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Ceramics Affected by Floods: Insights from the First Response to Conservation Treatment

Julia Wagner, Géraldine Bussienne, Francisco Mederos–Henry, Caroline Henry, Catherine Cools, Valentina Mazzotti and Anne–Sophie Barnich

1 How do ceramics respond to floodwater and mud? Information has been gathered from three sites in Belgium and Italy that have experienced flooding to address this question. Each site's collection comprises various types of ceramics, primarily glazed and unglazed earthenware. Several cultural heritage professionals involved at different stages were interviewed, ranging from the initial emergency response to the extensive cleaning and inventory tasks undertaken in the years following the event. This article does not aim to provide a comprehensive overview of the effects of flooding on all types of ceramics, nor does it recommend specific treatment methods. Instead, it serves as documentation of particular cases that underwent multifaceted decision–making processes based on their collections and available resources.

2 As Buys and Oakley note, ceramics are generally chemically stable; however, the wide variety of ceramic types, characterised by their differing compositions, constructions, firing temperatures, and decorations, results in varying susceptibilities to specific environments. Low–fired ceramics, which may retain some degree of water solubility, are typically more susceptible than high–fired varieties,[1] primarily due to their greater porosity and lower levels of sintering and vitrification during firing.[2] In disasters such as floods, their most significant vulnerability often manifests as mechanical shock, leading to breaks, cracks, and chips that result in the most severe damage. Nevertheless, under these conditions, staining and even chemical alteration may occur.[3]

3 Considering the inherent chemical resistance of ceramics in comparison to many other materials, it may not be surprising that certain flood–affected sites across Europe have reported no significant damage. Nevertheless, the collected data indicate that the

reality is more complex and influenced by various factors, as evidenced by several selected cases.

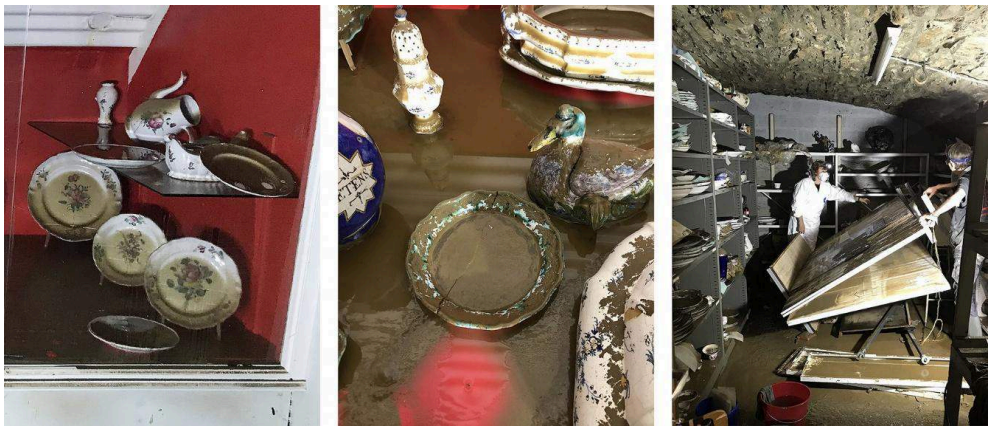
Fine Earthenware at the Musée des Beaux–Arts et de la Céramique in Verviers, Belgium

4 Contributors: Caroline Henry (Curator, Musées de Verviers); Catherine Cools (Lecturer in ceramics and glass conservation at École Supérieure des Arts Saint–Luc de Liège/ Atelier SiO2–Liège)

5 One of the sites affected by the floods in Belgium during July 2021 is the Musée des Beaux–Arts et de la Céramique in Verviers. Its collection includes over 2,500 ceramic pieces, comprising approximately 1,100 fine earthenware items, 1,050 porcelain objects, and 285 stoneware pieces. The exhibition and storage areas in the basement, which house around 1,500 ceramics (predominantly fine earthenware), were entirely flooded.

6 On the night of 14 to 15 July 2021, water flooded the entire basement to the ceiling and 15 cm onto the museum's ground floor, affecting ceramics in display cases and storerooms. The water remained for less than 24 hours before receding, leaving behind mud that covered the objects. As early as 16 July, following a call for assistance to Blue Shield Belgium NPO (BSB), the recovery of objects and the removal of remaining floodwater by the museum team, supported by numerous volunteers (freelance conservators, staff from other museums, KIK–IRPA, and citizens of Verviers), commenced. After the retrieval of more delicate materials, ceramics could be salvaged from 19 July onwards. During this time, the mud did not dry owing to the high humidity from residual water still present in the display cases (fig. 1). By 3 August, all objects from the museum's basement had been recovered.

[Fig. 1]



Ceramics in display cases (a, b) and in storage areas in the basement (c) have been covered with mud after the floods and are at risk of physical damage due to their precarious positions or proximity to other objects that might collapse.

7 The precise makeup of floodwaters and mud differs by location. However, in addition to rainwater, they may include sediment and soil particles, urban pollutants like oil and chemicals from roads and vehicles, agricultural runoff, sewage and wastewater from

overwhelmed systems, and debris from damaged buildings and infrastructure, among others.[4] In the case of Verviers, the butter and textile factories situated upstream from the Musée des Beaux–Arts et de la Céramique may have also affected the composition of the floodwater present at the museum.

8 Fortunately, as the floodwaters rose and subsided slowly, not much breakage occurred. Nonetheless, the risk of damage from mechanical shock remained high, for instance due to the deformation of the wooden shelving boards made from medium–density fibreboard (MDF) (fig. 2b). Some objects settled in precarious positions while floating within the display cases illustrated in Figure 2a. Therefore, it was essential to assess the highest risks thoroughly in each room as possible before taking action.

[Fig. 2]

Ceramic sculptures at risk of falling (a) due to warped MDF storage shelves (b).
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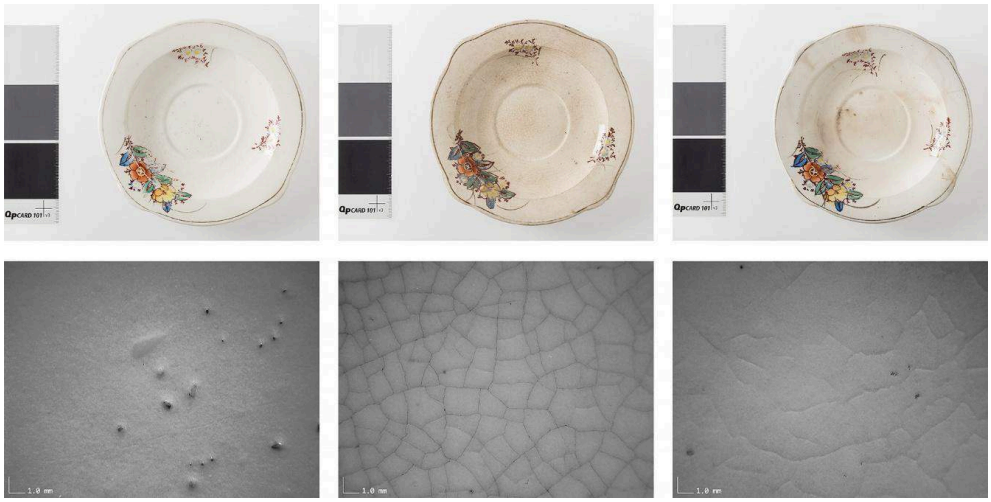
9 Among the challenges faced were a lack of financial resources, materials, and products, along with the need to make decisions rapidly to prevent more severe damage, for instance training a team of volunteers in the basics and organising effective teamwork. Following the removal of objects made from more vulnerable materials, such as works on paper, the Bethlehem of Verviers, a puppet theatre, alabaster, ivory, and wood objects, the recovery of ceramic pieces commenced with the earthenware on display. It was decided to recover one exhibition case at a time to avoid loss of information, as the inventory numbers or labels had faded or detached. This was succeeded by the recovery of porcelain and stoneware in storage. A chain for recovering the ceramic items from the basement was established, and display case was emptied individually, following a plan that included the number of each case. Emergency treatments performed by another team included an initial rinse with tap water under a gently flowing stream to remove as much mud as possible. This was followed by a more thorough cleaning with toothbrushes and sponges, along with localised application of Marseille soap,[5] followed by rinsing in two basins of demineralised water. The objects were dried manually and placed on Tyvek to dry further before being re–inventoried and stored. Using the museum's exhibition rooms that were unaffected by the floods for drying was the best possible solution, with dehumidifiers minimising any impact on the paintings as much as possible (fig. 3).

[Fig. 3]

Ceramics undergoing emergency treatment (a), laid out to dry in the unaffected rooms of the museum (b), and ceramics that have been re–inventoried and packed for storage (c).

10 Twenty–six fine earthenware objects, mainly from the 19th century, were entrusted to KIK–IRPA for research following the floods. Fine earthenware is characterised by a white or cream–coloured porous ceramic body coated with a transparent glaze that often shows crazing. The crazing of the glaze (or *craquelure*) may be linked to the production process or develop later, potentially leading to unsightly staining of the porous white or cream–coloured body beneath the transparent glaze. A closer examination of the correlation between the degree of staining and the extent of crazing supports this (fig. 4).

[Fig. 4]



A set of three fine earthenware saucers by Royal Kentucky Registered Trademark, dating from the 19th to 20th century, with a diameter of 15.5 cm (Musée des Beaux–Arts et de la Céramique, Verviers, inv. #0901, #1105, #1104). These saucers show varying degrees of crazing: one with no crazing and some glaze defects from manufacture without staining (a), another with the most extensive crazing and staining (b), and the last exhibiting irregular localised crazing and corresponding staining (c) at 20x magnification in raking light.

11 Treating stains on fine earthenware is a complex task, not only because of the limited accessibility of the stain through the glaze cracks, but also due to the nature of the stains themselves, which often consist of a mixture of organic and inorganic materials, alongside ingrained surface deposits from use, handling, previous restorations, and/or burial storage. Moreover, the absence of research regarding any adverse effects that current treatment methods may have on such objects adds to the difficult decisions

conservators must make when deciding on a course of treatment. As a result, conservators from the Glass and Ceramics Studio and the Polychrome Artefacts Lab (KIK–IRPA) are collaborating with CReA–Patrimoine (ULB) to conduct research aimed at assessing the efficacy and safety of common treatment methods. However, while recreating the staining on reconstruction tiles to perform cleaning tests, it became apparent that muddy floodwaters alone might not suffice to induce significant staining. It seems that the floodwaters exacerbated existing stains rather than created new ones. Due to the lack of documentation, especially photographs with colour checkers, accurately reconstructing the pre–flood condition proves challenging. Nevertheless, thanks to the extensive knowledge of museum staff, the pieces chosen for the study were those that likely exhibited the most alteration (fig. 5).

[Fig. 5]

Fine earthenware plate by Boch Frères Keramis, mid–1800s, measuring 20.9 cm in diameter (Musée des Beaux–Arts et de la Céramique, Verviers, inv. # 2008.02.BRA.206), photographed in January 2009 (a) and again in 2024 following the floods in July 2021 (b). The surface is crazed with glaze imperfections visible under 20x magnification in raking light (c).

12 Catherine Cools (ESA) reports that the fine earthenware, tin–glazed earthenware, and archaeological terracotta objects exhibited no staining or discolouration resulting from the immersion caused by the floods of July 2021. The mud remained localised on the surfaces of the objects. It primarily contained minerals and, to a lesser extent, river clays, materials whose grain size was too large to penetrate the pores of ceramics through capillary action. Only the hydrocarbons present in the water persisted. Traces of fats and hydrocarbons could not be quantified.[6] Although some photographs of the objects were taken prior to the floods, they are often captured under varying light conditions and without colour checkers. However, it can be stated that stains already existed before the floods (fig. 6).

[Fig. 6]

Example of a fine earthenware cup of British provenance, manufacturer unknown, date unknown, diameter 7.6 cm, height 4.6 cm (Musée des Beaux–Art et de la Céramique, Verviers, inv. # 0851) before flooding (a) and after treatment (only reassembly, no stain removal) at ESA Saint–Luc, Liège (b) and crazing under 20x magnification (c).

13 Among the damage observed were the loss of design and flaking of the pictorial layer of the only cold–painted dish, as well as an increase in flaking on a tin–glazed earthenware dish (Fig. 7).

[Fig. 7]

Decoration on a Maastricht earthenware dish from 1788 (cold–painted landscape by Germay in 1894), inv. # Pir–2846–2, before (2011) (a) and following damage after the floods (b); also, an increase in flaking of a tin–glazed earthenware dish from 1821, inv. # Pir–2440–2, before (2019) (c) and after (d) the floods (Musée des Beaux–Arts et de la Céramique, Verviers).

14 Previous restorations, such as adhered breaks and painted plaster fills, were detached, making handling quite dangerous, as the earlier fills and adhered breaks were initially concealed beneath the mud. Some objects exhibited new breaks or cracks, or the deterioration of existing ones, primarily due to water movement, handling during the removal of objects from display cases, or during cleaning. It was also essential to ensure that all fragments accompanied the object during subsequent treatment. The risk of dissociation (i.e., loss of objects, their associated data, or the ability to connect the two) was present because inventory numbers did not always remain intact, necessitating immediate verification via the museum database and temporary reassignment of inventory numbers. Efflorescence of soluble salts already present in the object reoccurred on an earthenware terrine with a brown glaze during drying.

Glazed Earthenware, Stoneware (and Plaster) in Faenza, Italy

15 Contributors: Claudia Casali (Director, MIC Faenza), Valentina Mazzotti (Chief Curator, MIC Faenza), Paola Rondelli (Conservator–Restorer, MIC Faenza)

16 During the floods of 16 and 17 May 2023, the collection of the Museo Internazionale delle Ceramiche (MIC Faenza, Italy) was fortunately not among the affected sites. Their staff were involved in the conservation of ceramics from two local sites, particularly the Museo Guerrino Tramonti, which was the home that the artist Guerrino Tramonti built, resided in, and worked from between 1958 and 1992. Approximately 390 works were on display, including paintings and a significant quantity of ceramics (both modern glazed and unglazed earthenware, stoneware, and porcelain), as well as plaster casts and tapestries. Twenty–one of these ceramics (glazed earthenware and stoneware) were entrusted to the restoration laboratory of the MIC Faenza (fig. 8), along with a maiolica plaque depicting the Assumption of the Virgin Mary by Baldassarre Manara (*c.* 1535), from the Municipality of Riolo Terme.[7]

[Fig. 8]

The ceramics and plaster mould at the Tramonti Museum are covered in mud (a); a selection of glazed earthenware and stoneware has been entrusted to the MIC for treatment (b).

17 Another site affected in the city of Faenza was the Carlo Zauli Museum, dedicated to the ceramicist Zauli and his works from the early 1950s to the 1980s. The mud removal protocol during the onsite emergency treatment depended on the level of drying of the mud. They received preliminary cleaning with water, sponges, and brushes, taking care to avoid overly abrasive brushes on the saturated surface. Whenever possible, they were dried outdoors or in well–ventilated areas of the museum. Plaster moulds that were particularly affected by prolonged contact with mud were cleaned by minimising water usage, employing mechanical methods and non–abrasive tools such as polyester tissue. The tissue, made from repurposed vegetable bags, was pressed onto the mud adhering to the mould and carefully lifted, removing large portions of mud at a time (fig. 9 a, b). This was followed by cleaning with soft–bristle brushes and latex rubbers and subsequently drying with warm air provided by a hairdryer. It is worth noting another method of cleaning mud from water–sensitive plaster moulds, which involves gentle dabbing with the same mud from the floods, due to its ingenious and cost–effective nature.[8] As the mud adheres to itself, this technique facilitates mud removal from the surface without the use of water (fig. 9 c, d). These operations were carried out with the involvement of restorer Camilla Mazzola, an expert in contemporary materials and a professor at the Brera Academy of Fine Arts.[9]

[Fig. 9]

Mud removal from water–sensitive plaster moulds at the Zauli Museum using polyester tissue (left) and by dabbing with balls of mud and sponges (right).

18 The ceramics from the Tramonti Museum, consigned to the MIC Faenza for conservation treatment, were submerged in water for two days and covered in mud for thirteen days. The duration of submersion for the maiolica plaque from the municipality of Riolo Terme remains unknown. The plaque delivered for restoration was wet and soiled, with a small amount of mud remaining on the object until February 2024. They underwent both dry and wet cleaning using scalpels, brushes, and deionised water containing a biocide (2–3% benzalkonium chloride),[10] followed by rinsing with deionised water. Conductivity measurements of the washing water confirmed the absence of soluble salts. A final cleaning was conducted using a mixture of water, ethanol, and acetone, applied with a cotton swab. The objects were initially dried at room temperature and subsequently in a drying oven at 50°C (fig. 10). Due to uncharacterised efflorescence on the maiolica plaque, paper pulp poultices were applied through a barrier layer of Japanese tissue to remove, as thoroughly as possible, any substances that had penetrated the ceramic body. This was followed by rinsing with deionised water. Conservation students from the Università di Bologna (UniBo), under the supervision of Ana Cecilia Hillar (professor, UniBo), participated in the emergency response for the ceramics at the Tramonti Museum, as well as in the treatments at the MIC.

[Fig. 10]

Ceramics from the Tramonti museum, upon arrival at the MIC Faenza restoration laboratory, underwent dry and wet cleaning to remove mud from the ceramics.

19 It appears that physical damage was the primary cause of breaks and cracks, rather than alterations due to exposure to water or mud, although mud also seeped into cracks and crazed glazes. No stains, darkening, or damage to the decorations were reported. The glaze on most objects seems to have remained intact, largely free from crazing. However, opaque glaze may conceal potential alterations to the ceramic body. Previous restorations suffered from exposure to floods, resulting in adhesive failure and fading of retouching. While mould was not observed on any of the ceramics themselves, the plaque from the municipality of Riolo Terme displayed mould growth on the plaster support at the back, as well as whitish deposits, which could originate from plaster, mud, or possibly salt efflorescence at the front. White deposits were also evident on the Tramonti ceramics, alongside dark deposits on some break edges that were difficult to remove (fig. 11).

[Fig. 11]

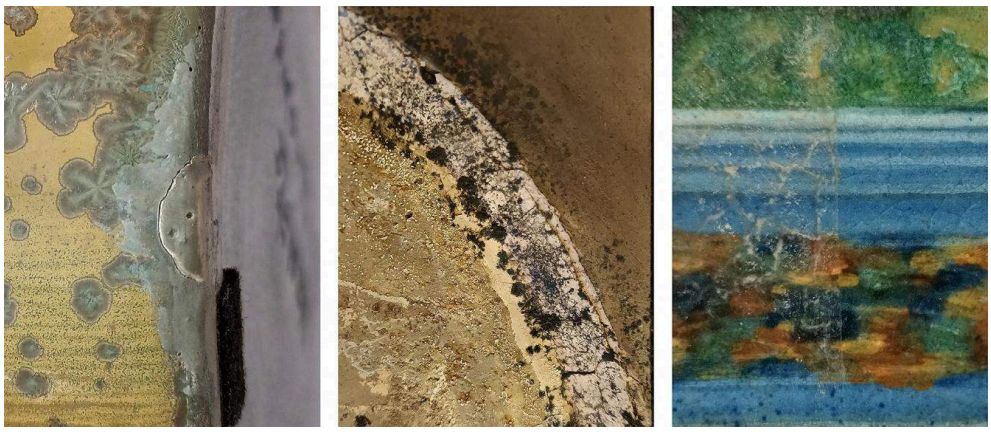


Image gallery showcasing some of the previously mentioned alterations: fading and loss of retouching (a), mould on the plaster support at the back of the maiolica plaque (b), and mud deposits or efflorescence in the glaze crazing partially removed to the right (c).

Archaeological Ceramics from the Agence wallonne du Patrimoine (AWaP) and the Centre de Conservation et d'Étude (CCE), Namur, Saint–Servais, Belgium

20 Contributors: Anne–Sophie Barnich (Collections Manager, Archaeological Collections, AWaP), Adeline Vanryckel (Conservator of Glass, *Recherches et Prospections Archéologiques*, RPA), Laura Mary (Archaeologist, RPA), Mathilde Patin (Archaeologist, RPA), Maïwenn Barrial (Archaeologist, RPA), Wanda Zaluzec (Archaeologist, RPA), Vanessa Boschloos (Blue Shield Belgium), Hélène Blanpain (Freelance Conservator of Inorganic Materials).

21 The CCE is responsible for managing and preventing the deterioration of certain archaeological materials resulting from excavations carried out in Belgium's Walloon Region. It served as AWaP's central repository for various archaeological items[11] from all periods, including excavation plans and archives. The repository occupied approximately 2000 m² and housed 200,000 items, with ceramics comprising about 35%. The ceramic collection includes both porous and non–porous wares from the Neolithic period to the present day,[12] predominantly featuring unglazed, low–fired, and unfired wares without painted decoration.

22 The entire repository was devastated by the floods that struck Belgium in July 2021, during which the facility experienced flooding twice: first on 15 July with approximately 1.5 metres of floodwater, and then it was completely inundated with about 2 metres on 25 July. With the support of numerous volunteers, AWaP staff worked tirelessly to recover and preserve the affected material. Approximately 75% of the ceramic collection was affected by the floods (fig. 12).

[Fig. 12]

The site soon after the floods (a), with boxes filled with water and mud in 2021 (b), alongside boxes of ceramics awaiting treatment in 2022 (c, d).

23 In addition to finding a space for storing all salvaged materials, initial tasks included clearing pathways and documenting objects, their condition for triage, and noting their discovery locations to prevent loss of information. At the start of August 2021, over 300 pallets of archaeological items (approximately 15,000 boxes) were transported to the military site of Sart–Hulet, provided by the Belgian Ministry of Defence. Specific working areas were established (e.g., rinsing station, drying, inventorying, repackaging, etc.), protocols for handling the affected materials were implemented, and the processing of collections was prioritised.

24 Unsurprisingly, the prioritisation of recovery and treatment is multifaceted, complex to organise, and challenging to secure approval for. Items were triaged based on their fragility; for instance, metals, organics, paper, and glass were considered more fragile than ceramics. Furthermore, priority was assigned according to their classification as treasures of the Fédération Wallonie–Bruxelles (FWB), their archaeological and aesthetic value, and the need to make them available for study or exhibition. Among the ceramics, priority during the recovery and cleaning process was given to the older and more porous pieces.

25 Initially, information about the objects was recorded, which included the inventory number from labels, the site name, and other relevant details. Given the substantial amount of ceramics submerged in muddy water, running tap water and brushes were used to rinse them. Mud was meticulously removed from fragile sherds or lesser–fired pieces with spatulas, scalpels, cotton swabs, or, in some cases, poultices (Medicomp non–woven tissue, 30g/m^2). Subsequently, the items were gradually dried in perforated containers within an uncontrolled environment. The large number of objects awaiting treatment meant that some pieces remained submerged in water for days or even weeks, and, in the case of mud, sometimes for months. However, by the end of November 2023, all items affected by the water and mud had been cleaned, dried, labelled, and inventoried, including documentation of excavation data and packaging according to suitable preventive measures for storage in crates (fig. 13).

[Fig. 13]

Cleaned sherds drying in perforated boxes (a, b), an example of final storage boxes (c) and an increasing number of completed boxes on crates (d).

26 This resulted from collaboration among several parties. The CCE established priorities and protocols through discussions with external advisors, including KIK–IRPA, Préhistomuseum de Ramioul, Recherches et Prospections Archéologiques (RPA), Blue Shield Belgium, and freelance conservators. Cleaning was conducted by teams of internal staff (archaeologist, collection manager, etc.), external conservators, and volunteers, including students from the École nationale supérieure des arts visuels de La Cambre (ENSAV–La Cambre) (fig. 14).

[Fig. 14]

Students of the ceramics and glass conservation course (taught by Sarah Benrubi, ENSAV–La Cambre) volunteer on–site for two to three days once a year, helping to clean, inventory, and package objects.

27 While the condition of 25% of the objects before the floods was well documented, approximately 40% remained undocumented. Furthermore, photographs often lacked colour checkers. Nonetheless, it can be asserted that some alterations were observed as a result of exposure to floodwaters and mud. For instance, breakages occurred due to the falling or shifting of crates and shelves as the mud and water fluctuated within the storerooms. Previous restorations deteriorated, with adhesives failing either completely or softening slightly, leading to warping and misalignments. Fills swelled, cracked, and/or lost colour. If objects had been restored with Paraloid B–72, whitening appeared along break edges or across the surface if the object had been consolidated with it. This water whitening effect may disappear over time as the moisture content evaporates.[13] However, a small spot test indicated that cleaning with acetone effectively reduced the whitening effect (fig. 15). Some cellulose–based consolidants, likely Klucel

G, MCE2000 or MCHPC400, migrated to the surface. Unlike the water whitening effect of Paraloid B–72, the surfaces of objects consolidated with cellulose–based adhesive appeared slimy and gelatine–like, as though the consolidant had resolubilised to its pre–consolidation state.

[Fig. 15]

Roman ceramics before (a) and after the floods, showing the effects of failed adhesive (b) and the water whitening effect of Paraloid B–72 (c).

28 After exposure to floodwater and mud, traces of adhesive tape became more noticeable, although this was less apparent with Tesa blue. Bubble wrap, used to store some ceramics prior to the floods, also left marks or imprints on certain ceramics (fig. 16). There was a risk of losing fragments or entire objects due to labels or marks being washed away. When this occurred, whitish–pink markings remained on the surfaces of the objects. Mould developed within the boxes and on various storage materials, such as silk paper, cardboard boxes, and labels. In some instances, it formed on the objects, particularly in areas where adhesive tape had been applied, while in other cases, it affected the entire ceramic surface, leading to small black stains once dried. These stains were successfully cleaned with a 50:50 ethanol–water mixture if the ceramics were still wet, or simply dusted off if they had already dried, all while wearing personal protective equipment (PPE) such as masks, gloves, and coveralls, and conducting the treatment in well–ventilated areas or outdoors. In certain instances, plant growth (moss) occurred within cracks. Furthermore, paper excavation sheets that adhered to the surface of the ceramics proved difficult to remove from low–fired wares. Additionally, some pieces made from unfired clay ‘dissolved’ or disintegrated during the floods (fig. 16).

[Fig. 16]

Mould on ceramic surfaces (a), plant growth in cracks (b), adhesion of paper sheets blackened by mud (c), and loss of cohesion in very low or unfired sherds with imprints of bubble wrap (d).

29 Ceramologists working on–site reported a slight change in the colour of the ceramic body at the surface due to the mud, which could pose problems for the identification and dating of pieces. However, this did not seem to be the case for whole ceramics or sherds but rather for parts of objects. Iron oxide staining also occurred rapidly on porous, unglazed ceramics (e.g., Roman jugs and Merovingian ceramics) after four to eight weeks. Pieces that had partially rested in the mud within the boxes exhibited orange and black circular staining corresponding to the stratigraphy of the mud in the boxes: the orange circles deriving from the iron oxides and the black circles resulting from the layer of dark mud that remained atop the iron oxide layer. The deposited mud from the second flooding event in July 2021 was significantly darker and more compact than that from the first. The presence of iron oxides was confirmed through analysis of the mud. Only one instance of ‘salty’ or ‘sandy’ deposits was reported (fig. 17).

[Fig. 17]

Localised blackening from dark mud (a), orange oxide, and black mud staining on Roman and Merovingian ceramics (b, c), with an example of staining before (d) and after cleaning (e).

30 For porous fired wares, the mud in closed boxes had a more detrimental effect than water, whereas the opposite was true for unfired wares that disintegrated in water. Mud shrinkage during drying and its adherence to the surface did not appear to pose a problem for fired wares with stable surfaces.

Overview of Flood–Related Damage, Vulnerabilities, and Other Influencing Factors

31 As illustrated in the three cases mentioned above, Buys and Oakley’s succinct statement regarding the vulnerability of ceramics in flood situations accurately summarises the issues observed at all three sites. In every instance, across all types of ceramics, damage

from mechanical shock poses the greatest risk. This may occur during the event due to the movement of ceramics, their storage boxes, or entire shelves during the flood and mud flow. Even in the more 'fortunate' cases of slowly rising and receding floods, damage can arise later from the warping of wooden shelves or from handling the affected pieces, where breaks, cracks, or structurally weakened restorations may be concealed by mud.

32 Another common vulnerability across all types of ceramics is the deterioration of previous restorations caused by floodwater and mud. This can lead to colour fading and plaster ghosting from infills, as well as more significant structural issues such as swelling or failing fills, which may result in new or worsening cracks. Adhesives may become discoloured, making breaks more noticeable or softening them, potentially leading to warping and misalignment of sherds or even complete failure. Consolidation treatments might also be impacted, either migrating to the surface if water–soluble or whitening in water, as observed with Paraloid B–72.

33 Pre–existing conditions can worsen, such as the physical damage caused by the crystallisation of soluble salts already present in the object. Newly introduced salts do not appear to have posed an issue, apart from the unidentified whitish deposits in Faenza, which may also have consisted of plaster or fine mud residue. However, this could depend on the specific composition of the flood and mud waters.

34 The risk of dissociating fragments or entire objects arose from the loss or fading of labels and inventory numbers, along with the dispersal of sherds across the flooded site as floodwater and mud flowed. Throughout the recovery process, it was essential to take care to keep the sherds together.

35 Although ceramics and related materials are relatively chemically stable under various environmental conditions compared to more vulnerable materials like organics and metals, different types of ceramics have specific susceptibilities to floodwater and/or mud. Unfired clay, in particular, is quite vulnerable to water exposure, which can lead to a loss of cohesion or even complete disintegration of certain pieces. Concerns arose about mud shrinkage during drying, which could create tension that may damage fragile ceramic surfaces. Consequently, the drying of mud before cleaning was deliberately slowed as much as possible to prevent any damage. Furthermore, wet mud was significantly easier to remove than dry mud. No deterioration from mud shrinkage was observed at the CCE. It remains unclear whether drying mud posed a problem for crazed glaze or decoration in Verviers, although tension can exacerbate crazing depending on the extent, type, and condition of the glaze.

36 The surface roughness of unglazed ceramics and unfired clay can cause surrounding materials, such as softened paper labels and archaeological cards, to adhere stubbornly. Paper is not the only material that can impact the object's surface; in some instances, adhesive tape and bubble wrap have also left marks or imprints.

37 Organic packaging materials, such as paper and tape, encourage mould growth. However, mould has also developed across the entire surface of certain ceramics, leading to staining characterised by black dots when dry. While mould did not appear on fine earthenware in Verviers, there have been instances of mould forming beneath ceramic glaze outside of the flooding context, which is challenging to remove.[14]

38 The staining examples on unfired and low–fired wares without glaze appeared to be localised, depending on the specific composition of the mud and the positioning of the

objects within it. Intriguingly, the CCE case study also demonstrated that the composition of floods between two flood events, occurring merely days apart at the same site, can vary, leading to distinct alterations. In the case of unglazed wares, exposure to mud seemed to pose a greater challenge than exposure to floodwater alone, with the exception of unfired pieces that disintegrated completely. For fine earthenware, glaze serves as a protective layer against water and mud, rendering them less susceptible to staining compared to unglazed wares. When the glaze is crazed and the ceramic body is porous, water can infiltrate and potentially result in staining. While staining experiments at KIK–IRPA and mud analysis at ESA Saint–Luc Liège indicated that, in these instances, the mud itself did not induce new staining – possibly due to its excessively large particle size – it is conceivable that existing stains may have worsened or become more pronounced. This appears to be the case with iron staining or stains resulting from use that re–solubilised and migrated due to the penetration of floodwaters through crazing. However, confirming whether and to what extent this type of staining occurred is challenging due to the absence of photographic documentation of the object's previous condition using colour checkers, underscoring the significance of such documentation.

39 There are few examples of painted decoration at the CCE that allow us to draw conclusions about the decoration's susceptibility to mud shrinkage and water. While many different types of glaze decoration are present in the Verviers collection, no significant damage was reported, except for one object that suffered loss of cold–painted decoration. This can be attributed to the prompt access to the site shortly after the flood for recovery and cleaning, which likely prevented more substantial deterioration of the decoration due to the shrinking and drying mud.

40 It is essential to emphasise that this article does not provide a comprehensive account of the damage that can occur to all types of ceramics. However, the observations gathered from three specific flooded sites containing ceramic collections offer an overview of several factors that affect ceramics during floods. These factors include object–specific elements (e.g., ceramic type, decoration, condition, previous restorations), the context of the collection (e.g., the number of objects to be recovered and treated, the presence of more susceptible or valuable materials, and the storage materials used), flood–specific considerations (e.g., the composition of flood water and mud, the speed or extent of flood movement, and safe early access to the flooded site), and, equally importantly, available resources (e.g., time, budget constraints, staff, external advisors and volunteers, as well as the expertise to train, organise, and supervise them, along with the location for materials and equipment storage and treatment). Furthermore, it underscores the necessity of conducting systematic documentation and analysis of alterations to accurately assess the actual impact of a natural or man–made disaster on heritage collections.

41 Further research is essential to support the complex decision–making processes and compromises necessary in protocols treatments in view of the multitude of issues that demand attention following a flooding event, exacerbated by financial constraints, limited availability of materials, and a shortage of time and human resources. Among these research areas are the deterioration processes specifically triggered by flood disasters, including the effects of drying mud on ceramic surfaces, the discolouration of ceramic bodies, and the impact of floodwaters on the stability of previous consolidation treatments. Given the necessity for accessible and cost–effective cleaning materials,

comparing various treatment methods could assist conservators and collection managers in making decisions during emergencies; this includes evaluating the suitability of commercial sponges, brushes for bottles, teeth, and nails, a range of biocides, and cleaning agents such as Marseille soap, alongside other readily available commercial alternatives, including non–ionic detergents. During the 2021 floods in Belgium, there were no established or widely accepted protocols for protecting ceramics. Responses were improvised, relying on professional experience, *ad hoc* support from institutions, and emergency ingenuity, underscoring a significant gap in disaster preparedness for cultural heritage, particularly concerning ceramics. Publishing further case studies outlining disaster preparedness and response strategies would enhance the limited resources tailored for ceramic collections,[15] as most existing protocols have primarily been developed for archives and libraries.

We would like to thank all heritage professionals who contributed to this article for their willingness to share experiences from what would have been a traumatic event followed by an extended period of work in a high–pressure environment. Not only has their swift decision–making, actions, and determination safeguarded entire collections, but their transparency will provide insights and assist others in strengthening preventive measures and navigating similar challenges.

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NOTES

1. Buys and Oakley 2016, p. 18–19.

2. Buys and Oakley 2016, p. 9–10.
3. Buys and Oakley 2016, p. 18.
4. Bellanova *et al.* 2024; Koks *et al.* 2022.
5. Marseille soap (by Marius Fabre) with a slightly alkaline pH was chosen because grease from the butter factory had contaminated the water. It requires successive rinses to ensure no residues remain.
6. Analyses were conducted at the ESA Saint–Luc in Liège by Dr. Meriam El Ouahabi, PhD in clay geology and professor of chemistry at the ESA.
7. Stored in the bank vault of the Banca di Credito Cooperativo – BCC di Castel Bolognese.
8. Personal communication, Claudia Casali 2024.
9. Mazzotti 2023.
10. This biocide with disinfectant action is generally used at the MIC laboratory when it is not possible to conduct a characterisation of the biological growth.
11. Archaeological objects made of ceramic, terracotta, lithic/lapid clay, glass, metals, bone, leather, wood, textiles, paper and clapboard archives, sedimentary samples, etc.
12. Biscuit, stoneware, very little porcelain, or fine earthenware.
13. Molina *et al.* 2023.
14. Example shared by Dana Norris in Lauren Fair's stain reduction Google group, 03/09/2022.
15. See chapter 16 *Emergency procedures*, in Buys and Oakley 2016.

ABSTRACTS

How do ceramics respond to floodwater and mud? Data from three flood–affected sites in Belgium and Italy have been collected to address this question. The assemblage from each site comprises various types of ceramics, primarily glazed and unglazed earthenware. Several cultural heritage professionals involved at different stages – from the initial response to extensive cleaning and inventory tasks in the years following the event – were interviewed. This article does not provide a comprehensive account of the damage that all types of ceramics may endure. Nevertheless, the observations gathered from these three specific flooded sites housing ceramic collections offer an overview of some of the factors influencing ceramics during floods. These factors include object–specific elements (e.g., ceramic type, decoration, condition, previous restorations), a collection's context (e.g., the number of objects to be recovered and treated, the presence of more vulnerable or valuable materials, and the storage materials used), flood–specific influences (e.g., the composition of floodwater and mud, the speed or extent of flood movement, and early access to the flooded site), and, importantly, resources (e.g., time, budget constraints, personnel, external advisors and volunteers, as well as the necessary expertise for training, organising, and supervising them, materials, equipment storage, and treatment locations). Furthermore, it underscores the necessity for systematic documentation and analysis of alterations to assess the true impact of a natural or man–made disaster on heritage collections.

Comment les céramiques réagissent–elles à l'eau d'inondation et à la boue ?
Des données issues de trois sites touchés par des inondations en Belgique et en Italie ont été recueillies afin de répondre à cette question. L'ensemble de chaque site comprend différents types de céramiques, principalement des faïences vernissées et non vernissées. Plusieurs

professionnels du patrimoine culturel ayant été impliqués à différentes étapes – de l'intervention d'urgence aux opérations de nettoyage intensif et d'inventaire menées dans les années succédant l'événement – ont été interrogés.
Cet article ne prétend pas offrir une vue exhaustive des dommages que peuvent subir tous les types de céramiques. Cependant, les observations recueillies sur ces trois sites spécifiques abritant des collections céramiques permettent d'esquisser un aperçu de certains facteurs influençant leur comportement lors d'inondations. Ces facteurs incluent des éléments propres aux objets (par exemple, type de céramique, décor, état de conservation, restaurations antérieures), le contexte de la collection (par exemple, le nombre d'objets à récupérer et à traiter, la présence de matériaux plus fragiles ou de plus grande valeur, les matériaux de stockage utilisés), des influences spécifiques à l'inondation (par exemple, la composition de l'eau et de la boue, la rapidité ou l'étendue du phénomène, l'accès anticipé au site sinistré), et, de manière déterminante, les ressources disponibles (le temps, les contraintes budgétaires, le personnel, l'encadrement externe et les bénévoles, ainsi que l'expertise nécessaire pour leur formation, leur organisation et leur supervision, les matériaux, les équipements, les espaces de stockage et de traitement).
L'article souligne également l'importance d'une documentation et d'une analyse systématiques des altérations afin d'évaluer l'impact réel d'une catastrophe – naturelle ou anthropique – sur les collections patrimoniales.

Hoe reageert keramiek op overstromingswater en modder? Om deze vraag te beantwoorden, zijn gegevens verzameld van drie door overstromingen getroffen sites in België en Italië. De collecties van de drie sites bestaan uit verschillende soorten keramiek, voornamelijk geglazuurd en ongeglazuurd aardewerk. Diverse cultureelerfgoedprofessionals die bij verschillende stadia betrokken waren, van de eerste hulp tot de uitgebreide schoonmaak en inventarisatie in de jaren na de ramp, werden ondervraagd. Dit artikel geeft geen uitgebreid verslag van de schade die alle soorten keramiek kunnen oplopen. Niettemin bieden de waarnemingen van deze specifieke sites met keramische collecties een overzicht van enkele factoren die van invloed zijn op keramiek tijdens overstromingen. Deze factoren omvatten objectspecifieke elementen (bijv. keramieksoort, decoratie, toestand, eerdere restauraties), de context van een collectie (bijv. het aantal te recupereren en te behandelen objecten, de aanwezigheid van meer kwetsbare of waardevolle materialen en het gebruikte opslagmateriaal), overstromingsspecifieke invloeden (bijv. de samenstelling van overstromingswater en modder, de snelheid of omvang van de overstroming en vroege toegang tot de overstroomde locatie), en, belangrijker nog, de middelen (bijv. tijd, budgetbeperkingen, personeel, externe adviseurs en vrijwilligers, evenals de nodige expertise voor het opleiden, organiseren en begeleiden ervan, materialen, opslag van apparatuur en behandelingslocaties). Bovendien onderstreept het de noodzaak van systematische documentatie en analyse van veranderingen om de werkelijke impact van een ramp, veroorzaakt door de natuur of door de mens, op erfgoedcollecties te beoordelen.

INDEX

Trefwoorden keramiek, aardewerk, overstromingen, schade, aantasting, casestudies
Keywords: ceramics, earthenware, floods, damage, deterioration, case studies
Mots-clés: céramique, faïence, inondations, dégâts, altérations, études de cas

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