the Icon Book & Paper Group, London 8–10 April 2015* (London, The Institute of Conservation: 2017), 99–109.

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Introduction

Besides Tibet, Mongolia is one of the largest distribution areas of Tibetan Buddhism and looks back over a period of 800 years of Buddhist history. In the 1930s, Buddhism in the former Mongolian People's Republic suffered under violent persecution and destruction.[1] Religious buildings and works of arts were destroyed. Surviving written records are therefore rare.

This article outlines the conservation treatment of a modern Mongolian mandala, dated to the early twentieth century, which was purchased recently at the Bavarian State Library in Munich (München, Bayerische Staatsbibliothek, Cod.tibet. 992) and prepared for conservation at the Library's Institute for Conservation and Restoration (IBR). The mandala had been folded twice and locally damaged by an acidic substance, resulting in several extremely degraded brown areas with adjacent losses. The conservation treatment and preceding analysis of the Mongolian mandala were conducted in the author's Bachelor's thesis in 2014 and in a subsequent case study in the Master's programme at the Technical University of Munich.[2] To explore the options for conservation, extensive analyses of the fibres, the colourants and the damaging substance were conducted. The practical conservation treatment comprised the following main steps: releasing sticking paper parts, stabilizing the damaged areas locally, applying a local stretching technique to address remaining creases, and finally stabilizing the losses. The local stretching technique is an adaption of existing drying techniques on the *karibari* and will be examined separately in this article. It was evaluated regarding its success in dry stretching of this flexible but highly damaged paper, and proved to be useful for reducing remaining distortions.

The Mongolian mandala

1 Illustration

The term mandala includes different symbolic and spiritual meanings in Hinduism and Buddhism. Literally translated, the Sanskrit word refers to 'circle' or 'circle with a centre point'. Mandalas may be employed for spiritual guidance, as a tool for focusing the attention of practitioners or as an aid to meditation. It can be merely mentally visualized or set into diverse materiality, while the specific materials and creation methods are determined by its cultic intention.[3] The specific layout of a mandala can also be recognized in the layout of the Stupa or the Indian temple. A mandala can also represent the entire universe, traditionally depicted with Mount Meru as the cosmic axis, surrounded by the continents.[4]

The Mongolian mandala illustrates the Buddhist cosmology according to two different Buddhist sutras, *Abhidharmakośa* and *Kālacakra* (Fig. 1).[5] The central quadrant with four descending terraces represents the holy Mount Meru, a quadrant mountain column lying on the central axis of a plethora of world systems. Each world system is divided again into a sub-terrestrial, a terrestrial and a celestial world, whereas the mandala only

1 Klaus Sagaster, 'Der Mongolische Buddhismus: Geschichte', in *Dschingis Khan und seine Erben. Das Weltreich der Mongolen*, ed. Claudius Müller (Bonn, 2005), 342–47.

2 Ann-Kathrin Eisenbach, 'Rare Buddhist Documents from Mongolia. The Conservation of Two Mandala on Paper (Cod.tibet. 982 and Cod. tibet. 992, Bayerische Staatsbibliothek München)' (Bachelor's thesis, Technische Universität München, 2014), https://www.rkk.ar.tum.de/fileadmin/w00ble/www/media_rkk/downloads/Diplom-_und_BA-Arbeiten/Eisenbach_2013_BA-Thesis_online.pdf (accessed 5 June 2017).

3 Gerd-Wolfgang Essen and Tsering Tashi Thingo, *Die Götter des Himalaya* (Munich, 1989), 180.

4 Martin Brauen, *Das Mandala. Der Heilige Kreis im tantrischen Buddhismus* (Cologne: DuMont Buchverlag, 1992), 11–14.

5 *Abhidharmakośa* (Treasury of Higher Knowledge) was written by Vasubandhu in the fourth or fifth century and refers to the Buddhist *Tripitaka*. *Kālacakra* (The Wheel of Time) refers to a special practice in Tibetan Buddhism.

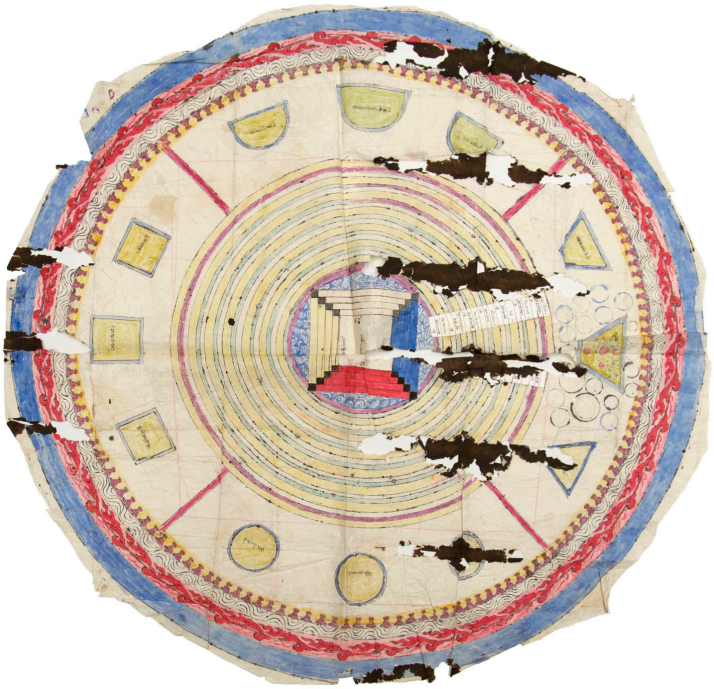

Fig. 1 The Mongolian mandala after unfolding at the beginning of the conservation treatment (recto). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

visually illustrates the terrestrial world. Mount Meru itself is surrounded by 21 rings, representing the encompassing seven concentric mountain ranges, which are divided by seven oceans and seven isles. Glued to the mandala are two paper labels displaying the designations of the rings in the Tibetan language. While one of the labels is highly damaged, the other one is clearly legible and was kindly translated by Ralf Kramer, Tibetan art historian at the Bavarian State Library. The rings obviously represent a confusion of the two named Buddhist sutras, as according to the *Abhidharma* Mount Meru is only surrounded by seven mountain ranges and seven oceans, whereas the seven isles could derive from the cosmology of the *Kālacakra*.[6] In the so-called Outer Ocean or Salt Ocean, which encloses Mount Meru and the concentric mountains and oceans, 12 continents are situated. The four main continents in the cardinal directions and their accompanying two side continents are believed to be in distinct shapes: *Purvavideha* in the east is semi-circular in shape, *Uttarakuru* in the north is quadratic, *Godaniya* in the west is circular in shape and *Jambudvipa* in the south is trapezoid. The continents are coloured in yellow with a blue border, and their Tibetan names written inside the continents. The human world is believed to be located at *Jambudvipa*, which is accentuated on the Mongolian mandala through several different coloured circles. The whole system is enclosed by the outer *Cakkavala* mountain range or Iron Mountains, which might be represented on this mandala by the four outer circles. In this form, the mandala may have been used for meditation, teaching Buddhist cosmology or as a draft for a later work of art.

The painting itself was conducted with modern, presumably water-based dyes on a flexible, semi-transparent and unsized paper. The colourants penetrated the paper nearly completely to the back. The mandala consists of 15 paper pieces of varying size, which are pasted together with an irregular overlap of around 3 mm to 7 mm. In the overlap areas, the colourants did not penetrate the double-layered paper as easily as they did in the single-layered parts. The outer border of the mandala is cut irregularly into a round form.

6 Conversation with Ralf Kramer, Bavarian State Library, in 2014.

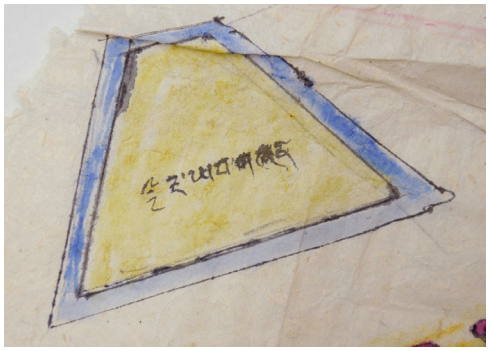

Fig. 2 Detail of the painting and the paper structure. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

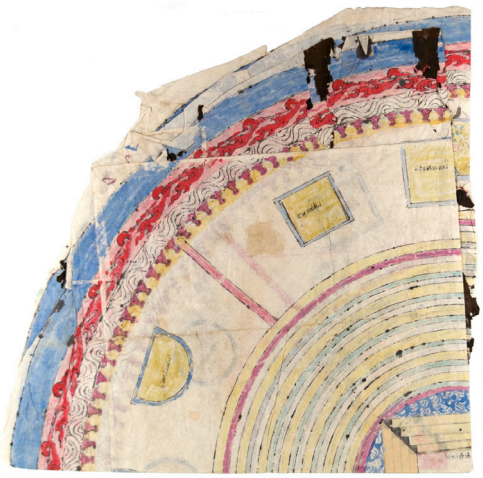

Fig. 3 The mandala was originally folded twice at acquisition. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

The paper is composed of various types of bast fibres, forming an irregular paper structure with inclusions of brown particles and fibre bundles (Fig. 2). As little is known of paper manufacturing in Mongolia itself and several authors mention paper imports from Russia or China, the exact provenance of the paper material remains unclear.[7]

2 State of preservation

The mandala was initially folded twice (Fig. 3), and was presumably in this state when severely damaged by a spilled liquid substance, resulting in 11 extremely brittle and inflexible areas. The substance had caused the degradation of the paper fibres in the affected areas. Due to severe losses in the damaged areas, the paper was highly fragile and unstable, especially during handling. In several damaged areas, fragments and larger folds in the paper were sticking together, causing tension within the paper as a consequence of the missing paper (Fig. 4). There were a lot of creases and cockling in the whole paper, possibly caused by extensive usage and/or incorrect storage. In this state, the mandala was at high risk of further damage and could not be safely handled.

Tests revealed the acidity of the damaged areas, revealing a pH value of 3.30, and a varying content of free iron-(II)-ions, indicating that in these damaged areas the natural ageing process of the paper was enhanced by

7 György Kara, *Books of the Mongolian Nomads. More than Eight Centuries of Writing Mongolian* (Bloomington, Indiana, 2005), 233–34; Elisabetta Chiodo, 'Die mongolischen Manuskripte auf Birkenrinde aus Charbuchyn Balgas', in *Dschingis Khan und seine Erben. Das Weltreich der Mongolen*, ed. Claudius Müller (Bonn, 2005), 112.

Fig. 4 Distortions and sticking paper parts caused severe tension within the paper. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

the combined degradation processes of acid-catalysed hydrolysis and iron-(II)-catalysed oxidation. These combined processes are known to be mainly responsible for the ink corrosion of iron-gall inks.[8] However, as the vitriol part, in particular sulphur, could not be traced in the substance, the damaging substance cannot be identified as an iron-gall ink. It is unclear whether the substance was even meant to be a writing ink, as it is not used on the mandala or on other objects from the same collection. In contact with water, coloured degradation products of the damaged areas are easily dissolved. Unfortunately, the substance could not be specified any further. For the treatment of the mandala, however, it was important to treat the damage with processes similar to those used for ink corrosion, as the degrading mechanisms can be seen as analogue due to the presence of the acid and the free iron-(II)-ions.

8 Gerhard Banik and Hartmut Weber, *Tintenfraßschäden und ihre Behandlung* (Stuttgart, 1999), S. 9; Jana Kolar and Matija Strlič, 'Ageing and Stabilisation of Paper containing Iron Gall Ink', in *Iron Gall Inks: On Manufacture, Characterisation, Degradation and Stabilisation*, ed. Jana Kolar and Matija Strlič (Ljubljana, 2006), 181–94.

Conservation treatment

1 Conservation concept

To prevent the further migration of acid and iron-(II)-ions from the degraded paper areas, water-based treatments were ruled-out for these areas. This included humidifying for flattening or water-based stabilization methods for the damaged areas and also local washing of the damaged areas. A local washing would have been useful for removing damaging components and soluble degradation products from the damaged paper areas. Yet, judging from the highly absorbent paper and the water sensitivity of the dyes, even washing on a suction table would not prevent a spreading of coloured degradation products within the paper and a removal of the colourants. Despite the advantages, we therefore decided against attempting to remove damaging components. However, repairs in undamaged paper areas or the attachment of Japanese paper strips to the borders for stretching could be carried out with wheat-starch paste under given precautions.

Primarily, the sticking folds had to be separated in order to achieve a relaxation of tensions within the paper. After that, the brittle, damaged areas had to be stabilized to prevent any further losses. To address remaining cockling and creases, a local, dry stretching on the *karibari* had to be evaluated for its success. Finally, to close the large losses and by that to stabilize the fragile mandala, a thin Japanese paper had to be applied to the verso of each damaged area. This Japanese paper had to be glued around each damaged area and its losses only to the undamaged paper using wheat-starch paste. In this way, the losses would be kept in place, the mandala stabilized and the brittle paper areas additionally protected whilst being handled.

Fig. 5 Detail of one damaged area, in which a major fold is stuck. The damaged paper is only sticking together locally. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

Fig. 6 A large fold was mechanically released after the separation of the sticking paper parts in this area. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

2 Separation of sticking paper

To loosen severe tension in the paper, parts of the degraded paper had to be separated in six small spots, not larger than 3 mm each. The paper layers could be separated mechanically with a spatula after locally applying a tiny amount of vaporized ethanol. While separating the larger folds, more loose fragments occurred (Figs. 5–6). They were either reattached to the appropriate area or were stored with other fragments which were not localized. These fragments will be mounted in a separate folder to be stored with the mandala. One particular fold that was sticking together was responsible for severe tension in the mandala. By releasing this fold, a considerable relaxation of the tensions within the paper was achieved (Fig. 7).

3 Stabilization of degraded paper parts

The spilled substance had caused a severe degradation of the paper fibres in the affected areas, leaving them extremely brittle and likely to be further damaged through handling. A large amount of damaged paper was already lost due to its brittleness. Hence the remaining paper parts in these fragmented areas had to be stabilized in order to prevent a further loss of material.

The combination of highly soluble degradation products and the presence of harmful iron-(II)-ions plus acid in the affected areas presented difficulties for stabilization. Common methods include water-based adhesives such as wheat-starch paste or gelatine. However, even applying a remoistenable

Fig. 7 The separation of sticking paper parts achieved a considerable relaxation of the tension within the paper. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

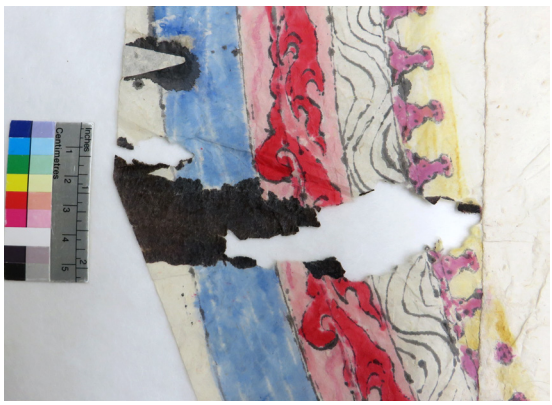

Fig. 8 Example of the stabilization with the 'Munich Tissue'. It covers only the degraded paper parts from verso. It overlaps the unaffected paper by about 2 mm to 3 mm and lines up precisely with the edges of the lost area. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

tissue, which has the advantage of requiring a minimal amount of water for activation of the adhesive layer, seemed questionable when using it for such large areas.[9]

An alternative method of applying the thinnest Japanese paper to such water-sensitive areas without water-based adhesives has been established by the Institute of Book and Manuscript Conservation as the so-called 'Munich Tissue'.[10] It refers to a 'Gossamer Tissue' that is pre-coated with an acrylic film which can be activated by heat.

The pre-coated tissue was applied on the verso side of each damaged part of the mandala, with an overlap on the unaffected paper of about 2 mm to 3 mm (Fig. 8). By applying it to the verso side only, a sufficient stabilization was achieved and the appearance of the painted surface was not affected.

4 Addressing the instability of the mandala

After conducting the local stretching, which is described below, the whole treatment was completed by a closure of the losses. This aimed to address the general instability of the mandala. As inlays would have required gluing directly to damaged paper areas, it was decided that attaching a thin Japanese paper (11 g/m^2) to the verso around each damaged area would provide sufficient protection. The Japanese paper was attached to the verso of a damaged area by starch dots on the unaffected paper close to the lost areas (Fig. 9). Use of dots minimizes potential tension created by the pasting. The Japanese paper prevents distortions of the whole through movement of damaged areas and thus increases the stability of the mandala.

Fig. 9 Protection of the losses (verso). The Japanese paper was attached by wheat-starch paste dots from the verso on the unaffected paper close to the damaged areas. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

9 Eliza Jacobi, 'Rendering the Invisible Visible. Preventing Solvent-Induced Migration during Local Repairs on Iron Gall Ink', *Journal of Paper Conservation* 12, no. 2 (2011): 25–34.

10 The utilization and preparation of the 'Munich Tissue' at the IBR was presented by Karin Eckstein et al. at the Adapt & Evolve Conference 2015. The paper 'Trust the Fibre: Introduction of Gossamer Tissue into European Paper Conservation and its Use for the Stabilization of Iron-Gall Ink and Copper Corroded Paper' will soon be published.

Local stretching

Although the separation of the sticking parts created a considerable relaxation, a number of smaller creases and distortions were present. As the paper composition of the mandala itself allowed a certain flexibility, it was possible to achieve a better overall flatness by applying a flattening method.

There are, however, several restrictions. Most importantly, no moisture could be applied because of the water sensitivity of the colourants and the migration of iron-(II)-ions and acid from the brittle areas. To prevent a migration of harmful iron-(II)-ions, any increase in relative humidity should be avoided.[11] Secondly, due to the vulnerability of the brittle paper areas to pressure, an overall weighting was not possible.

To reduce creases and cockling a localised technique, viable without humidification, was needed.

11 Helen Wilson, 'Analysis of the Current Research into the Chemistry of Iron Gall Ink and its Implications for Paper Conservation' (Master's thesis, St Anne's College, Oxford, 2007), 66–73.

1 Adapting existing techniques

Workshops like 'East meets West' at the IBR disseminate East Asian materials and techniques in Western conservation.[12] Using a *karibari*, it is possible to dry and simultaneously flatten objects with sensitive surfaces. In general, these methods use the shrinkage of the moist paper fibres while drying to flatten the paper. The humidified object is mounted on the *karibari* with disposable Japanese paper borders or strips. The borders are attached to the periphery of the object with the tips of the long fibres, adhered by a particular dilution of wheat-starch paste. The other ends of the strips are pasted to the *karibari*. This set-up has the advantage that weighting down the object is not required, and it seemed promising for an adaption to the mandala.

12 Since 2009, the workshops 'East meets West' and 'East meets West for students', held by conservators from Japan, have taken place at the IBR.

As it was not possible to moisten the mandala, the method could only be carried out without moistening the whole paper, thereby modifying the flattening process itself to a dry stretching technique. As a consequence, the flattening was achieved through applying slightly increasing tensions over a longer period of time. In this case, the *karibari* acted as a sturdy but lightweight board that facilitated the repeated removal and re-pasting of the Japanese paper strips.

Due to the circular and irregular shape of the mandala, only individual paper strips could be applied (Fig. 10). Through this set-up an individual and variable stretching of the different areas could be carried out according to their damages and creases. Furthermore, it was possible to locally stretch distinct areas by weighting down parts of the paper.

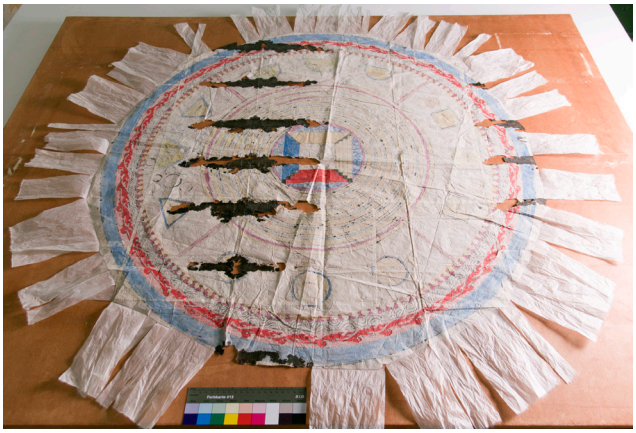

Fig. 10 The Mongolian mandala with its individual paper strips in raking light (verso). The strips are not yet pasted to the *karibari*. München, Bayerische Staatsbibliothek, Cod.tibet. 992.

Fig. 11 Detail of the attachment of the Japanese paper strips to the border of the mandala (verso). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

Attention had to be paid to the different stretching characteristics of the mandala: the brittle areas, especially the borders between damaged and undamaged paper, and also the big losses, are vulnerable to higher tensions and thus can be in danger of breaking or opening up under higher tensions.

2 The set-up

Around 40 individual paper strips were pasted to the verso border of the mandala. The paper strips were fitted to the particular border section in width and were initially left as wide as possible, as they could still be divided in the course of stretching, if necessary, to vary the tension. With diluted wheat-starch paste, the strips were attached to the border of the mandala by the tips of the long fibres only (Fig. 11). By using the wheat-starch paste sparingly and additionally couching the coated tips of the paper strips on blotting paper before the attachment to the mandala, a bleeding of the colourants could be prevented. In areas where damaged paper is located in the periphery, no strips could be applied. A small line of diluted wheat-starch paste, applied to each strip for the attachment to the *karibari*, facilitated releasing the strip mechanically with a spatula, without damaging either the *karibari* or the paper strip.

The paper strips were crinkled before attachment for a better reaction to changes in dimension. This is, of course, more important while stretching moist objects, but was also useful in this case, as it facilitated the application of the paper strips to the uneven periphery of the mandala. In the course of stretching, this crinkling was reduced.

3 Stretching the mandala

Initially, the mandala was mounted on the *karibari* with diluted wheat-starch paste with slight tension. In a second step, the strips were released and repasted one by one with increasing tension. The applied tension and its direction depend on the given condition of each paper section and its reaction to the applied tension. As the flattening with this dry stretching works very slowly, it is useful to let around one week pass between each repositioning of the strips.

While stretching the mandala, the damaged area of the second paper label, which represents a large tear in the paper, had to be secured through light weights, placed on both sides of the damaged area (Fig. 12). This prevented the tear from slightly opening up through the course of treatment. In the same way, light weights can be placed on the object for applying different stretching tensions to various parts of the mandala. This allows the

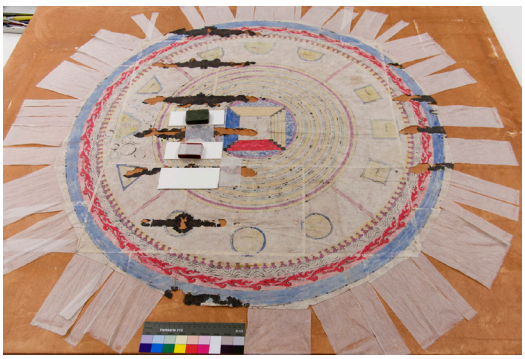

Fig. 12 Dry stretching of the mandala on the *karibari* (verso). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

application of higher stretching tensions to stable areas and simultaneously a protection of weaker paper areas. This local application was necessary as the mandala exhibited different distortions and creases on each paper piece.

In particular, two outer paper pieces of the mandala were treated locally with higher tensions (Figs. 13–14). In both cases, the outer paper showed more distortion than adjacent papers. The weights were placed on blotting paper strips for protection and aligned over the glued overlap (Fig. 13). Repasting the paper strips, more tension with a different stretching direction was applied to the outer paper and its distortions. Through this local stretching, it was possible to reduce the uneven creases.

Both paper pieces are, nevertheless, examples of several restricting factors.

Fig. 13 Creases and remaining cockling can be noticed in raking light (verso). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

Fig. 14 Detail of one outer paper piece and its distortions in raking light (verso). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

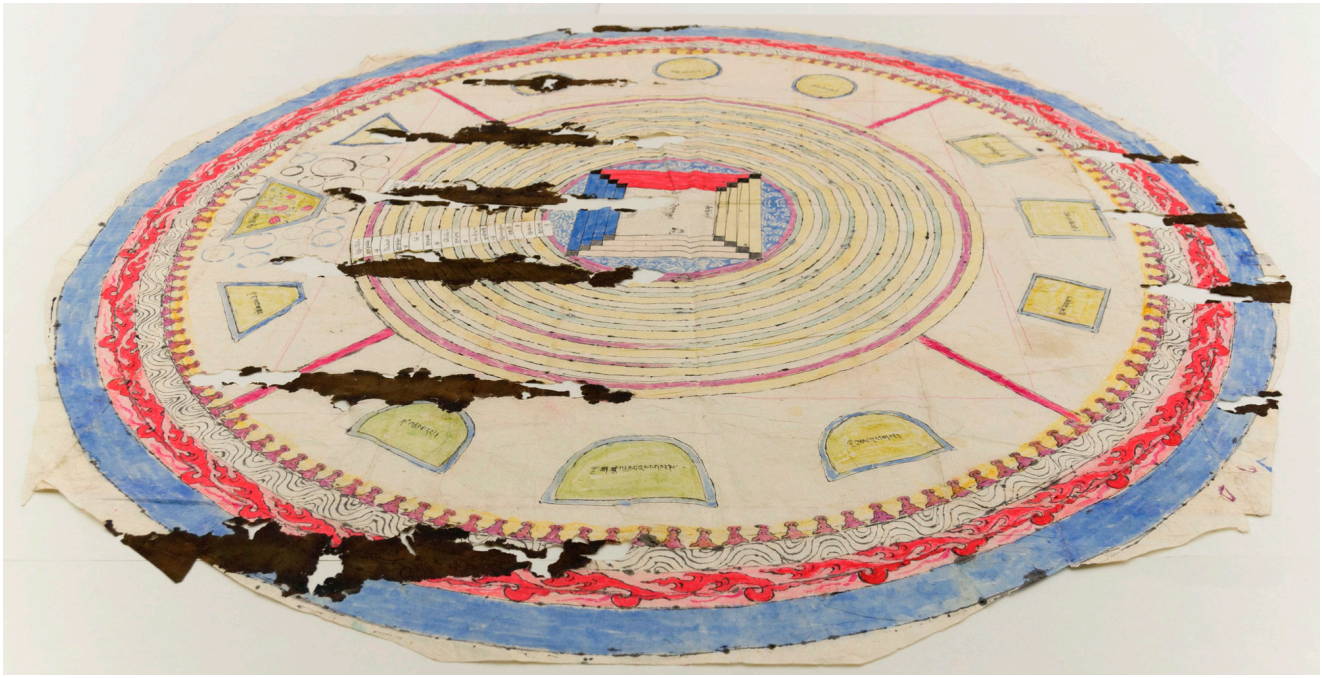

Fig. 15 The mandala after one month on the *karibari* (recto). München, Bayerische Staatsbibliothek, Cod.tibet. 992.

Obviously, during manufacture of the mandala the outer paper pieces must have been glued to the rest inaccurately, creating the initial distortions. To lay out these creases completely, one would have to separate the overlapping paper pieces. As an alignment of the painting would then be impossible, such an intrusion was not an option. As a result, it was only possible to slightly reduce these creases through partially stretching the outer papers. The degraded paper areas themselves acted as additional restricting factors to this local stretching. Some areas of cockling could not be addressed through the stretching, because they were trapped between rigid areas, an example of which was detected between the damaged areas in the front on Figure 13. There, the stretching tension cannot reach through the degraded and brittle areas.

4 Results

Over a period of one month the strips were repositioned around five times to vary the tension and its stretching direction. After each repositioning of the strips, the mandala was left in this position for about a week. At some points, there was scarcely any improvement to be expected, mostly because of the individual restrictions of the overlap areas and the damage, as explained above.

Nevertheless, the treatment achieved a main overall flatness of the paper and a massive reduction of the tensions within. Comparing the measurements of the mandala before and after the local stretching, an expansion of 1 cm to 1.5 cm in diameter can be noted. This confirms a flattening of the remaining creases and distortions, which was also observed visually (Fig. 15).

Using the *karibari* and individual paper strips for dry stretching turned out to be a useful alternative when addressing a highly damaged and water-sensitive object with a flexible paper structure. As the tension can be applied individually according to the damage and the flexibility of the paper, this set-up is suitable for sensitive objects.

Summary
The Mongolian mandala had been damaged by an acidic and iron-(II)-ion containing substance, resulting in several highly degraded and brittle areas. The damaging substance could not be identified as an ink, however, the damage had to be regarded similarly to ink corrosion. Based on the results of the analysis, practical conservation treatment steps were developed. Sticking paper parts were separated with the local application of a small amount of vaporized ethanol. The degraded paper areas were stabilized from the verso with the 'Munich Tissue'. Thin Japanese paper was applied from the verso to each loss area for the general stabilization of the mandala and the closure of losses. Before this last step, a local stretching technique was adapted. As the strength of the tension could be adjusted according to areas of damage and the flexibility of the paper, the chosen set-up was suitable for this sensitive object. Despite several restrictions arising from the overlap areas or the damaged areas themselves, a comparison between the distortions before any treatment and after stopping the stretching showed that the whole conservation treatment achieved a general overall flatness of the paper and a reduction of the tensions within.

Acknowledgements
Many people contributed to the successful completion of the Bachelor's thesis and the following Master's project. I would like to thank in particular Dr Irmhild Schäfer, Karin Eckstein MA, and Heidi Fischer for their supervision and permanent and supportive guidance and Dr Thorsten Allscher (IBR) for his support during completion of the analysis. I would also like to thank Ralf Kramer from the Oriental and Asia Department of the Bayerische Staatsbibliothek München for the translation of the Tibetan labels and the elaborate explanation of the Buddhist cosmology.

Abstract
The paper outlines the conservation approach to a highly damaged modern mandala from Mongolia, which was developed as part of the author's Bachelor's thesis in 2014 at the Technical University of Munich in cooperation with the Institute for Conservation and Restoration at the Bayerische Staatsbibliothek München. The Mongolian mandala illustrates the Buddhist cosmology according to two different Buddhist sutras, *Abhidharmakośa* and *Kālacakra*, and is dated to the early twentieth century. It had been folded twice and locally damaged by an acidic substance, resulting in brittle and degraded areas and adjacent losses. Research into the provenance and the analytical examination of the fibres, the colourants and the damaging acidic substance provided the basis for the practical conservation approach. The conservation treatment comprised the release of sticking paper parts, stabilizing the brittle and damaged areas and flattening the object. The successful approach of applying a dry stretching technique to address remaining creases in the paper is presented and discussed.

Biography
Ann-Kathrin Eisenbach recently completed a Masters in book and paper conservation at the Technical University of Munich (TUM) in cooperation with the Institute for Conservation and Restoration (IBR) of the Bayerische Staatsbibliothek München, having previously completed her BA in Restoration, Art Technology and Conservation Science at the TUM. In 2013-14, as part of her studies, she completed a four month internship at the City Archive in Amsterdam and a three month internship at the Albertina in Vienna, as well as several short internships in museums and archives. In 2011, and again in 2015, she attended the Workshop 'East meets West' for students at the IBR.

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