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The Inherited Condition: The Complex Methodology Required to Conserve the West Choir Windows of Naumburg Cathedral, Germany

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Der ererbte Zustand: die komplexe Methodik zur Erhaltung der Westchorfenster des Naumburger Doms, Deutschland – Zusammenfassung

Während seiner Entstehungszeit zwischen 1241 und 1250 wurde der Westchor des Naumburger Doms mit fünf figurativen Fenstern ausgestattet. Der Westchor mit seinen berühmten Stifterfiguren stellt ein Gesamtkunstwerk dar und war maßgeblich für die Verleihung des UNESCO Weltkulturerbe-Titels im Jahr 2018.

Im Laufe der Jahrhunderte wurden die Fenster des Chors vielen Eingriffen unterzogen. Drei der fünf Fenster weisen einen großen Anteil von Glasmalerei aus der Entstehungszeit auf, ergänzt durch Glas aus Restaurierungsphasen des 19. und 20. Jhs. Zwei verlorene Fenster wurden im 19. Jh rekonstruiert und der originalen Gestaltung angeglichen.

Jede Restaurierung hat sich signifikant auf den Zustand der Glasmalereien ausgewirkt. Während allen Ergänzungen ein historischer Wert zugesprochen werden kann, verursachen viele der angewendeten Techniken und eingebrachten Materialien heute eine restauratorische Herausforderung. Das Glas aus dem 19. Jh zeigt extremen Malschichtverlust und Craquelé des blauen und gelben Glases. Die Vorarbeiten an den Glasmalereien des 13. Jhs zur Durchführung des Jacobiverfahrens führten zu starker Glaskorrosion, fragiler Malschicht und Acrylatrückständen.

Dieser Artikel befasst sich neben der Restaurierungsgeschichte mit dem überkommenen Zustand der Fenster und den durchgeführten Restaurierungsmaßnahmen. Des Weiteren wird beschrieben, wie der Gesamteindruck des Westchors visuell harmonisiert wurde.

The Inherited Condition: The Complex Methodology Required to Conserve the West Choir Windows of Naumburg Cathedral, Germany – Abstract

Over the centuries, the windows in the West Choir of Naumburg Cathedral have been exposed to many alterations. These figurative windows were originally installed between 1241 and 1250, during the Choir's construction. The entire ensemble or Gesamtkunstwerk was a key factor in the Cathedral gaining World Heritage status, in 2018.

Today, three of the five windows retain considerable expanses of original glazing, as well as 19th- and 20th-century additions from previous restorations. Two windows were entirely remade in the 19th century with sympathetic designs.

Each restoration has significantly impacted upon the current condition of the stained glass. Whilst, over time, all introduced materials can attain historic value, it is clear that many of the techniques and materials applied to the West Choir windows have created substantial conservation challenges. The 19th-century glass exhibits extreme paint loss and craquelé of the blue and yellow glasses. The 13th-century glass exhibits severe corrosion, fragile paint and acrylate residues as a result of preparations for Jacobi-plating in the 1940s.

This paper will describe the restoration history and the balanced methodology required to unify these windows, whilst addressing the urgent interventions needed for their conservation.

Introduction

Naumburg Cathedral's West Choir has one of Germany's most extensive figurative window cycles from the High Middle Ages. These windows portray the victory of Christian faith over pagan traditions. Apostles and saints stand triumphant over their adversaries and personifications of virtues defeat vices. The medieval scheme also epitomises the *Zackenstil* or jagged style, which takes its name from the depiction of heavy folds in drapery, seen in the figure's heraldic clothing. This 13th-century aesthetic mixed French Gothic and Byzantine influences, with Naumburg at an intersection between these artistic movements. A narrow colour palette is combined with large figurative iconography on a monumental scale. Comparable in quality to the clerestory and transept windows of Chartres Cathedral, this glass undeniably has a strong identity and is instantly recognisable.

This scheme of five monumental windows remains a highly significant medieval work of art, despite now being a composite of interventions by the many generations of glass painters and conservators to work on them. Despite the 19th-century recreation of two windows, strong iconographic unity has been retained. However, the durability of these additions has created problems with the uniformity of tone and light across the Choir.

The last 150 years have witnessed three major restoration campaigns. Each successive team respected the quality of these windows and strove to ensure their interventions were ethical, harmonious and enduring. Unfortunately, each suffered a combination of poor execution, irreversible procedures, flawed

decisions and misfortune. Many of the materials and techniques utilised have culminated in the long-term degradation of the glass.

Between 2018 and 2020, a glass workshop was set up in the grounds of Naumburg Cathedral to address the urgent conservation required to stabilise and secure these windows for future generations.

The Impact of Past Decisions

Prior to the late 19th century, there are scant archival records about the condition and maintenance of the West Choir windows. The first record dates from 1584 and refers only to three medieval windows.[1]

The loss of windows swII and wI is attributed to an undated extreme weather event. Archival images from the mid-19th century reveal they were replaced by rectangular quarry glazing.

Subsequently, there have been three major restoration campaigns. What follows is a synopsis of how these interventions have impacted the glazing. This combines archival research undertaken by Dr. Deiters and Dr. Aman,[2] together with our onsite and studio analyses (fig. 1).

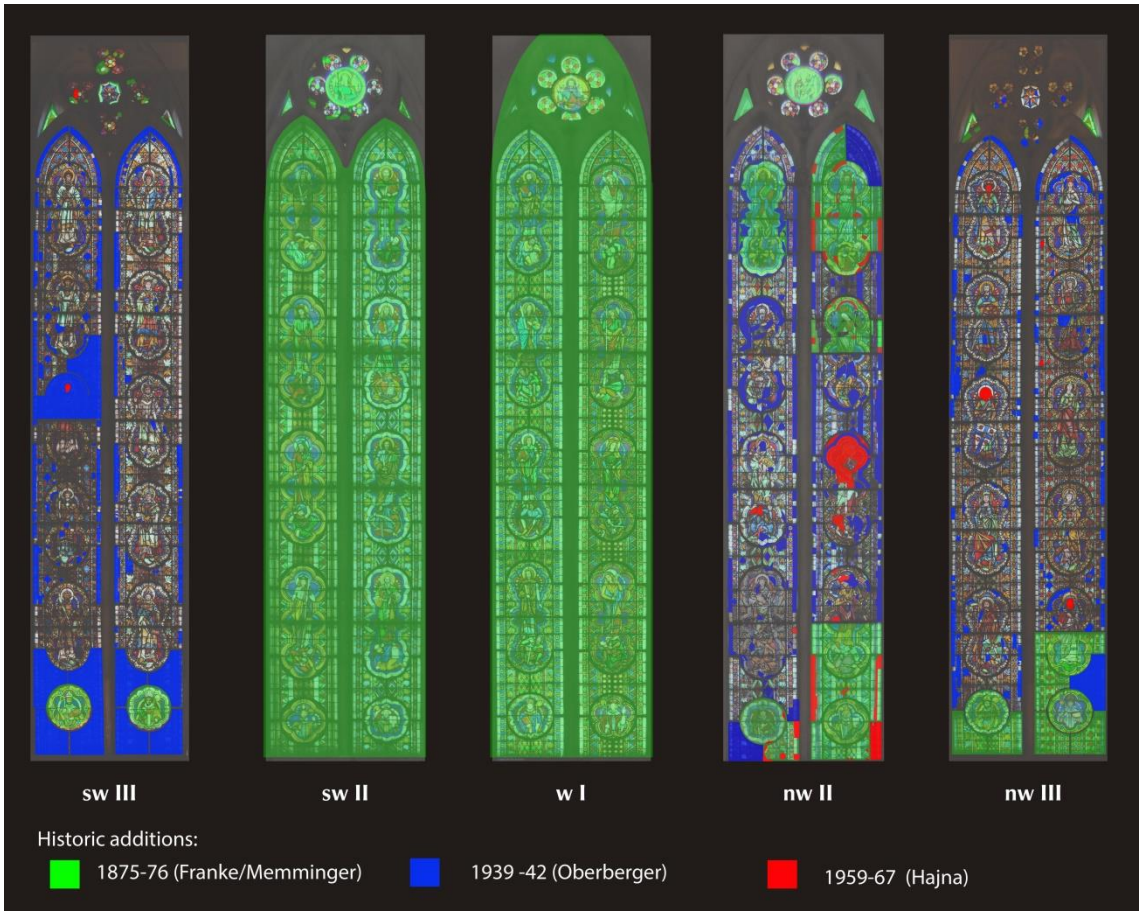

Fig. 1. Diagram of the restorations in the West Choir. © Vereinigte Domstifter.

Franke/Memminger 1875–1879

The first restoration was by Wilhelm Franke (Naumburg Master Glazier) and Karl Memminger (Architect). By the 19th century, the medieval windows (swIII, nwII and nwIII) were in disrepair, with gaps and missing panels. Memminger designed a scheme to unify all five windows, whilst remaining sympathetic to the original glass. The new glazing adhered to the same colour palettes for glass and

[1] Reinhard Köpf and Ivo Rauch, *Die Verglasungen des West- und des Ostchores des Naumburger Doms. Gutachterliche Stellungnahme zu Bestand und Zustand der Fenster und Empfehlungen für eine Sanierung bzw. Konservierung der Scheiben*, 2017, p. 8.
[2] Cornelia Aman, Maria Deiters, and Martina Voigt, *Vorabgutachten zur Restaurierungsgeschichte der Westchor- und Ostchorverglasung des Naumburger Domes*, 2016.

paint and used traditional painting techniques mimicking the three-tone medieval iconography. They used an early mouth-blown glass, leaded with fine cames suggestive of the medieval lead. As this glass was largely available only in light tones,[3] the design relied upon the use of multiple layers of paint.

In addition to remaking two windows, the three medieval windows were cleaned. Some of this work was conducted *in situ,* as Franke recorded, using a brush and soapy water from ladders and scaffolding.[4] Corroded brush marks are now evident across the interior surface of the 13th-century glass. The traceries were also treated *in situ*. New glass infills were added by splicing the medieval lead from the interior side and resealing it with ample putty. Where panels were removed, they were reinstalled with cement.

Franke added cold paint to enhance missing grisaille. To make the windows appear less patchy, he applied a darkening layer to medieval pieces thinned by corrosion and a separate protective coating to the better preserved glass. One of these layers was later identified as an iron varnish or 'eisenlack'.[5]

Despite their best efforts, the final result was inharmonious. As with many 19th-century studios, paint-loss was a major problem. Franke was recalled to effect repairs that included the addition of cold paint to his own windows. However, this new glazing remained much brighter than the medieval glass. By the 1930's, substantial paint-loss was evident in all but the West Window, whilst the iron varnish had become black/brown and opaque. In addition, the blue and yellow glasses were unstable and began to show signs of craquelé. In 1937, Prussian state conservator Robert Hiecke lamented the Choir's "divided effect" and the next conservation team was commissioned.[6]

Oberberger 1939–42

In 1937, Josef Oberberger of Munich was commissioned to redesign and restore unity to the West Choir windows. He worked closely with the Dörner Institute and was keen to use their new scientific methods. Prior to conservation, large sheets of paper were stuck to the windows with protein glue.[7] The paper's subsequent dry removal resulted in significant shaling of the glass surface; particularly, that of the 19th-century glass.

In 1939, as Oberberger planned to remake all Franke's glazing, only the lancets of the medieval windows nwII, nwIII and swIII were deinstalled for safety, due to WW2. This glass was stored in the basement of the north-west tower, from where it was taken piecemeal for conservation. Records reveal these windows were in poor condition, with swIII particularly fragile. Oberberger described the medieval lead as weak and unsalvageable, which was opportune as he was keen to test the new plating technique designed by Jacobi at the Dörner Institute.[8]

Jacobi's aim was to protect fragile glass and paint from water damage through a process of lamination. Plates were applied to both sides and the interspace filled with a liquid thermoplastic. Oberberger trialled this method using a mixture of PMA with diisobutyl phthalate plasticisers.[9] This glass 'sandwich' was then shipped to the SIGLA (*Sicherheitsglas* or laminated glass) factory in Kunzendorf, where it was heat sealed at 130°C, rendering it waterproof.[10]

In 1940, two trial panels (swIII 11b and nwIII 17a) were selected for lamination.[11] In spite of unsuccessful results (due to excess weight and highly reflective surfaces), Oberberger plated at least 400 glass pieces, although PMA remnants have been found across most of the medieval glass. In order to accommodate these laminated pieces, the glass required reglazing. By 1941, all the medieval lead had been discarded.[12]

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[3] KOPF & RAUCH 2017, p. 8.
[4] AMAN et al. 2016, p. 8.
[5] *Ibid.*, p. 9.
[6] KOPF & RAUCH 2017, p. 12.
[7] AMAN et al. 2016.
[8] AMAN et al. 2016, p. 12.
[9] Elisavet KANAKI and Joseph BRANDT, *Erforschung historischer Konservierungsmethoden für Glasfenster. Ein Bericht zu Erhaltung mittelalterlicher Glasmalerei einschließlich der Ergänzungen aus dem 19. Jahrhundert im Naumburger Dom*, 2019, p. 13.
[10] AMAN et al. 2016, p. 11.
[11] AMAN et al. 2016, p. 21, 23.
[12] *Ibid.*, p. 12.

Prior to lamination, Oberberger's team thoroughly cleaned the glass, using hydrofluoric acid to remove all dirt and traces of 19th-century iron varnish, coatings and cold paints.[13] Two glaziers, Zörn and Bauer, were particularly skilled at judging how long to leave the glass in the acid without losing the glass paint.[14] However, they did remove the corrosion products. Glass breaks were edge-bonded, and the paint consolidated using the PMA formulation.[15]

The Oberberger team began systematically replacing the Franke glass with mouth-blown real antique glass, in the same colours as the medieval windows. They achieved their aim of an artistically satisfying approach that did not falsify the iconography. Ornamental details were reproduced but glass pieces within the figures were remade using a stippled design. Infills were signed with the year and/or an 'x', and signatures were included within remade panels. These panels are extremely dark in comparison with the rest of the scheme.

Franke's team had replaced eight missing medieval heads, but these had either lost their paint or were badly executed. Oberberger created new heads for many panels but made a 'cloud head' for St Matthew in nwII. We cannot know whether this approach was planned for all eight panels, as the restoration was abruptly suspended in 1942. The two glaziers were conscripted and neither man returned. The medieval glass spent the next decade in the north-west tower basement, where it was badly affected by the damp, humid conditions.

Hajna 1959–1967

By the time Hajna was commissioned, the medieval glass pieces had stuck to the layout paper, fungus was growing on the acrylate, and the laminated panels exhibited broken plates, water ingress and acrylate discolouration.[16] Franke's glass remained *in situ* and Hajna inherited the task of reunifying the choir.

The immediate priority was to reglaze the medieval glass. Hajna reversed most of the laminated plates by gently heating them, cutting the PMA with a long flat blade, and cleaning the surfaces with acetone.[17] He did very little additional cleaning, retaining historic dirt and lacquer. Broken pieces were glued with 4-5 coats of PMMA or PBMA (Piaflex) applied to the exterior side.[18] These products were applied liberally and cover up to 5mm of the surface on either side of the break. Piaflex was also used to consolidate paint and large deposits remain on the glass.

Whilst Hajna retained the majority of Oberberger's infills, he replaced remaining Franke additions with antique glass coated with fired and unfired paint, the latter proving undurable. He also dated some pieces and added seven further 'cloud heads', as well as 'cloud hands'. These cloudy pieces have remained contentious ever since.

Finally, Hajna placed all five windows, except the traceries, in protective glazing. To accommodate this, the medieval ferramenta was moved 10cm into the church and new bars were installed. This external glazing comprised rectangular quarries of different hues to tone down the 19th-century glass. It was not mortared into the stone and was sealed with putty to the condensation trays. Therefore, whilst affording the windows some protection, it did not shield the glass from the effects of humidity or air pollution.

Inherited Problems

Despite the best intentions of past conservators, the extant collection remained disunited and problematic. The 13th-century glass exhibited considerable active, powdered corrosion; likely exacerbated by the coatings, acid cleaning and damp storage conditions. Comparison between Hajna's photos from the sixties and the glass today, clearly demonstrate the increase in corrosion products. Where the corrosion had pierced the surface, the surrounding paint was flaking and extremely vulnerable.

[13] *Ibid.*, p. 18.
[14] *Ibid.*, p. 18.
[15] *Ibid.*, p. 8.
[16] AMAN et al. 2016, No: 61.
[17] *Ibid.*, No: 78; No: 69.
[18] KANAKI & BRANDT 2019, p. 12.

The glass also exhibited extensive PMA/DiBP residues. The acrylate held absorbed water against the glass surface during cycles of wetting and drying. Water ingress had contaminated the PMA, producing various shades from pale yellow to dark amber and darkening the appearance of the medieval glass. This PMA formulation has a low glass transition temperature (10°C) and the windows' thermal variation resulted in dust and dirt adhering to the sticky surface on the south facing windows.

Hajna's acrylates were more durable. However, many bonds had failed and small flies (thrips) had burrowed underneath the glue. Many of his infills were very bright, due to the failure of the cold paint. The Franke glass displayed substantial paint loss and the historic cold paint repairs had either failed or accumulated thick dirt layers. The glass surface exhibited large areas of shaling due to dry removal of paper and protein glue, which had become brown. Many pieces exhibited stages of craquelé. In spite of darkening attempts, these panels remained very bright. By contrast, the thirteen Oberberger panels appeared extremely dark.

All the panels were filthy, with dust and thick black particulate deposits comprising soot, gypsum, putty, and mortar, as well as silicon and aluminium particles.[19] The dirt adhered to the paint and cold-paint, as well as traces of PMA.

Chemical analysis revealed these windows had been exposed to high levels of air pollution. In addition to gypsum and sodium sulfate, zinc oxalate and zinc ammonium oxalate were found on both sides of the panels.[20] The area surrounding Naumburg is rich in lignite deposits (brown coal), which contain high levels of carbon, nitrogen and sulfur, and heavy metals, including lead and zinc, that are released during incineration. During the GDR, many households were fuelled with lignite. The Geisel valley, 20km to the north east, was the location of vast opencast mines between 1698 and 1994. This mining gave rise to many chemical plants e.g. the BASF ammonia plant at Merseburg.[21]

Naumburg sits in the Saale river valley, where high humidity is common in the summer months. Since 2016, the relative humidity (RH) and temperature around the West Choir windows have been monitored, most recently with the Custos Aeris system.[22] Between 2016 and 2017, the glass was exposed to extremes of temperature (from -5 to 46°C) and changes in humidity (between 10-99% RH).[23]

Our Conservation Methodology

Primarily, the entire project was guided by preventative conservation. In order to address the rapid increase in glass corrosion, paint fragility and craquelé, environmental control was essential. As most stained glass corrosion and pest infestation are caused or exacerbated by moisture, the replacement of the protective glazing was imperative.

We also inherited the longstanding aim to try and unify this scheme of windows, whilst addressing the damage phenomena described. Enhanced iconographic legibility was also desirable. The project was overseen by an international Scientific Advisory Committee, comprising art historians, conservators and heritage officials. Their counsel was sought when defining the scope of any intervention.

Our approach was to preserve as much historic material as possible. In doing so, the strategy mixed preventative and interventive techniques. Over time, all materials introduced to an object attain value. However, historic value alone cannot be the defining factor in a conservation strategy, where damage can be related to specific materials.

It was thought that historic arguments for creating the cloudy heads and hands, no longer aligned with current views on aesthetic value and the balance required to ensure liturgical function, cultural and community value.[24] In consultation with the expert committee, it was decided to improve legibility by

[19] Katrin RAHFOTH, Nicole STERZING and Ines TRAPPIEL, *Erforschung historischer Konservierungsmethoden für Glasfenster. Ein Beitrag zu Erhaltung mittelalterlicher Glasmalerei einschließlich der Ergänzungen aus dem 19. Jahrhundert im Naumburger Dom, Bericht zur Materialprobenentnahme für die wissenschaftlichen Untersuchungen an den originalen Glasmalereischeiben*, 2019, p. 39.
[20] *Ibid*., p. 41.
[21] D. BACHMANN, *Geisel Valley*, 2020.
[22] For further information visit https://custos-aeris.ixtronics.com/en/.
[23] Data collected from the interspace between the stained glass and Hajna protective glazing on window swIII.
[24] HISTORIC ENGLAND, *Conservation Principles, Policies and Guidance*, 2008, p. 27-35.

reconstructing lost text, faces and hands. This was achieved through a combination of painted plates and infills (please refer to the article *Finding Faces* within this volume).

Unifying the Choir

The new environmental protective glazing is weathertight and internally ventilated. Lamberts mouth-blown Restauro UV glass was used, which filters wavelengths between 280nm and 400nm and has no risk of delamination. By removing the influence of weather, UV radiation and air pollution, we have ensured that the organic conservation materials will not deteriorate further.

As a first step towards unifying the light distribution in the Choir, a faint wash of paint was applied to the protective glazing, using the optical brightness of the medieval glass as a reference point. Reflecting their aspect and degree of paint loss, the glazing behind the 19th-century windows was darkened further. Tests ensured the UV protection would not be lost by firing the glass to 620°C. These results were corroborated by the BAM UV glass study.[25]

As a further complication, the three medieval windows contained 19th-century panels with extreme paint loss. To address the light discrepancy, large painted plates were installed between the stained glass and the protective glazing (fig. 2). Each bespoke plate addressed the light balance for a specific panel, using stippled paint which followed the iconography.

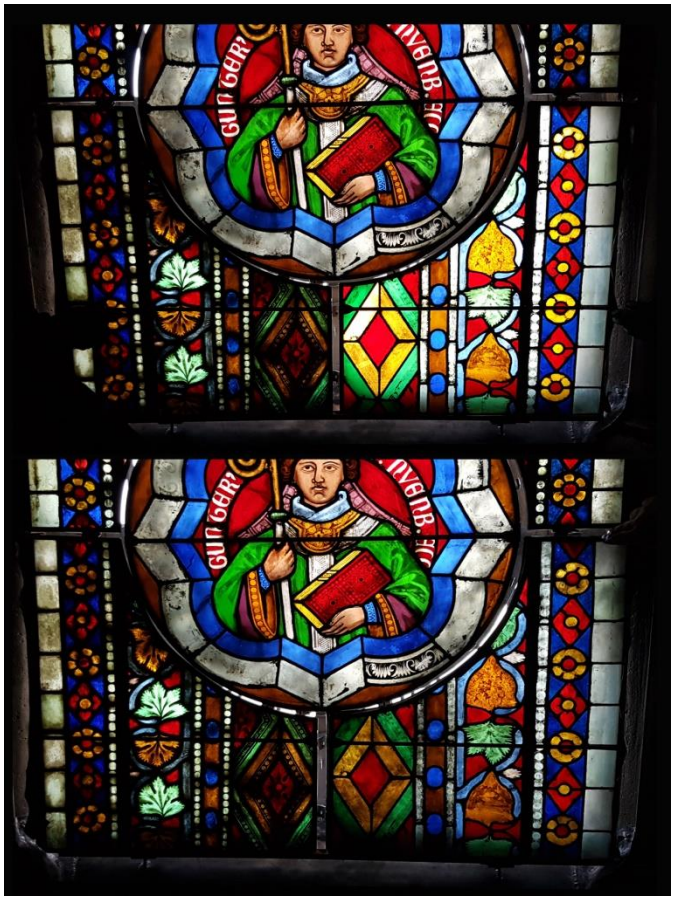

Fig. 2. Naumburg Cathedral: Before and after installation of the darkening plate for panel nwII 1a1.
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Cleaning

Varied levels of cleaning can be used to unify light transmission across a scheme of windows. However, due to the extent of glass degradation, our priority was surface stabilisation. As windows swII and wI were uniformly darkened by the external glazing, a straightforward approach was adopted, using wet and dry methods. However, on the Franke panels of the medieval windows, a balance was sought between how much dirt to remove and how bright the panel would become.

The medieval panels required careful intervention. Dirt, dust and active powdered and flaking corrosion products were removed using brushes and vacuum cleaners. Hard corrosion layers were thinned, but not removed entirely. The biggest challenge was safe removal of the PMA/DiBP. Where it had become hard and brittle on the north windows, it could be removed with the gentle application of a scalpel or brush. However, on swIII it was well-adhered. Timed trials were made using acetone; ethyl acetate poultices; and a DMSO and Klucel G gel.

The DMSO gel was most effective at removing thick PMA residues. The gel prevented DMSO run-off and lowered the possibility of glass infiltration. Where pieces had an uneven topography, from corrosion and/or paint, this technique was used with extreme caution. The DMSO was used to thin the PMA, which was then removed with a scalpel. As sulfur is unstable at the pH of corroding glass, the use of

[25] In collaboration with Dr. Manfred Torge, Bundesanstalt für Materialprüfung, Berlin.

DMSO was limited and all traces were thoroughly removed post-treatment with swabs of deionised water.

Whilst acetone was less effective, it allowed a more cautious approach when cleaning over paint. Where the PMA/DiBP had been used as a consolidant, it was thinned but left in place. Acetone was also used as a fumigant to soften the acrylate when opening the few remaining Jacobi plates.

Retaining Craquelé Glass

During the 19th century, glass manufacture was redeveloped and industrialised. Experimentation resulted in some unstable glass compositions. Within Franke's glazing, all variations of the blue and yellow, glasses are prone to craquelé. The worst damage was seen in swII; by contrast, in window wI there were only two small pieces in the tracery exhibiting advanced craquelé deterioration.

At Naumburg, the craquelé can be attributed to low lime glass degradation and the LLHA (low lime high alkali) composition of the glass. This weakness, combined with high pollution and a damp environment resulted in the degradation. Calcium content is recognised as an important factor in the durability of glass, as it appears to slow the leeching of alkalis via hydrolysis. The most resilient glasses contain over 10% calcium,[26] whereas a sample of blue craquelé contained 6.78% calcium (and 25.44% combined Na and K).[27] Similarly, EDX analysis found a sample of amber yellow contained 6.34% calcium (and 27.19% total alkali). Both results fit within the anticipated parameters for vulnerable glasses.

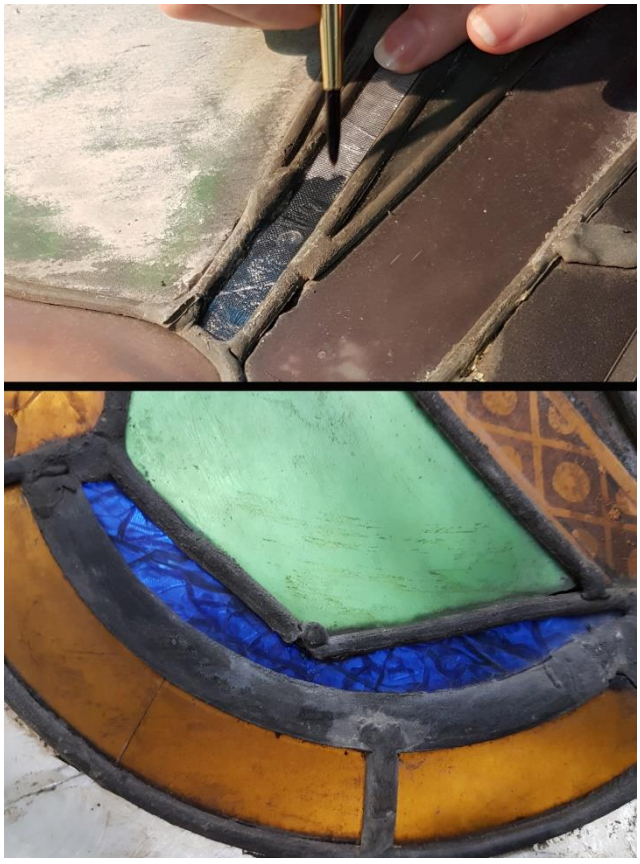

Fig.3. Craquelé consolidation technique and post treatment result in nwIII 2a © Vereinigte Domstifter.

The craquelé process witnessed in Naumburg corroborates other descriptions of this phenomenon. The leeching of alkalis resulted in an efflorescence of sodium sulfate salts.[28] The glass surface developed micro-cracks, allowing water to penetrate deeper, causing the bulk glass to fragment. As well as environmental control, we researched consolidation methods, including the work of Marie Stumpf at the Burrell, Merlyn Griffiths at YGT, and the DBU project at the Cologne Dombauhütte.

At Cologne, they attached glass fibre material to the surface using either Ormocer or Paraloid B72. Both were found to be similarly effective and durable.[29] Building on their results, we conducted trials using glass fibre webbing with HXTAL and silane, and Paraloid B72 in ethyl acetate. Paraloid provided the best results.

The webbing was treated with a 10% coating of B72, to provide rigidity for measuring and cutting. A solution of 25% B72 in was applied to the exterior side of the breaks. The webbing was then adhered to this surface, with the 25% solution (fig. 3). Gaps were filled with B72 (or Araldite 2020, if the hole was larger than a Euro coin) and retouched with acrylics. We ensured the webbing did not adhere to the

[26] M. Griffiths, *St John the Evangelist, Howsham (Yorkshire): Further Research into 'Crizzling'*, Vidimus Issue 98, 2016.
[27] Kanaki & Brandt 2019, p. 47.
[28] Rahfoth et al. 2019, p. 17.
[29] Ulrike Brinkmann and Katrin Wittstadt, *Anwendungen innovativer Restaurierungsmaterialien und methoden zur Sicherung craquelierter Glasmalereien Modellhafte Anwendung an Glasfenstern des Kölner Domes*, 2013, p. 67.

lead, as the differing thermal expansion rates of these materials could potentially damage the B72 film. The results were aesthetically satisfying, with the webbing undetectable from the interior side, and robust enough to retain these pieces.

As Paraloid B72 is known to fail in high humidity, this technique can be used only with internally ventilated protective glazing. In 2017, this technique was trialled in the West Choir by Derix, Taunusstein. This test panel has been monitored regularly over the last 4 years. The repairs remain stable, with no loss of adhesion or blistering in the webbing's surface.

Conclusion

Since the loss of windows wI and swII, many generations of conservators have attempted to restore a sense of unity to the West Choir. Each employed the most current knowledge and methods of their time. Their combined legacy – and our inheritance – was a disparate assemblage, ranging from the spectacular 13th-century windows, to the bright Franke panels, and the very dark Oberberger additions. Each element has its own intrinsic value and contributes to the overarching narrative of the West Choir.

Our methodology prioritised the immediate conservation needs of the windows. We also returned legibility to the iconography and replaced missing details with plates and infills. We stabilised the medieval glass and retained the 19th-century craquelé. All five windows are now protected with UV-filtered weathertight protective glazing and the disparity of light has been softened by the careful application of paint (fig. 4).

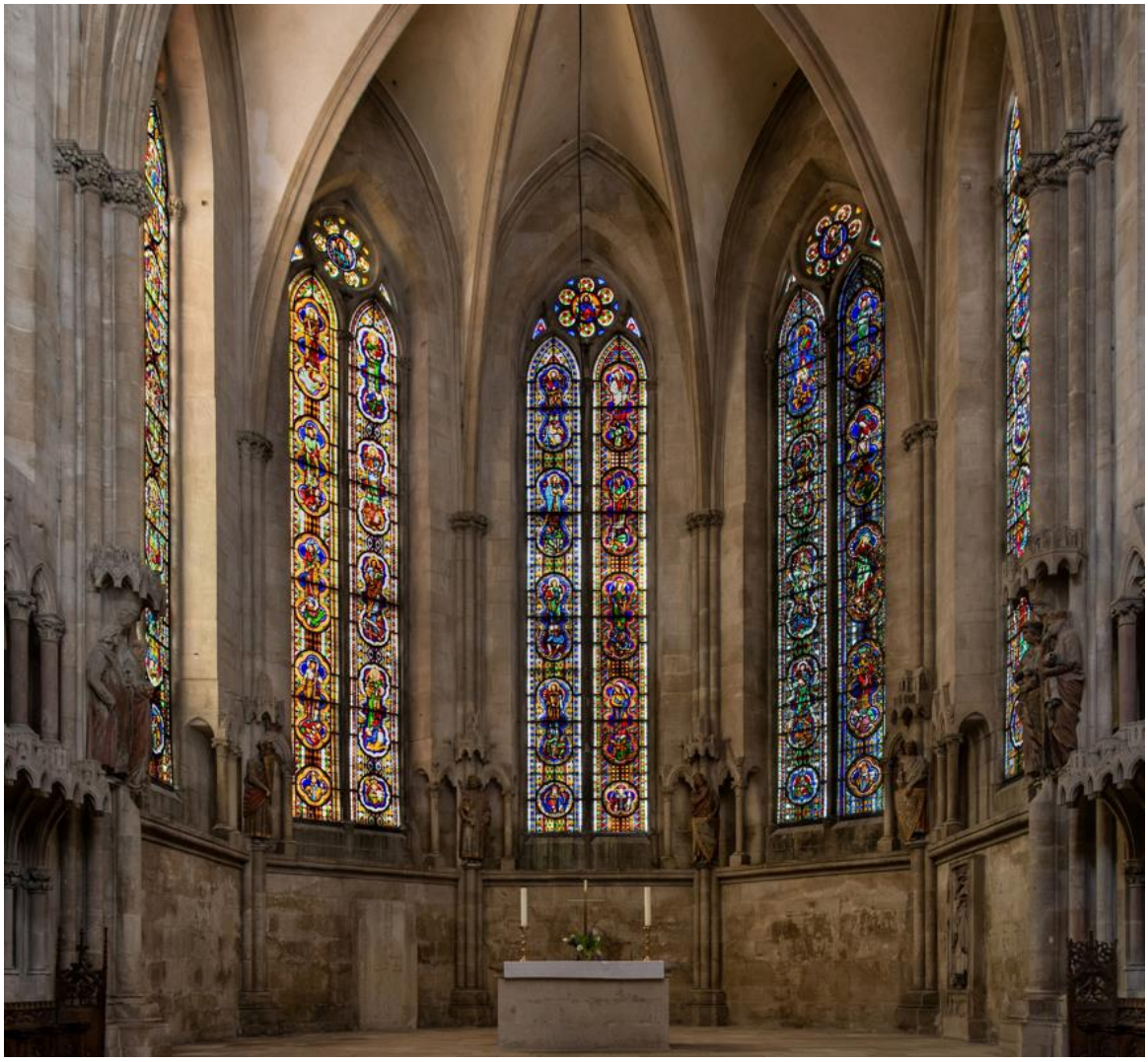

Fig. 4. The West Choir Windows post conservation, in 2020. © Vereinigte Domstifter.

In isolation, elements of this approach may be considered highly interventive. However, within the context of the overall scheme, the integrity of these iconic windows is undiminished, and our methodology has helped to unify the West Choir of Naumburg Cathedral.

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