The Conservation of a Late Renaissance Tiled Stove: A Non-Aqueous Approach

ABSTRACT

A large 16th-century tiled stove at the Castle Hohensalzburg was treated after a severe episode of salt efflorescence, in addition to previous inappropriate interventions. Gypsum efflorescence causing blistering and spalling of the glaze became apparent after the object's installation in its current location in the year 2000. Scientific analyses indicated that the damage was driven by the prolonged presence of water after the installation and, consequently, any aqueous conservation treatments were deemed inappropriate. Affected areas were first consolidated in 2015 using a 5-10 percent (w/v) solution of PARALOID B-72 in acetone, which was successful in preventing further spalling. Subsequently, an eight-week conservation project was initiated in 2018. This paper presents the practical implementation of this fairly large scale, non-aqueous treatment, including cleaning, consolidation, and filling of hollow sections using putties made from polyvinyl butyral combined with glass microballoons, mineral fillers, and dry pigments.

KEYWORDS

Tiled stove · Salt efflorescence · Gypsum · Non-aqueous · Polyvinyl butyral · Glass microballoons

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INTRODUCTION

The late Renaissance stove central to this paper is prominently displayed at Castle Hohensalzburg and belongs to the Salzburg Museum. Despite being heavily damaged and most probably incomplete, as compared to similar contemporary objects, the stove is a striking object (Figure 1). The stove reportedly originates from Castle Arenberg in Salzburg, which was rebuilt several times. Around 1920, the stove was sold to the Jewish art collector Oscar Bondy in a deconstructed and, likely, already incomplete state. During the Nazi Regime, it was confiscated and given to the Salzburg Museum, in the practice infamously called *Führerspende*, or Führer's donation. In 1950, the wife of Oscar Bondy officially gifted the stove to the museum, though the exact circumstances of this gift are still being investigated.

By this time, the tiles had been moved several times and were heavily damaged. Conservator Hans Kronberger reconstructed the surviving fragments between 1966 and 1967. Remarkable for the time, Kronberger chose to complete the fills in the monochrome tone of the reddish clay observed underneath the glaze to allow for a clear

Figure 1. *Late Renaissance tiled stove comprising 79 multi-coloured tiles at Castle Hohensalzburg, after intervention. Glazed tiles, H 256 cm × W 115 cm × D 148 cm. The Salzburg Museum, K 305-49 · Courtesy of Salzburg Museum*

Figure 2. *Detail of a corner tile from the top level before intervention, showing losses of glaze, paint drips, plaster of Paris fills, and overfilled grouts*

distinction between original and reconstruction. The stove was then installed and disassembled in a further two locations, as the main site of the Salzburg Museum changed during the late 20th century, before finally arriving at Castle Hohensalzburg in the year 2000. A stove fitter carried out the last disassembly and installation using traditional techniques including soaking each tile in water and grouting with a clay-sand mixture. Active damage to the glaze became apparent soon afterwards. When the tiles were inspected in 2012, it became apparent that a considerable amount of original glaze had been lost due to salt efflorescence, which had resulted in blistering and spalling, leaving an extremely fragile surface.

DESCRIPTION OF CONDITION

To the trained eye, the tiled stove is obviously incomplete, with missing elements particularly at the top and base. Furthermore, there is evidence that the current assembly of the preserved tiles is not historically correct, resulting in some very wide, grout-filled gaps. It is also possible that unrelated tiles were pastiched into the assemblage during one of the previous interventions.

The assemblage is structurally sound, with the primary cause for concern being the ongoing loss of glaze due to salt efflorescence. The underlying clay matrix was generally soft and powdery. Additionally, many hollow sections were identified by lightly tapping the surface with a finger. During a tile-by-tile condition survey in 2015, approximately 2 percent of the surface was affected by recent loss of glaze and, in addition, approximately 4 percent had hollows beneath the glaze. Acute concern for further loss led to 'emergency' consolidation, which was carried out in 2015 using a 5-10 percent (w/v) solution of PARALOID B-72 in acetone.

At this stage, the original glaze was not only unstable but also, in many areas, obscured by grout, paint, and discolored fills, which were probably added during a 1983 installation (Figure 2). Conversely, the clay-colored large-scale gap fills added between 1966 and 1967 were still in very good condition. The clay-sand grouting was fairly soft and had cracked and crumbled in a few areas.

SCIENTIFIC INVESTIGATION

In order to understand the root cause of the salt efflorescence, the Scientific Laboratory of the

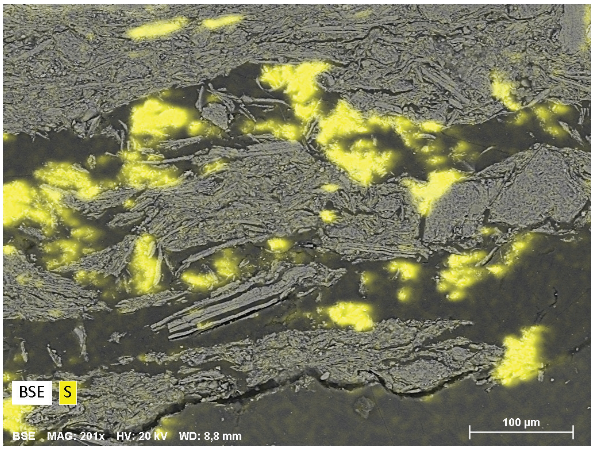

Figure 3. *(above) SEM image of salt-damaged ceramic with sulfur mapped in yellow*

Figure 4. *(right) Damage mapping of lower tile section with large areas of discoloured previous restoration represented with yellow dots*

Federal Monuments Authority Austria in Vienna and the Institute of Science and Technology for Ceramics laboratory in Faenza carried out scientific analyses in several stages (Linke 2012; Linke 2014; Gualtieri 2016). The salt efflorescence was identified as gypsum using scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX) and X-ray diffractometry (XRD) on several small samples.

It can be assumed that gypsum was part of the original clay and would have then been turned into anhydrite during the firing process. In several samples, the presence of the element sulfur was established using SEM-EDX (Figure 3), and XRD identified the presence of gypsum and varying, but generally small, amounts of anhydrite. A few samples did not contain significant amounts of sulfates; however, this could be due to the natural inhomogeneity of the clay as seen with the naked eye when studying the tiles.

A second possible source of gypsum is the plaster of Paris fills added to the stove at various stages in the object's history (Figure 2); however, the salt efflorescence is not localized near these fills but, rather, evenly distributed over the surface. The grout itself was ruled out as a gypsum source as it showed no traces of sulfur when examined with SEM-EDX. Regardless of the original source, the ultimate cause for the gypsum efflorescence was most probably the excessive use of water during the 2000 installation. Furthermore, the construction inside the main part of the stove was made from cellular concrete blocks combined with two horizontal 4 mm steel sheets. Whilst this provides structural support, it would also have retained the excess moisture for a long period.

Records of the environmental conditions in the display area over 14 months were consistent with an indoor space without humidity control and very limited options for heating in winter. For the period recorded, the relative humidity fluctuated around 40 ± 7% in winter and 52 ± 7% in summer. The average temperature was 17 ± 3 °C in winter and 24 ± 2 °C in summer. These conditions triggered salt efflorescence in the tiles, made susceptible by the water-soaking treatment.

Based on the scientific analysis, it was concluded that excess water mobilised sulfate (SO_4^{2-}) and calcium (Ca^{2+}) ions, either from the original clay or the materials used in past interventions. These migrated towards the surface where they precipitated and crystallised underneath the glaze layer, causing considerable damage due to the increase in volume.

TREATMENT GOALS AND PRACTICALITIES

The use of water was to be strictly avoided so as to not induce any further movement and crystallisation of salts. Desalination to remove the sulfates was not pursued as gypsum generally has a very poor re-solubility rate, typically only around 0.2 percent. The primary goal was the prevention of any further loss to the glaze through careful consolidation and filling to stabilize the remaining glaze.

Secondly, discolored fills, paint splashes, and grout obscuring the original surface and interfaces were to be removed. In discussion with the Federal Monuments Authority Austria, any new fills were to match Kronberger's high-quality monochrome intervention carried out in the 1960s. A complete deconstruction of the stove to understand the likely original appearance was briefly considered but could not be justified in the absence of any clear evidence of the original structure.

It was calculated that a team of two conservators would require approximately eight weeks to complete the project. All work was to be carried out in situ and during visiting hours. A purpose-built enclosure was designed in such a way that the public could not interact with the conservators, as the timeframe for the intervention was tightly scheduled. Basic information about the work, together with a large-scale image of the object, was provided on the outside of the enclosure. Social media was occasionally used to give the public a glimpse of what was happening inside the enclosure. Working in a public space also meant that dust, noise, and the use of solvents had to be kept to an absolute minimum.

CLEANING AND CONSOLIDATION

The stove's structure and tiles were photographed in detail, and thorough condition maps were produced before treatment. Unstable and obscured glazed sections and obsolete mortars and fills were mapped using Adobe Photoshop on a tile-by-tile basis (Figure 4). The conservation intervention started by partially removing any crumbling clay grouting, gypsum fills, and several unidentified fills, which obscured the glazed surfaces and tiles' edges. At the same time, unstable areas were consolidated with repeated applications of PARALOID B-72 in acetone at either 5 percent or 10 percent (w/v). Old adhesives were softened with solvents and removed mechanically. As work was carried out during visiting hours, an efficient but low-toxicity solvent was needed. Ethanol proved to be the best option but, where PARALOID B-72 residues and discoloured retouching required removal, small amounts of acetone were employed. Surface cleaning was repeated several times during the intervention, keeping the workstation clean and the display area dust-free.

Figure 5. *Injection of 10 percent PARALOID B-72 consolidant into hollow sections under the glazed surface*

The removal of mortars and obsolete fills allowed for better access to the fragile glaze and hollow sections. Consolidation was mainly performed by injection with syringes. PARALOID B-72 in acetone at 10 percent (w/v) was used on its own or with the addition of Aerosil fumed silica to fill the hollow sections more evenly in repeated applications (Figure 5). PARALOID B-72 was used for its well-known advantageous properties in conservation (Horie 2013). This procedure was continued until areas stopped sounding hollow when tapped, which required several applications. Bulking the consolidant with glass microballoons was considered, but prior testing at the Salzburg Museum Conservation Department showed a lower gap-filling capacity of PARALOID B-72 mixed with microballoons in comparison to the resin alone, as the bulked fill material would surface and block the entrance of more consolidant.

Once the fragile and hollow areas had been stabilized, grouts and any low-quality fills were further reduced. Where plaster of Paris fills were found deeply embedded between the tiles, it was decided to consolidate rather than remove them so as to not destabilise the object. Consolidation of the grout was also needed between many tiles on a fairly large scale to form a cohesive base for later application of fills, as well as to act as a barrier between layers. The consolidant solution was brushed on later in the day so as not to disturb visitors. Museum staff were asked to ensure more ventilation on those days as well by controlled opening of windows.

The cleaning and consolidation of glazed surfaces greatly improved the appearances of the individual colourful tiles. Cleaning also uncovered previously undocumented information, such as letters applied to the fresh clay during manufacture and crayon numbers applied later. These findings were detailed in a photographic report before any fills were made.

GROUTING AND GAP FILLING

To emphasize the original materials, new fills were colour-matched to the neutral clay-toned fills created in the 1960s. Glaze losses were only filled where necessary for the preservation of surrounding glazed areas and in order to minimize dust deposits on horizontal surfaces and fragile proud edges.

There is no consensus regarding the original need to grout tiled stoves of this period, and the authors found little information or relevant studies regarding the ultimate appearance of grouts and their historic interpretation. Other similarly-aged stoves in the region display grout that was actually painted to match the surrounding tile's glaze, hinting that grout was structurally needed but aesthetically disguised. However, in the absence of sound research on the original assembly and grout scheme of the stove, a neutral grout tone was chosen to highlight the tiles' colour and brilliance. Additionally, the poor condition of the tiles led to the conclusion that grout was needed to colour-matched assemblage of the stove, as well as to enhance the original glazed surface.

All the decisions regarding fill materials' thicknesses, textures, and colours were agreed to in regular meetings with members of the Salzburg Museum conservation team and The Federal Monuments Authority of Austria.

In selecting the best materials for filling losses and for grouting, the need for a low-toxicity approach due to work being done in the museum's galleries and the stove's previous episode of salt efflorescence limited the pool of available choices. Despite their known stability over time and compatibility with this type of ceramic (Botas, Veiga, and Velosa 2014), traditional lime and sand mortars in various ratios were not an option due to their water content, which would likely mobilise incipient gypsum. Likewise, the use of polyvinyl acetate (PVA) putties, such as Modostuc, was ruled out due to their water content and shrinkage upon drying. The team initially considered a putty made from PARALOID B-72 and glass microballoons, a well known filling option in conservation of porous ceramics, but acetone as a solvent in addition to workability issues were both factors against its use. These workability issues include the sagging of fills on vertical surfaces, the difficulty of levelling fills while wet, and the creation of dust with mechanical levelling.

Polyvinyl butyral (PVB) was thus considered as an alternative; it is lightweight, has good adhesion and workability properties, and is soluble in ethanol, a low-toxicity solvent. PVB is already a popular choice for ceramic conservation in hot climates where the low glass transition temperature of PARALOID B-72 is problematic (Schmidt 2017).

Sannikova (2018) discusses uses of PVB in a variety of past conservation treatments of organic and inorganic objects. PVB is praised for its stability to ultraviolet (UV) radiation and valued for its excellent resistance to biological growth. However, it has been found that some PVB products can crosslink over time (Feller et al. 2007) due to photo-degradation and heat exposure, for example Rhovinal B10-20 with prolonged UV exposure (Horie 2013). The present intervention used polyvinyl butyral 30 from Kremer, which, according to a study by David Thomas (Davis 2010), yellows slightly but remains reversible in ethanol after exposure to full sunlight spectrum lamps.

Reports of PVB-based putties' shrinking were also taken into consideration (Horie 2013). Therefore,

Figure 6. *Preparation of fills with polyvinyl butyral, inorganic bulking agents, and dry powder pigments*

instead of using organic fibres as bulking agents (Patterson 1978), inorganic bulking materials, such as glass microballoons, quartz sand, and chalk (Florian et al. 1990, 268-9), were used to control shrinkage whilst mimicking the texture of an original clay-sand mortar mixture.

Grout and gap filling were undertaken with polyvinyl butyral 30 as medium (Figure 6). Grout losses were filled with a mixture of 100 g of 15 percent (w/v) PVB in ethanol, 35 g glass microballoons, 150 g coarse quartz sand, and 75 g fine quartz sand. Ceramic and glaze losses were filled using a mixture with a finer texture, coloured to match nearby ceramic tones. This mixture comprised 100 g of 15 percent (w/v) PVB in ethanol, 35 g glass microballoons, and 35 g of calcium carbonate and inorganic pigments. To this, on the conservator's pallet were added small amounts of fumed silica to slow down the evaporation of solvent (Koob 1986).

The recipes served as a starting place and were modified for a workable consistency within the gallery environment that allowed an even surface and minimal need for levelling after drying. The putties prepared with polyvinyl butyral and inorganic bulking materials resulted in pastes that are easy to apply with a spatula, have a working time of approximately 20 minutes, and are well solidified after 24 hours.

Compared to PARALOID B-72 putties that tend to be stringy, the PVB putties can be more easily levelled with an ethanol-wetted spatula during application, minimising any sanding after drying. Putties showed consistent adhesion between layers allowing successive applications, as well as the possibility of retouching with various materials including acrylic paints. For larger gaps, the putty was sometimes cast and dried in advance. Pieces were then cut to shape and fixed in place with fresh putty. This reduced the risk of shrinkage and sagging on vertical surfaces.

Figure 7. *Tray with fragments belonging to the stove found in the Museum's archive; the small curl in the center was replaced, and the triangular shard with a tower was used to create a fill*

RECONSTRUCTION OF MISSING SECTIONS

On visiting the Salzburg Museum's tile store, several more original elements belonging to the stove at Castle Hohensalzburg were identified (Figure 7). It was possible to reinstate a small curl on a prominent corner that had been replaced by a replica in the past (Figure 8). For most of the fragments, however, reinstatement was deemed inadvisable due to structural issues: to totally remove the previously fabricated hard fills and reintroduce the original ceramic elements would likely cause more damage to the surrounding ceramic tiles and increase the risk of structural damage to the whole stove.

This was, unfortunately, also true for one particularly large piece, which showed a totally different design to the gap fill on the stove. The fill was dated to the 1980s and was not only based on a false design assumption, but also was discoloured and concealed original glaze. The 1980s fill was therefore carefully reduced and replaced. Since the original fragment had been found, it was possible to make a silicone mould in order to cast

Figure 8. *Detail of the replica of the section found in the archive (left), and the original fragment reinstated (right)*

Figure 9. *Area of reconstructed tile with the silicone mould made from the original fragment found in the archive (right), and the cast-in coloured polyvinyl butyral putty fill (left)*

the missing area, thus reproducing exactly the original design (Figure 9). This reconstruction was made to be discernible by the public. The removable cast mimicking the tile's surface was made with the polyvinyl butyral 30 putty and attached to a gap-fill made with the same putty. To better match the colour of the surrounding area, the cast was retouched using inorganic pigments dispersed in the polyvinyl butyral solution in ethanol. All aspects of the treatment intervention were documented in detail to avoid any misleading interpretations in the future.

PROTECTIVE MEASURES

Following the successful conservation campaign, several measures were enacted to ensure the future preservation of the stove. A subtle acrylic guard was designed to run along the bottom edge of the object as inattentive cleaning under and around the stove was identified as the greatest risk to the consolidated but still friable surface. Dust covers were made for the open top and back sections of the stove to reduce dust accumulation and minimise the need for cleaning. These are not visible from visitors' viewpoints. The space between the wall and the object was filled with polyethylene foam to allow air circulation on the back of the stove and further limit dust accumulation. Only conservation staff will carry out cleaning of the original surface.

CONCLUSION

The challenges of working on a water-sensitive, large-scale ceramic object in a public space were overcome with a range of solutions, foremost the use of putties based on polyvinyl butyral 30 bulked with inorganic fillers. The working properties of the PVB putties were preferred to those of comparable PARALOID B-72 putties, and PVB allowed for the use of lower-toxicity solvents. The final texture and look of the fills on tiles and grout were pleasingly similar to the original. The conservation team was therefore able to meet the aims of preventing any further loss to the glaze and improving the appearance of the obscured original surface hidden by inappropriate previous interventions. The striking original substance of the late Renaissance stove can now be fully appreciated by the visitors to Castle Hohensalzburg.

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SELECTED MATERIALS

Polyvinyl butyral 30 (Kremer 67600), dry powder pigments
https://www.kremer-pigmente.com