NOVA SCHOOL OF SCIENCE & TECHNOLOGY

DEPARTAMENT OF
CONSERVATION AND RESTORATION

LEONOR CORREIA CONCEIÇÃO

Bachelor in Conservation and Restoration

FILLING IN THE GAPS

The conservation and restoration of a Ming dynasty porcelain dish from the Monastery of Santa Clara-a-Velha

MASTER IN CONSERVATION AND RESTORATION

NOVA University Lisbon

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I thought that writing the acknowledgments would be the easiest part, but I am no poet and finding the right words to convey the immense gratitude I feel towards the people that have helped me throughout all the ups and downs is no easy task. Nevertheless, I shall try my best.

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ABSTRACT

The present thesis discusses the conservation and restoration treatment of a 16-17th century archaeological Ming Dynasty porcelain dish from the Monastery of Santa Clara-a-Velha, in Coimbra, Portugal. This case-study was challenging for being fragmented in a total of 39 fragments and having considerable material loss that compromised the integrity of the object. The intervention's goal was to obtain a unified stable object that could be appreciated by present and future generations. Addressing the inherent instability of the dish was the focal point of this work. The decision-making process was informed by a bibliographic review of conservation methodologies for porcelain objects, complemented by an international survey.

Ceramic conservators frequently deal with material loss. While several conservation and restoration disciplines use materials similar to the object, in ceramic conservation, contemporary substitutes such as plaster, epoxy resins and acrylic-based fillers are usually preferred to ceramic materials. This thesis goes beyond such preferences and explores a methodology to create fillings with an uncommon material - porcelain. Porcelain was considered an interesting filling material due to being robust, stable and having a similar nature to the one of the treated object, ensuring a durable intervention that respects the original materiality and aesthetic of the case-study. As such, in collaboration with Vista Alegre® Factory, a methodology to create porcelain fillings was developed. This led to fascinating ethical and practical challenges. To overcome several of these challenges, a distinctive feature of this work was the successful exploration of three-dimensional (3D) techniques combined with traditional porcelain crafting techniques, in a multidisciplinary industrial environment.

Despite having succeeded in producing structural porcelain fillings, this material is unlikely to come to replace synthetic filling materials on a conservation daily basis. Nevertheless, this is an approach that allows to respect the materiality of the object and may open new perspectives and tools for the conservator-restorer, as 3D techniques become more easily available and accurate. Vista Alegre®, as a porcelain factory with a full-time conservator-restorer provides a unique environment for the further development of such methodology.

In the end, the goal of this thesis was achieved, having successful conserved and restored the MSCV PP90 dish, which can now be exhibited and appreciated as a whole.

Keywords: Ceramic conservation, Porcelain, Fired fillings, 3D printing, Digital modeling, Santa Clara-a-Velha, Ming dynasty, Vista Alegre®

Resumo

A presente dissertação incide sobre o tratamento de conservação e restauro de um prato de porcelana arqueológico do séc. XVI-XVII pertencente à dinastia Ming e proveniente do Mosteiro de Santa Clara-a-Velha, em Coimbra, Portugal. Este caso de estudo foi desafiante por se encontrar fragmentado em 39 fragmentos, e por ter considerável perda de material que comprometia a sua integridade. O objetivo da intervenção consistia na obtenção de um objeto unificado e estável que pudesse ser apreciado por atuais e futuras gerações. Abordar a inerente instabilidade do prato foi o principal foco deste trabalho. A tomada de decisão foi informada por uma revisão bibliográfica das metodologias de conservação usadas em objetos de porcelana, complementada por um inquérito internacional.

Os conservadores de cerâmica têm frequentemente de lidar com perda de material. Enquanto diversas disciplinas de conservação recorrem a materiais semelhantes ao objeto, em conservação de cerâmica são tipicamente preferidos substitutos contemporâneos, como gesso, resinas epoxídicas e materiais acrílicos, em lugar de materiais cerâmicos. Esta dissertação vai além de tais preferências e explora uma metodologia para criar preenchimento com um material incomum – a porcelana. A porcelana foi considerada como um material de preenchimento interessante por ser resistente, estável e por ter uma natureza semelhante ao objeto, garantindo uma intervenção durável que respeita a materialidade e estética do original. Assim, em colaboração com a Fábrica da Vista Alegre®, foi desenvolvida uma metodologia para criar preenchimentos em porcelana. Isto levou a fascinantes desafios a nível ético e prático. Para ultrapassar alguns destes desafios, um aspeto singular deste trabalho foi a exploração bem-sucedida de técnicas tridimensionais (3D) combinadas com técnicas tradicionais de produção de porcelana, num ambiente industrial multidisciplinar.

Embora se tenha tido êxito em produzir preenchimentos estruturais em porcelana, é improvável que este material venha a substituir materiais sintéticos no dia-a-dia do conservador. Independentemente deste facto, a abordagem efetuada permite respeitar a materialidade do objeto e poderá abrir novas perspetivas e ferramentas para o conservador-restaurador, à medida que técnicas 3D se tornam mais acessíveis e precisas. A Vista Alegre®, como fábrica de porcelana com um conservador-restaurador a tempo inteiro, fornece um ambiente único para a continuação do desenvolvimento de tal metodologia. No final do trabalho, o objetivo da dissertação foi alcançado, tendo-se conservado e restaurado o prato MSCV PP90, que pode agora ser exibido e apreciado como um todo.

Palavras-chave: Conservação e restauro, Porcelana, Preenchimentos cozidos, impressão 3D, Modelação digital, Dinastia Ming, Mosteiro de Santa Clara-a-Velha, Vista Alegre®

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ACRONYMS

ATR-FTIR	Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy
DCR	Departamento de Conservação e Restauro (Department of Conservation and Restoration)
IR	Infrared
MSCV	Monastery of Santa Clara-a-Velha
Tg	Glass transition temperature
UNL	Universidade NOVA de Lisboa
UV	Ultraviolet
VA	Vista Alegre® Factory
VICARTE	Research Unit Glass and Ceramic for the Arts
3D	Three-dimensional

1 Introduction

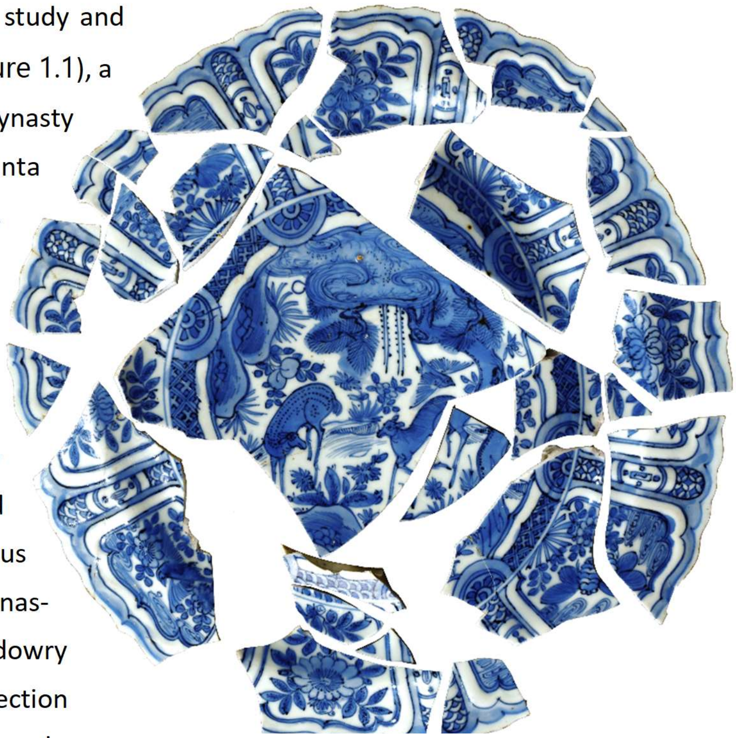

Figure 1.1 - Front view of the MSCV PP90 dish (Before conservation).

The present master thesis focuses on the study and conservation of the object MSCV PP90 (Figure 1.1), a 16-17th century archaeological Ming Dynasty porcelain dish from the Monastery of Santa Clara-a-Velha (MSCV), in Coimbra, Portugal. Discovered as part of archaeological excavations made until 2000, this object is only a small sample of the vast assemblage that was found in the monastery, which included 7000 fragments of Chinese porcelain. At the time, these items held great fascination, being considered luxurious and of high quality. Their presence in a monastery may be resultant from the admission dowry of nuns or royal patronage. The strong connection of the MSCV to queen D. Isabel (1271-1336) made it an important place of pilgrimage, worship and led to its community becoming more aristocratic, therefore explaining the rich spoil excavated.

The MSCV PP90 dish was chosen as this thesis case-study due to the conservation challenges it presented. Besides being fragmentated in a total of thirty-nine fragments, there is considerable material loss that compromised the integrity of the whole group. This led to an interesting discussion in terms of "if" and "how" to bond, fill, and retouch the object. Ultimately, the goal was to obtain a stable unified piece that could be exhibited and appreciated by viewers. All aspects of the conservation and restoration of the MSCV PP90 dish will be discussed after presenting its characteristics, historical background and conservation state.

The developed methodology was initially informed by a literature review of materials and methodologies mentioned for conserving and restoring porcelain objects, complemented by an international survey on what conservators are currently using. Finally the intervention was discussed and actually implemented with the help of different professionals, from conservators to specialists in technical drawing, to mould-makers and porcelain manufacturers. For this collaborative effort a partnership with Vista Alegre® (VA) became crucial, as will later be demonstrated.

1.1 A Bibliographic Review - Materials used in porcelain conservation

To support the conservation proposal for the MSCV PP90 dish it was important to understand which methodologies have been and continue to be used in porcelain conservation for removing old repairs, cleaning, bonding, filling, and re-touching. This was accomplished by making a brief bibliographic review. Literature on the removal of stains and desalination was not researched as these problems were not pertinent for the present case-study. Porcelain conservation seems to rarely be approached exclusively, therefore several of the consulted authors, such as Ćurković (2014), Hawkins (2020), Hyoyun (2014) and Oakley (2002), reflect on the conservation of all types of ceramic.

In terms of the removal of old repairs on ceramic, both Hawkins (2020) and Oakley (2002) specify methodologies dependent on the identification of the previously used materials. Oakley (2002), however, presents more extensive information and a very useful and easy to read summary table of such methods. It's also this author who, when discussing the cleaning of dirt, specifies that immersing porcelain objects in water with a detergent is an appropriate, safe, cheap and effective approach (Oakley & Jain, 2002). Other cleaning methods found for ceramic conservation include: brushing, using rubberised materials, steam-cleaning and using damp swabs (Corvaia, 2017; Hawkins, 2020; Oakley & Jain, 2002).

Bonding is a frequent conservation step when treating ceramic objects, due to their inherent susceptibility to physical impacts, as seen in the MSCV PP90 dish (Oakley & Jain, 2002). Since ancient times, different materials have been used for this purpose[1]. Repairing porcelain in Europe ("china mending") became a trade of its own as the 18th century progressed and frequently involved the use of metal rivets to bond broken ceramic (Garachon, 2010). Riveting continued well into the 20th century, being described in great detail in Parsons (1963). Recipes for glues and fillers based on egg whites, natural resins, waxes and oils, were also found in books of the 18th century (Garachon, 2010). Currently, a wide range of synthetic adhesives are available to the conservator, such as acrylic resins, cellulose nitrates, polyvinyl acetate emulsions, polyvinyl butyrate, polyester resins, and silicone-based adhesives (Ćurković, 2014; Hawkins, 2020; Lapérouse, 2020; Moncrieff, 1975; Oakley & Jain, 2002). Ćurković (2014), Hawkins (2020), Hyoyun (2014), Moncrieff (1975), Oakley (2002) and Tennent (2014) all mention epoxy resins as the ones typically used for porcelain objects, while Koob (1997) and Bidarra (2015) discuss Paraloid® B-72 (an acrylic resin) as a suitable option.

Just like in bonding, techniques for loss compensation are diverse and have evolved throughout history. Koob (1998) mentions several of these methodologies, some of which he considers to be obsolete. Current materials for filling ceramic objects are: plaster, cellulose strengthened binders (*e.g.* Polyfilla), acrylic resins mixed with bulking agents, polyester resins, polyvinyl acetate fill paste (*e.g.*

[1] Cases of ceramic restoration have been found as far back as 7000 B.C. on earthenware objects with traces of bitumen, wax, animal glue, metal rivets and lacings with metal wire, cord or sinew (Garachon, 2010; Hawkins, 2020). The use of urushi for ceramic repair also has a long-standing tradition, as early as 2500 B.C. (S. Koob, 1998).

Modostuc), epoxy putties (*e.g.* Milliput) and epoxy resins mixed with bulking agents (Ćurković, 2014; Hawkins, 2020; Hyoyun, 2014; Oakley & Jain, 2002; Parry, 2015). Specifically for porcelain conservation, both Hawkins (2020) and Oakley (2002) mention the advantages of epoxy resins mixed with bulking agents (*e.g.* fumed colloidal silica or microballoons), but the last author also recommends polyester resin. Additionally, Han (2009, 2018)[2] has researched the development of a poly-urea filling material for porcelain and a butyral gap-filling material for ceramic conservation. Besides the use of synthetic materials Geschke (2004) Hogan (1996) and Liefkes (2017) have discussed the use of ceramic materials to produce fillings, approach that will be discussed in the present thesis. The use of ceramic material is not necessarily a new idea, for example a case of a porcelain infill produced after 1830 can be found on a pheasant sculpture from the Rijksmuseum, inventory number BK-17495 (Garachon, 2017), however its use is not frequent in contemporary conservation due to several technical challenges (Geschke, 2004).

Lastly, retouching materials used in ceramic conservation, currently include: acrylic paints and varnishes; epoxy resins, acrylic resins, polyvinyl acetates or polyurethanes mixed with pigments; formaldehyde resins, alkyd resins and bleached shellac mixed with pigments (Hyoyun, 2014; Moncrieff, 1975; Oakley & Jain, 2002). Hyoyun (2014) mentions that, for porcelain objects, re-touching with pigmented epoxy allows for a better match, while Oakley (2002) states that both epoxy resins and formaldehyde resins are capable of producing a finish similar to a hard glassy glaze. Despite this advantage formaldehyde is considered to have a very poor resistance to aging (Oakley & Jain, 2002).

Still pertinent to mention is that, in the last few years, the application of three-dimensional (3D) technology in ceramic conservation (for documenting, reconstructing and producing fillings) has been researched by several authors, namely Acke (2018), Antlej (2012), Lee (2015)[2] and Stamatopoulos (2018). The present thesis is also now a part of this field of research.

This brief literature review, allowed to identify several methodologies used for porcelain conservation, which informed the author on treatment possibilities for the MSCV PP90 dish, as will be discussed in more depth in each step of the intervention. Simultaneously, it allowed to compile a list of materials used in the field (Appendix A), which was later used as the base for an international survey (see 1.2 An International Survey - Current Practices in Porcelain Conservation).

[2] Unfortunately, due to the language barrier it was only possible to read the abstracts of these articles.

1.2 An International Survey - Current Practices in Porcelain Conservation

The present case-study belongs to both a Chinese and Portuguese historical context. Subscribing to the notion that conservation judgments are relative and contextual (as first established in The Nara Conference (1994) (Gao & Jones, 2020)), it was considered valuable to analyse and compare Asian and European conservation principles and practices to inform the decision-making process concerning the intervention to be performed. For this, a direct contact with conservators was necessary, which led to the development of an international survey, launched in January of 2021 (having remained open until October of the same year) (Appendix B). The list of materials and techniques used in porcelain conservation compiled from the bibliographic review was used as a base to develop the survey's questions.

The survey was divided into five main topics - conservation principles, fragment bonding, filling, retouching and finishing. The first topic was thought-out to ascertain whether the answers from the remaining topics were coherent with the chosen ethical guidelines and, if not, what principles are compromised in real life interventions. The other four topics were chosen for being the most common conservation steps directly related with the treatment of the MSCV PP90 dish. Methodologies for the removal of old restorations were not approached in this survey as they are extremely dependent on what was used previously and the condition of the object, while cleaning was not incorporated due to it being frequently straightforward for porcelain objects (as mentioned in Oakley (2002)). To achieve a higher answer rate, the survey was designed to be synthetic and mostly comprised of closed-answer questions (thirteen) with only a few open-answer questions dependent on previous answers (six). Besides the mentioned selections, a final one was created to obtain some information on the participant's profile.

Conservators were reached indirectly, by promoting the survey in professional conservation platforms such as Global Conservation Forum; ICOM-CC Glass and Ceramics and Fórum de Conservadores-restauradores; and directly, by E-mailing museums, private ateliers and universities. The direct contact complemented the other method, allowing to purposely force the sample in countries where few answers were indirectly obtained. Similarly, the direct method allowed to force the sample in countries of interest for having a strong connection with ceramic conservation and/or porcelain objects, such as Belgium, China, Germany, Japan, The Netherlands, and The United Kingdom. Since the typical career path of a conservator-restorer is country-dependent, participants were not required to have a specific educational background. Nevertheless, the selection process, the use of specific conservation terms (*e.g.* patina, retreatability, reversibility) and providing the chemical compositions, instead of commercial names, for adhesives, filling materials and paints, ensured the participants had to have some understanding of ethical principles in conservation and materials properties.

In total, the survey received 139 answers from conservators currently working in 39 different countries (Figure 1.2), most of which are European countries. Unfortunately, despite several efforts, the present work clearly lacks participants from Asian countries, which could come to provide valuable insight into the porcelain conservation field. Therefore, what started as an intention to compare Asian and European practices became a worldwide gathering of information.

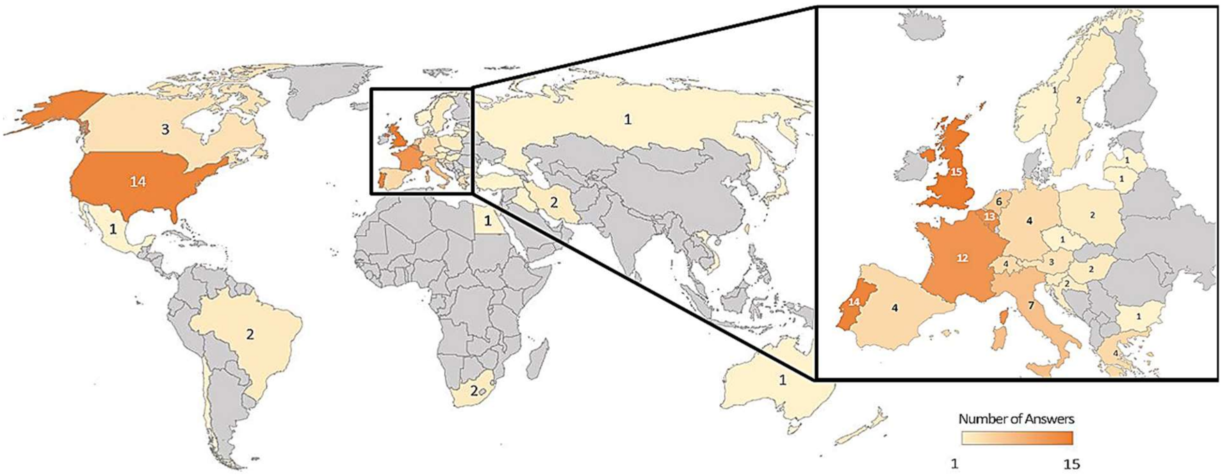

Figure 1.2 – Geographical distribution of the survey's participants, based on the countries where they work.

All investigation takes place out of sample by necessity, by no means does the author consider this a representative sample of the existing international conservators who have worked with porcelain objects. However, determining how many answers, per country, were needed to reach representativity was considered an impossible task, as many conservators are not registered in their local associations, if these even exist. This does not take away the importance of the present research as a first approach. Upon gathering and analysing all answers, a more personalized approach was made through open follow-up questions (Appendix C), reaching out to 86 participants via E-mail. This line of questioning was only capable of obtaining more information from 19 conservators.

This thesis author recognizes that treatment options should be determined on a case-by-case basis, however, the gathered information allowed for the identification of several materials currently used for bonding, filling and re-touching porcelain objects and, to some extent, to detect geographical trends in the preferred methodologies. Techniques considered by some as obsolete were also detected. These results will be briefly presented throughout the discussion of the treatment decisions made for the MSCV PP90, comparing literature findings and survey results with what was chosen in this thesis and why. A deeper analysis of the survey's methodology and results is presented in Appendix D and will also partly be included in an extended abstract for ICOM-CC Recent Advances in Glass and Ceramics Conservation 2022.

2 Case-Study: the MSCV PP90 Dish

2.1 Description and Iconography

The MSCV PP90 dish (Figure 2.1) is a blue-and-white heavily potted porcelain dish. It has a wide flat up-turned rim that finishes in a bracket-lobed lip rim, a v-shaped foot ring which slants inwards, and a circular base slightly convex. The object was decorated in underglaze cobalt blue, with tonalities ranging from a light greyish-blue wash to dark, almost black, outlines. Except for the foot ring, the dish is covered with a blue-tinged glaze. The decorative scheme present is characterized by the cavetto and rim areas being treated as a single unit, divided with the use of lines irradiating from the central medallion into eight moulded polylobed panels intercalated by eight narrow panels. This aspect, as well as the formal characteristics mentioned, are coherent with a specific style– *kraakporselein* [3]– a type of blue-and-white porcelain that was mass-produced by the end of the Ming dynasty in Jingdezhen (Jiangxi province) mainly for export in large quantities (Canepa, 2008; Coelho, 2008).

Figure 2.1 - The MSCV PP90 dish (Before conservation).

Apart from the base, iconographic motives can be found throughout the dish, both in the front and back. A summary table of the iconography can be found in Appendix E. The focus of the representation is clearly the central bracket-lobed medallion where a landscape with two deer in a rocky mountain, surrounded by flowers, under a pine tree partially covered by clouds, is depicted. This is a common scene that can be found, for example, in objects from the collection of Palácio de Santos and of Museum-house of Dr. Anastácio Gonçalves, both in Portugal (Coelho, 2008). Such representation symbolizes longevity, as in Chinese iconography the deer was the only animal capable of finding the sacred

[3] The origin of the name "kraakporcelein" is still debated (Canepa, 2008), but several scholars believe it derives from the word *carraca*, a type of Portuguese trading vessel, which the Dutch called *kraken*.

mushroom of immortality – the *lingzhi* – which is also painted in the back of the dish (Matos et al., 1996; Yeo et al., 1978). Likewise, other elements found have a connection with the Buddhist-Taoist symbology of longevity/immortality such as the pine tree, rocks and peaches (Matos et al., 1996; Yeo et al., 1978). This last is a sacred fruit to Taoists and is portrayed both in the front and back of the dish (Matos et al., 1996; Yeo et al., 1978). Naturalistic scenes are represented on the previously mentioned polylobed. Two opposing panels depict a bird flying above flowers; other two show a possible cicada also flying above flowers (according to Nilsson (2019) the cicada can be a symbol of immortality and resurrection); and the remaining four panels have a single flower amidst branches. The scenes depicting animals are intercalated by the ones with flowers. Although two of the flowers have some similarities with the chrysanthemum and blackberry lily depicted in Yeo (1978), the stylization of the flowers on this dish is very different from other objects found in Canepa (2008) and Matos (1996) catalogues. Due to this, the flowers names and iconography remains uncertain, so far.

2.2 Historical Context

2.2.1 Production

The beginning of Chinese porcelain production remotes to the Tang Dynasty (618-987) (Coelho, 2008; Sentance, 2004), however blue-and-white porcelain only started to flourish during the Yuan (1271-1368) and Ming Dynasties (1368-1644) (De Pauw et al., 2018). As the MSCV PP90 dish is of unknown authorship and does not present production marks, the identification of the *kraakporselein* style was what allowed to suggest a production year range. Commonly, this type of porcelain was mass-produced in Jingdezhen, Jiangxi province, mainly for export in large quantities and is considered to have started to be manufactured in the Ming Dynasty, during the Wanli reign (1573-1620), continuing into the Tianqi and Chongzhen reigns (1621-1627 and 1628-1644, respectively) (Canepa, 2008; Matos et al., 1996). However, according to Coelho (2008), the representation of deer as seen in this case, was recurrent during the Jianjing period (1522-1566) until the Wanli reign (1573-1620). The combination of these aspects led to the suggestion that the present dish was produced during the Wanli reign (1573-1620).

Chinese porcelain traditionally implied a sophisticated system of labour division, from obtaining and refining the raw materials to modelling, decorating, glazing, firing, and quality control (Coelho, 2008; Harrison-Hall, 1997). To produce this vitrified ceramic two basic materials were used – *petuntsé* and kaolin (also known as china clay) (Coelho, 2008). The first is a type of stone, extracted from deposits near the mountains of Jingdezhen, mainly composed of sodium feldspar and quartz, while the second is a very pure white clay that makes the *petuntsé* more plastic and easier to work with (Coelho, 2008; Dias et al., 2013). Both raw materials were usually carefully washed to become more refined (Coelho, 2008; Harrison-Hall, 1997). Once a uniform ceramic paste was obtained by combining the materials previously mentioned, an artisan could start shaping it to the desired form in a potter's wheel (Canepa, 2008; Coelho, 2008). The use of the potter's wheel is evident on the MSCV PP90 dish due to concentric marks found in its base. Moulds, possibly covered with a piece of textile to ease the detachment of the unfired body, were then pressed onto each side of the dish, imprinting a low relief on the cavetto and rim sections (Canepa, 2008). For porcelains decorated in underglaze blue, after the body had dried, the next step was decorating the surface in a free and spontaneous style, by applying washes of cobalt blue over the dried body (Canepa, 2008). The variations from object to object gave them a distinctive charm appreciated by oversees customers (Canepa, 2008). Cobalt oxides had been imported from Middle East to China, at different times, but by the time of the Wanli reign, indigenous Chinese cobalt was used (Coelho, 2008; Copper, 2000). As an impure ore of cobalt and manganese, indigenous cobalt resulted in the more subtle grey-blue colours seen in the present dish, rather than pure blues tones (Coelho, 2008; Copper, 2000). Following the painting of the surface, the object was then covered with a glaze (Coelho, 2008; Copper, 2000; Matos et al., 1996). Finally, it would go into a wood fuelled kiln to be subjected to one firing at very high temperatures (1250-1400°C), achieving a hard glassy finish (Buys & Oakley, 2011; Larsson, 2008; Sentance, 2004). The sand concretions stuck to the foot ring of the MSCV PP90 dish likely resulted from placing it directly on a sand layer spread onto the kiln shelves to prevent the molten glaze from sticking (Canepa, 2008).

2.2.2 Arrival at the MSCV and Unearthing

By the time of the Ming Dynasty, China actively traded with the "West" and the country saw its commercial activity and prosperity grow, resulting in a greater demand for porcelain (Canepa, 2008; Coelho, 2008). The Portuguese were the first Europeans to bring back Chinese porcelains from their travels. Commercial trade with China was facilitated by Vasco da Gama opening the sea route around Cabo da Boa Esperança (in English, Cape of Good Hope) in 1498, and Macao becoming a permanent trading post in 1557 (Corbeiller & Frelinghuysen, 2003; Dias et al., 2013). The MSCV PP90 dish is a testimony of such transactions between Portugal and China and would have eventually ended in The Monastery of Santa Clara-a-Velha, in Coimbra, possibly as a result of the admission dowry of nuns or of royal patronage (Canepa, 2008).

Built on the left bank of the Mondego River, the monastery was first founded by D. Mor Dias, a lady of the nobility, and dedicated to S. Clare[4] as well as S. Elizabeth of Hungary, the Virgin and Jesus Christ (Macedo, 2006; Trindade & Santos, 2009). Realizing that this project would deflect part of D. Mor Dias's fortune, canons at The Monastery of Santa Cruz, where she had stayed since 1250, immediately

[4] S. Clare followed S. Francis of Assisi (1182-1226) essential principles of humility, simplicity, poverty, and prayer. In 1212 she founded The Order of Poor Ladies (Macedo, 2006; Trindade & Santos, 2009)

opposed it (Trindade & Santos, 2009). In the end, the prior of Santa Cruz sentenced D. Mor to excommunication in 1292, and in 1302 she was executed (Macedo, 2006; Trindade & Santos, 2009). Such events, however, did not mean the end of the monastery and by initiative of queen D. Isabel (1271-1336), on the 10th of April 1314, pope Clement V gave permission for it to be re-founded (Macedo, 2006; Trindade & Santos, 2009). D. Isabel's connection to the MSCV was further established by being her chosen final resting place, as per her will. This resulted in a continued protection of the institution after the queen's death, on the 4th of July 1336, making it a famous place for pilgrimage and leading its community to become more aristocratic (Macedo, 2006; Trindade & Santos, 2009). However, from the 15th century onwards, the convent was subjected to regular floods, due to its proximity to the Mondego River, which ultimately resulted in its abandonment and transfer of the religious community to The Monastery of Santa Clara-a-Nova, in 1677 (Larsson, 2008; Macedo, 2006).

After the period of abandonment, in the 20th century, efforts to value and recover the monastery were made, including the archaeological procedures carried out until 2000, that led to the discovery of Chinese porcelain fragments including the ones of the MSCV PP90 dish (Larsson, 2008; Trindade & Santos, 2009). According to archaeological documentation, the case-studies' fragments were specifically excavated between 1996 to 1997 and found in several places which included the north choir-nave, central choir-nave, and the interior courtyard of the cloister.

2.3 Conservation State

In order to classify the conservation state of the case-study a scale of four levels was established (Table 2.1), using the structure presented in (Lavédrine et al., 2012) as a reference, but adapting it to the ceramic materiality. As other two master students, Beatriz Borges and Joana Fontes, were also involved in the conservation of ceramic objects from the MSCV, this scale was developed in collaboration with them, ensuring coherence throughout all diagnosis.

Table 2.1 – Developed scale to determine the conservation state of ceramic objects from the MSCV

Conservation State	Description
LEVEL 1 - GOOD	The object is stable and has good readability. It has none or few deterioration. It does not need intervention. Material loss is under 5%.
LEVEL 2 – FAIR	The object is still stable but has some significative forms of deterioration. It does not need immediate intervention. Material loss can range between 5 to 20%.
LEVEL 3 – POOR	The object is unstable physically and/or chemically and its readability might be compromised. It needs intervention as soon as possible. Material loss can be between 20 to 50%.
LEVEL 4 – UNACCEPTABLE	The integrity and/or readability of the object is completely compromised. It needs intervention immediately. Material loss is over 50%.

The MSCV PP90 dish was considered to be in a fair conservation state (Level 2 from Table 2.1) since it seemed physically and chemically stable, not needing immediate conservation treatment. Even though it was fragmented in a total of thirty-nine pieces and approximately 16.4%[5] material loss (aspects clearly demonstrated in Figure 2.2 (or, for an enlarged version, see Appendix F), its iconography and shape were almost entirely perceptible. As in many fragmented objects, in this state, the main risk was of loss by dissociation.

Aside from total material loss, partial[6] and glaze losses were also detected mostly occurring in con-choidal shapes around the edge of the fragments.

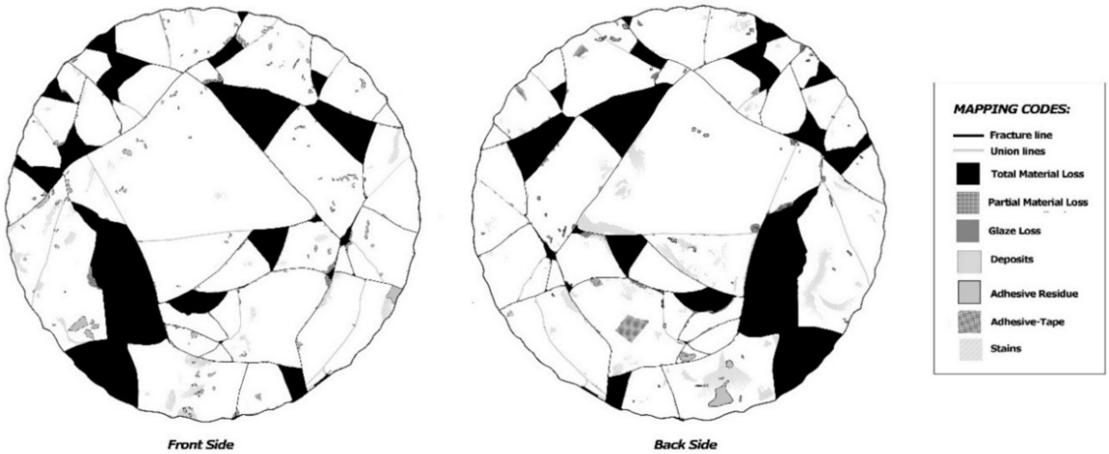

Figure 2.2 - Mapping of the deterioration forms detected on the MSCV PP90 dish.

When the object first arrived at the Glass and Ceramics Laboratory of the Department of Conservation and Restoration of FCT-NOVA, Caparica, Portugal, it was comprised of 26 fragments, as some had pre-viously been bonded in a conservation intervention, possibly made at the monastery. Although no record was found of such conservation attempt, adhesive residues were visible along fracture lines, having a shiny and slightly yellowed appearance, and over the glaze, with a rubbery texture and darker colour possibly due to the accumulation of dirt and fibres (Figure 2.3).

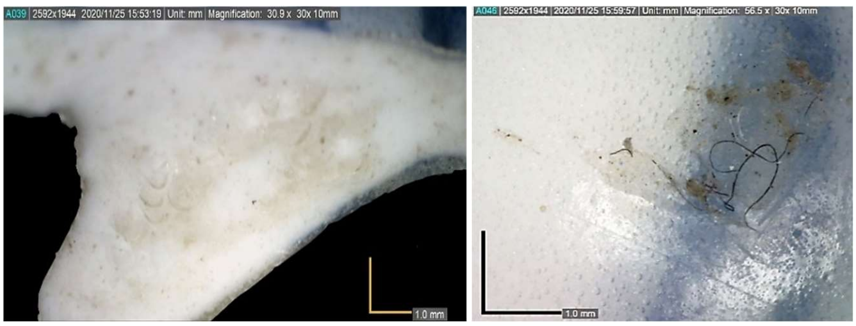

Figure 2.3 - Detail of the adhesive-residues found on the foot ring and over the glaze, respectively; (taken with Dino-lite® Edge Digital Microscope with a magnification of 30.9x and 56.5x).

[5] The percentage of material loss was calculated via Photoshop CS6 software.
[6] Partial loss is here used to designate a material loss of both glaze and porcelain body to an extent that does not go through the whole body's thickness.

The presence of adhesive excesses in fracture lines that are not currently adhered to others suggests that additional unions were made, but possibly fell apart or needed to be redone due to incorrect placement or adhesion order. Through UV light observation and Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy (ATR-FTIR), the adhesive was identified as being, possibly, an epoxy resin (Appendix G), which is already undergoing chemical deterioration, as it has a yellowed appearance and the carbonyl formation was detected by ATR-FTIR (Carvalho, 2016; Coutinho, 2008; Meiser et al., 2010). Adhesive-tape was also detected on the object which might indicate its use to help with the adhesion process.

Aside from the mentioned forms of deterioration, brown deposits were visible in areas without glaze and white stains were noticed over the glaze surface (Figure 2.4). The first are likely earths resultant from its archaeological context that got stuck into the porcelain body, while the second resemble acetone and/or adhesive traces, which could be related to a previous intervention. A small fracture covered in glaze, craters, dark-brown spots (possibly resultant from the oxidation of metallic particles on the glaze), pin-holes and an orange line in the interior of the foot ring (Figure 2.5) were not considered deterioration forms but aspects related with the production process of the object itself.

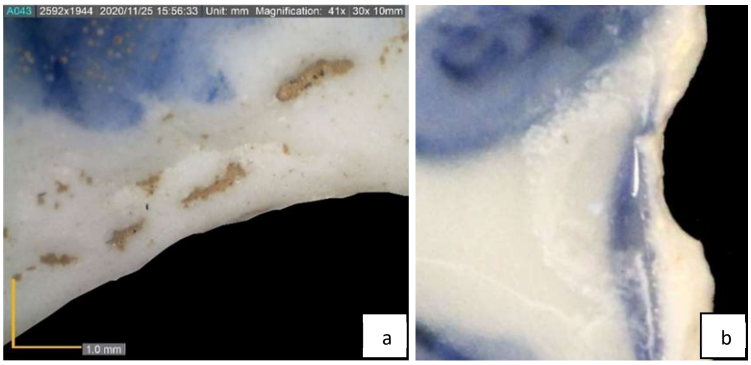

Figure 2.4 - Detail of deposits stuck to the porcelain body (a) and a white stain (b); (the first picture was taken with Dino-lite® Edge Digital Microscope with a magnification of 41x).

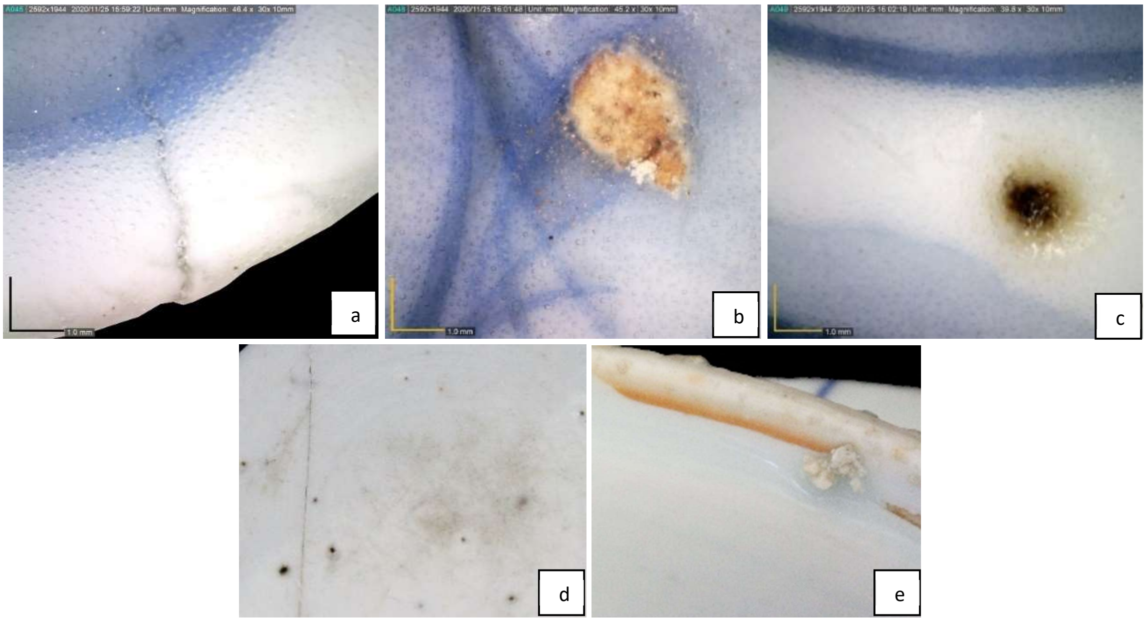

Figure 2.5 - Detail of a fracture (a), crater (b), brown spot (c), pin-holes (d) and an orange line (e), respectively, resultant from the production technique; (the first three pictures were taken with Dino-lite® Edge Digital Microscope with a magnification of 46.4x, 45.2x and 39.8x, respectively).

3 Conservation Treatment

The conservation intervention intended to achieve a single unified object from the several fragments presently available, thus becoming possible to directly perceive the dish's size, shape and aesthetic, as well as minimizing the risk of loss by dissociation (S. P. Koob, 2014; Oakley & Jain, 2002). In this sense, the conservation steps here discussed are: 1) disassembly, 2) cleaning, 3) fragment bonding, 4) manufacture of fillings and 5) filling small gaps. Finally, as the un-glazed solid white fillings highly contrasted to the complex original iconography, re-touching and surface finishing of the fillings was also executed, minimizing their distracting factor and allowing to appreciate the dish as a whole.

3.1 Disassembly

As already mentioned in "2.3 Conservation State", the MSCV PP90 dish had previously been interventioned and several fragments were bonded with an adhesive, identified as a possible epoxy resin (Coutinho et al., 2008; Oakley & Jain, 2002)

Two reasons are given to justify the need for disassembly. Firstly, it was crucial to establish a new correct bonding sequence that prevented locking out fragments. This was likely not performed in the former conservation attempt as adhered fragments were separated in groups (instead of joined to a single main fragment) making it impossible to continue the adhesion. Secondly, the adhesive-residues found present a slight yellowish hue which combined with the detection of the carbonyl group by ATR-FTIR analysis indicates that it is already undergoing chemical deterioration (Carvalho, 2016; Coutinho, 2008; Meiser et al., 2010). With the increase cross-linking in the polymer, due to its aging, the adhesive will become more rigid and thus likely to generate new tensions in the dish which increase the risks of damage (Coutinho, 2008). All epoxy also yellow, which might become too visually impairing, especially against the white porcelain object (Coutinho, 2008). As such, it was concluded that removing the adhesive and replacing it with a more stable one would improve the chemical and physical stability of the object, as well as its aesthetic.

Dichloromethane (or paint stripper) is usually referred to as the required solvent to soften and swell epoxy resins (Hawkins, 2020; Oakley & Jain, 2002). However, old repairs or incorrect joins may be weakened enough for hot water to disassemble the adhered groups (Hawkins, 2020; Oakley & Jain, 2002). As such, and considering that the least toxic method should be tried first, the bonded fragments were placed in a plastic container and immersed in warm water (Hawkins, 2020; Oakley & Jain, 2002). After four hours positive results were already accomplished, with some joins becoming sufficiently weak that they fell apart, when applying a small amount of pressure (Figure 3.1). More stubborn bonds were left submerged for longer periods of time, while warm water was routinely introduced to the container to maintain a higher temperature. This considerable easy disassembly of epoxy bonds was unexpected and could indicate that the adhesive was already considerably deteriorated and/or had been incorrectly prepared when mixing the resin and catalyst components. In the end, all joins successfully came apart with no record of new damage to the object.

Figure 3.1 - Disassembly of previously bonded fragments in warm water.

3.2 Cleaning

While warm water was successful in the disassembly, adhesive-residues remained stuck to the fragment's edges. These could lead to disappointing results during the subsequent adhesion, both visually and structurally, ultimately ending in a failed union, therefore they needed to be perfectly removed (Hawkins, 2020). For the same reason it was also imperative to clean all dirt and earthen deposits.

Washing the fragments was considered an appropriate cleaning method, since high-fired nonporous wares, such as porcelain, can usually be safely immersed in water with an appropriate detergent and the fired underglaze decoration should likewise be resistant to such process (Oakley & Jain, 2002). In an attempt to safeguard some of the archaeological earths, before washing, a scalpel, dental probe and petri dish were used to collect a sample. As only a miniscule quantity could be removed this way and considering that the archaeological documentation produced at the MSCV already informed what stratigraphic context was related to the object, the acquired sample was ultimately discarded. All fragments were then washed following Koob's (2006) methodology, and using Teepol® as a neutral and non-ionic detergent. Finally, mechanical cleaning was performed with a scalpel and a dentist probe in order remove the remaining adhesive residues (Figure 3.2). Ampliation tools such as a Waldmann® magnifier light and a Zeiss® Stemi 2000-C stereo microscope were crucial in this step.

Figure 3.2 - Mechanical removal of adhesive residues.

3.3 Fragment Bonding

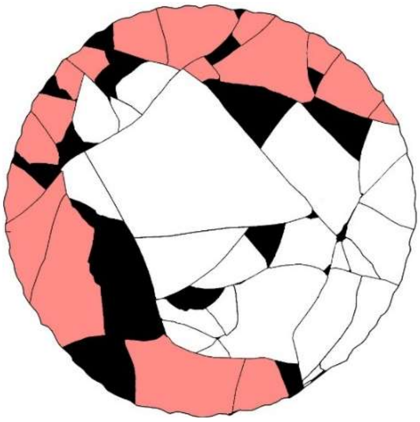

Figure 3.3 - Fragments thought to be structural unstable without a stabilizing support or fillings (highlighted in red).

Fragment bonding was desired as it is what allows one to obtain a single unified object and to minimize the risk of loss by dissociation (S. P. Koob, 2014; Oakley & Jain, 2002). Nevertheless, upon analysing the extension and location where material loss occurs, it was concluded that this would compromise the structural stability of the reassembled object. Particularly worrying were the raised fragments of the cavetto and rim sections that would only have a small bonding area to the base (Figure 3.3) which together with the force of gravity would likely cause a failed union. This led to the discussion whether structural fillings should be produced before or after bonding the original fragments. If produced before bonding, the structural fillings could be adhered simultaneously with the original fragments, which meant that the unions would be less likely to fail as there wouldn't be large areas of material loss and instability. The fillings also wouldn't get locked out by the original pieces since each element's assembly order could be taken into account. Despite seeming like a better option, such hypothesis was discarded due to the need to first obtain a three-dimensional (3D) scan of the bonded object before creating fitted fillings (this topic will be further developed in the next section "3.4 Production of Fillings"). Ultimately, it was decided that fragment bonding would be firstly performed, and temporary supports would be put in place, to provide structural stability until the fillings were manufactured.

Several authors, including Hawkins (2020) Hyoyun (2014) and Oakley (2002), recommend the use of epoxy resins for adhering porcelain, possibly because of the similar refractive index to the glazes on hard-paste porcelain (The Fitzwilliam Museum, 2020). In the international survey's results (
Figure 3.4) epoxy resins were indeed the most chosen adhesives (116 answers), closely followed by acrylic resins (97 answers).

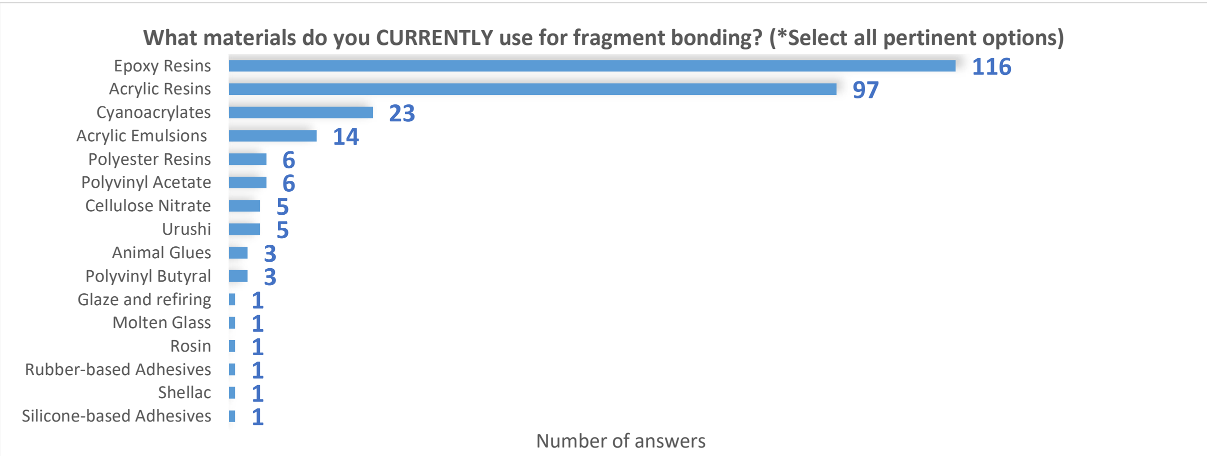

Figure 3.4 - Survey's participants answers related to the bonding materials they use in porcelain conservation.

Epoxy resins are extremely strong, which could prove helpful when securing fragments with a small bonding edge. However, once cured, these become insoluble and extremely hard to remove (Coutinho, 2008; Horie, 2010), which is particularly undesirable for the present case-study, since missing pieces might come to be identified in upcoming conservation and inventory efforts of the MSCV. Such difficult reversibility would also go against Article 9 of E.C.C.O. Professional Guidelines (2003) [7] when a more reversible and adequate option is available. The eventual yellowing of these adhesives, due to their aging process, is also concerning (according to Coutinho (2008), even HXTAL NYL-1®, one of the most stable epoxies, will start to be perceptible after circa 18 years in museum conditions).

The mentioned characteristics led to considering acrylic adhesives as a better option, in particular Paraloid® B-72 which, according to Koob (1997), is a suitable adhesive for bonding high-fired ceramics, such as porcelain. This adhesive is a copolymer of ethyl methacrylate and methyl acrylate, in a ratio of 70:30, which is reversible, has moderate strength and high stability (not yellowing or becoming brittle with time) (S. P. Koob, 2009). Its main problem is that it leaves air bubbles, but this can be minimized by using fumed colloidal silica as an additive (S. P. Koob, 1997) and is not a major concern in porcelain, since the fracture lines won't be visible.

Before bonding, a dry-run assembly was performed, using adhesive-tape and sandbags to support the pieces (Oakley & Jain, 2002). Once the assembly order was established the fragments were bonded with Paraloid® B-72 (40% in acetone) one at a time. Typically all fragments should be adhered to a main fragment that is either part of the base or the largest one (S. P. Koob, 1997), however the material loss seen in the MSCV PP90 dish made it necessary to, occasionally, join small groups apart from the main set. One of the biggest difficulties experienced was the alignment of the fragments, as the lack of material and deformation of the archaeological object made it difficult to perceive which was the correct position. In this sense, the thermoplasticity of the chosen adhesive was beneficial to the intervention, allowing to adjust the bonded fragments by heating them with a hair dryer. In one instance, Paraloid® B-72 (20% in ethanol) was introduced by capillarity to a join that got closed off while correcting a bonded group's position. Two types of supports were created while bonding the dish (Figure 3.5). The first was an underlying ring, obtained from stuffing socks with rice, that supported fragments from the cavetto and rim areas. The second consisted of wooden bridges between fragments created from toothpicks. In some places, adhesive-tape was also strategically placed to alleviate some tension. In the end it was possible to obtain a successful bond.


Figure 3.5 - Supports used during fragment bonding.

[7] "(…) the materials used should not interfere, if at all possible, with any future examination, treatment or analysis. They should also be compatible with the materials of the cultural heritage and be as easily and completely reversible as possible."

3.4 Production of Fillings

As previously mentioned, material loss compromised the stability of the re-assembled object. Two distinct approaches were initial considered to solve such problem.

If the responsible caretaker of the monastery wished to limit the intervention to its minimum, thus maintaining the object the closest possible to its original archaeological state, a viable solution would be to create a permanent concave structural support underneath, using inert and stable materials. This would also allow for break edges to remain easily accessible, facilitating, if necessary, the removal of samples for research purposes. However, such approach would difficult its future observation and maintenance, as the object would never be stable enough to be handled on its own, and access to its back would require an extra support, placed on top, to invert it. Aesthetic appreciation and interpretation of the dish, as a whole, would also be hindered due to the heavily contrast between the lack of material and the original decorative surface. Finally, exhibition options would be limited since the object could not be placed semi vertically onto a display stand, and instead should be displayed horizontally, requiring more vitrine space.

The negative aspects mentioned were the reason why the approach of only creating an external support was not advised. Instead, filling the object was considered a better option, as it would stabilize the adhered fragments, facilitate its future handling, and create a surface that, if so whished, could be reintegrated to minimize its visual impact and allow for a better aesthetic appreciation. Maintenance cleaning would also be facilitated for there would be less cavities were dirt and dust could accumulate. Although a discernible filling should not damage the interpretation of the object's archaeological context, it is important to recognize that this approach would limit the access to break edges, making it harder to remove samples from inconspicuous places. Nevertheless, as a reversible adhesive would be used to bond the fillings and fragments together, it would always be possibly to dismantle the object and remove samples in such state.

3.4.1 Choosing Porcelain

Unlike other disciplines of conservation (furniture, stone, metal, and paper) where repairs are routinely made with materials similar to the object, in the ceramic field this is less well established (although authors like Hogan (1996), Geschke (2004) and Liefkes (2017) describe methodologies to create ceramic fillings). In the literature, a mixture of an epoxy resin with pigments and bulking agents is generally advised for filling porcelain objects (Hawkins, 2020; Larney, 1975; Oakley & Jain, 2002). The international survey's results (Figure 3.6) are in accordance with such tendency as 90 participants selected epoxy resins as a filling material they use. Common alternative materials also registered in the survey include acrylic resin + bulking agents (63 answers); plaster (61 answers) and epoxy putty (53 answers).

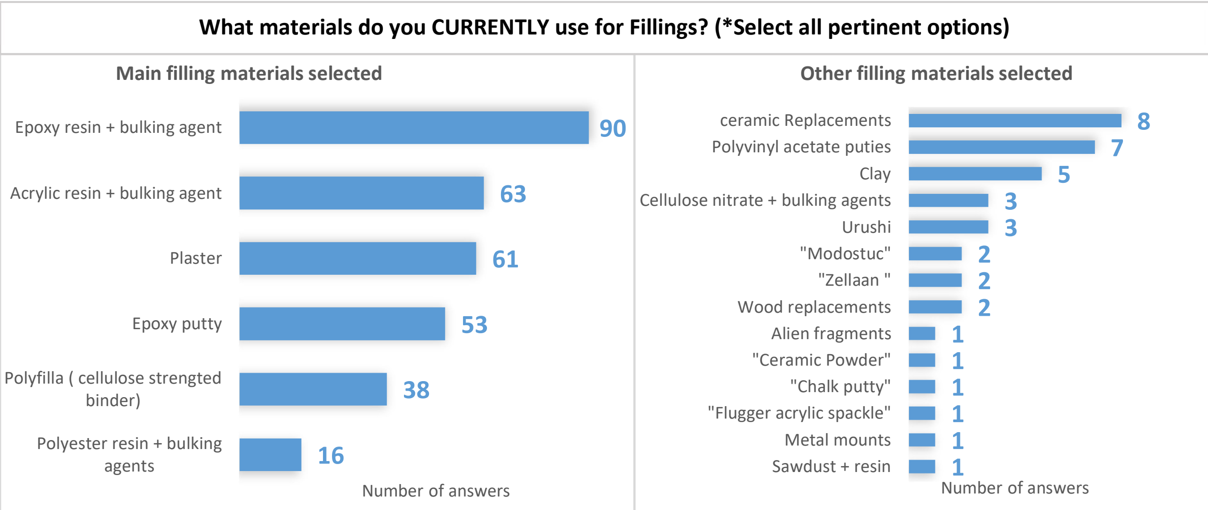

Figure 3.6 - Survey's participants answers related to the filling materials they use in porcelain conservation.

Instead of these approaches, the present thesis decided to focus on the development of fillings made with porcelain. According to the survey's results (Figure 3.7) only 5% of the participants has used porcelain to create fillings, demonstrating the rarity of its use in the conservation field. This material was considered as a viable option for allowing to create reversible detachable fillings of a similar nature, aesthetic, and thermal expansion/contraction to the original material, minimizing negative interactions that might occur (Geschke, 2004). Porcelain is also a very robust material that does not change appearance over time, ensuring a durable conservation intervention (Liefkes, 2017). There are, however, disadvantages to this approach.

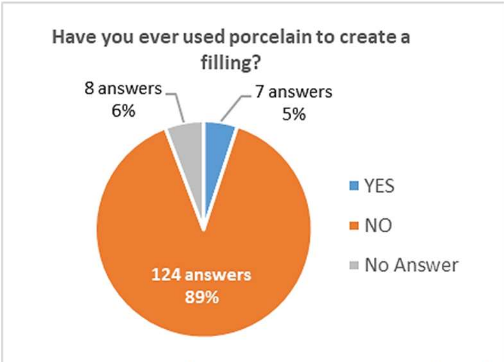

Figure 3.7 - Survey's participants answers related to their use of porcelain as a filling material.

- Ethical and Practical Concerns

Using a similar material to the original can raise ethical problems as it can be harder to distinguish them, especially if the surface texture and colours are well matched, and common detection methods such as tapping, scratching, use of solvents or UV light will not work (Geschke, 2004). This lack of detection would not only be unethical, going against Article 23 of the AIC Code of Ethics (1994), but might also compromise future archaeological studies if analysis is mistakenly performed on the fillings (Geschke, 2004). To avoid such issues, it was decided that fillings should have an incision on the verse, ensuring their detection and recognition as a posterior addition (Geschke, 2004). A purposeful mismatch in texture and/or colour would also make this approach ethically acceptable (Hogan et al., 1996; Liefkes, 2017) and if, in the future, the incisions are damaged or lost, the fills would still remain identifiable as such. It was therefore considered best not to glaze the porcelain fills. As the fills will remain unglazed, the underglaze decoration technique will also not be attempted and, instead, reintegration with modern materials is discussed on this report later on (see 3.5 Re-touching)

Besides ethical considerations, the main practical concerns in creating porcelain fills involve the natural shrinkage and deformation the clay suffers during drying and firing; the need for specialists' knowledge, skill and equipment and it being a more time-consuming process than traditional conservation techniques for making fills (Geschke, 2004; Liefkes, 2017). To overcome some of these problems a partnership with Vista Alegre® (VA) was sought out and fortunately accepted.

VA is a famous porcelain Portuguese factory based in Aveiro and founded in 1824 (Vista Alegre, n.d.). Besides the incredible amount of crafting knowledge gathered there, the VA has 3D scanning and printing technology that could assist this conservation process and a conservator-restorer – Dr. Joana Teixeira – who, as someone currently making efforts to develop porcelain fillings (which will also be presented in an article for ICOM-CC Recent Advances in Glass and Ceramics Conservation 2022), could provide valuable insight. The collaboration with different experts from VA offered, therefore, a unique opportunity in terms of the conservation treatment of dish MSCV PP90. Unlike the previous conservation steps where practical work was performed by the author, in the production of fillings the conservator assumed mostly four roles: the decision-maker, the intermediary between all involved, the handler of the object and the one that documents the whole process.

3.4.2 Transportation to the VA

Having the bonding process been performed in the Glass and Ceramics Laboratory of the Department of Conservation and Restoration of FCT-NOVA it was then necessary to move it to the VA to create porcelain fillings. Ideally both the bonding and filling would have been performed in one place to avoid the disassembly of the now re-assembled object. However, the schedules and deadlines of all the people involved did not allow for this to happen. Instead, great care was taken to avoid any damage during transportation. For this purpose, it was necessary to create of a form fitted cushioning support for the dish. Furthermore, a decision was made not to adhere two fragments to the MSCV PP90 due to their small bonding area, which would likely prevent them from staying adhered during transportation and could create tensions in adjacent fragments. Figure 3.8 presents the transportation support developed. The transportation was made by car which allowed to deliver it directly to the VA museum's door. Upon reaching its destination, the object was carefully unboxed and no new damage was registered, having arrived "in one piece".

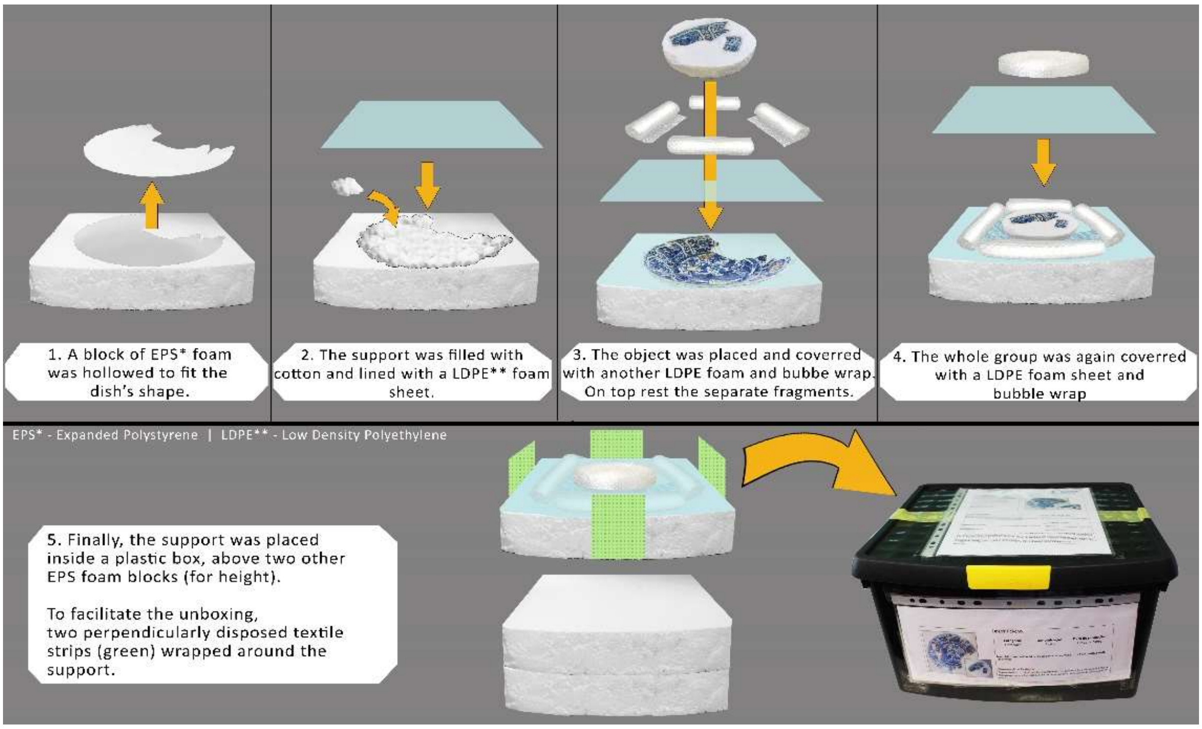

Figure 3.8 - Scheme of the cushioning support developed to transport the MSCV PP90 dish to VA.

3.4.3 3D Scanning, Modelling and Printing

3D technology, in terms of scanning, modelling, and printing, was used to facilitate the process of creating the porcelain fillings, since it reduced the amount of object handling and the time required for making small adjustments.

- Scanning

To obtain a model of the missing areas from the dish, the object was first scanned by means of optical based scanning. Handling was made by the conservators, while technical support was performed by the VA technical drawing team. The equipment set-up involved the use of a 3D scanner eviXscan 3D Heavy Duty Optima (which has incorporated a blue LED light source and two cameras (Evatronix SA, 2020)) a tripod and a rotary table onto which the object was placed. Upon calibrating the equipment, the MSCV PP90 dish was scanned. As the re-assembled object remained quite unstable, care had to be taken during this process. Instead of attempting to bond the two separate fragments to the dish, prior to scanning, a decision was made to scan them separately and then digitally assemble the whole group in Rhino6commercial® software to avoid stressing the joins. For scanning the front, the dish was left on top of the transportation support previously created, while for the back it was placed inverted onto a box of fine sand that could be adapted to its shape. The temporary toothpick supports were left untouched, but adhesive-tape had to be removed previous to scanning, in order to avoid light scattering. Porcelain itself can produce considerable light scattering, however the application of a light powder coating to turn the surface matte (Acke et al., 2018) was not a viable option in this case, as the foreign material would penetrate and remain in the fracture lines. Instead, to maximize the amount of information captured, several acquisitions were made under different light intensities and the scans were overlapped. In the end, each side was scanned 16 times with a rotation of 45º, half of which with a maximum light intensity and the other half with less intensity. Software Leios® was used to combine the opposing sides onto a unified object and to remove the toothpick supports digitally.

- Modelling

Upon having a digital version of the MSCV PP90 dish, the next step was modelling the missing areas, which was made in Rhino6commercial® software by using the available geometry (Figure 3.9). The fact that the object was hand-made in a potter's wheel difficulted this process, as it meant there was no single profile that could be used as a unique and perfect reference for the object, thus requiring adjustments throughout. The relief present in the cavetto and rim sections was something that could not be matched digitally, but was later attempted, manually, on the mould-making phase (see 3.4.4 Mould-making). In the end, the missing areas were divided into 14 modelled pieces.

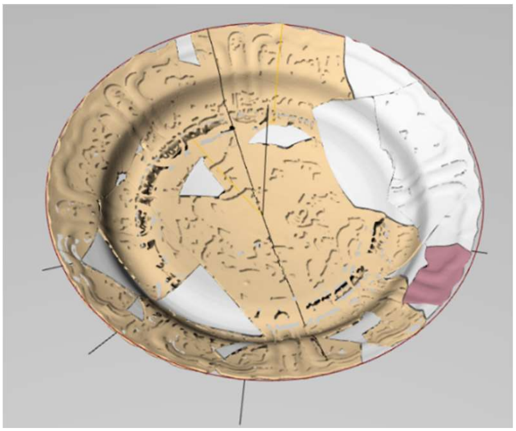
Figure 3.9 - 3D model of the MSCV PP90 dish after compensating the material loss.

- Printing

Finally, the models were printed with the available printer at VA, a ProJet CJP 660 Pro (ColourJet printer). The printer uses calcium sulphate hemihydrate (VisiJet® PXL Core) as the base powder material which is bounded by the VisiJet PXL® binder (an aqueous solution) (3D Systems Inc., 2019, 2020; Oca, 2019). Since plaster powder-base materials have a low mechanical strength, the printed pieces were then post-processed by means of an infiltration with StrengthMax®, a two-part epoxy infiltrant (Oca, 2019). The first fragments were printed in what should be the final size of the fired porcelain to directly compare them with the object and access whether it was necessary to adjust them (Figure 3.10 and Figure 3.11). This, inevitably, could only be made once the toothpick supports were removed.


Figure 3.10 - The MSCV PP90 dish with the 3D printed fillings.

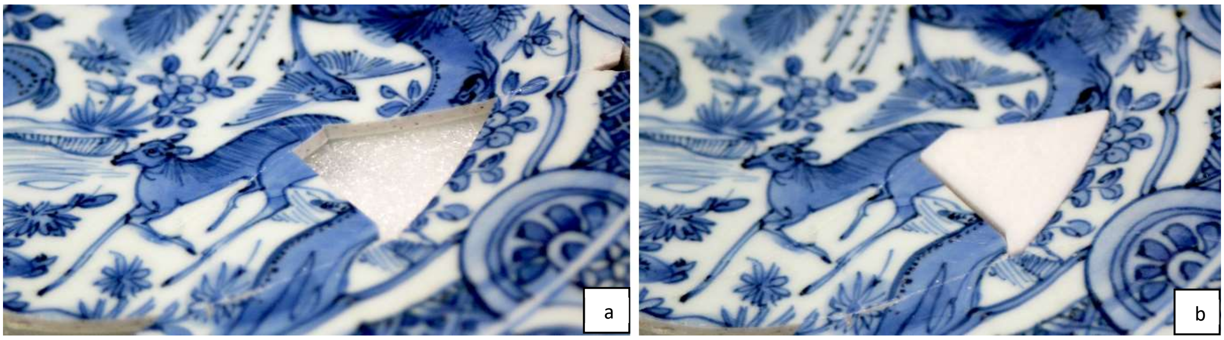

Figure 3.11 – Comparison of an area with material loss before (a) and after placing a 3D printed filling (b).

The first comparison revealed that three of the 14 pieces needed minor corrections, and the larger one showed more serious discrepancies. Minor adaptations were initially made in the digital models, expecting that this approach would be faster and reduce interaction with the original object. The mismatch observed in the larger fragment (Figure 3.12) was possibly caused by having scanned separately the two unattached original fragments and then digitally reconstructed the object. This meant that adapting the digital model would likely be insufficient, as the scan was not rigorous in such area, and a new digitalization and modelling were necessary after bonding the adjacent original fragments. It was, therefore, decided that the remaining thirteen fillings would advance to the next production step, while the last piece would wait for them and the unattached original fragments to be bonded to the object, only then making a new scan and model for it.

Figure 3.12 - The large 3D printed filling with an inaccurate shape

Trusting that the minor digital adjustments would be enough for the three mentioned fillings to fit correctly on the object, all digital models were once again printed, both at 1:1 ratio, and at an oversized ratio (Figure 3.13).

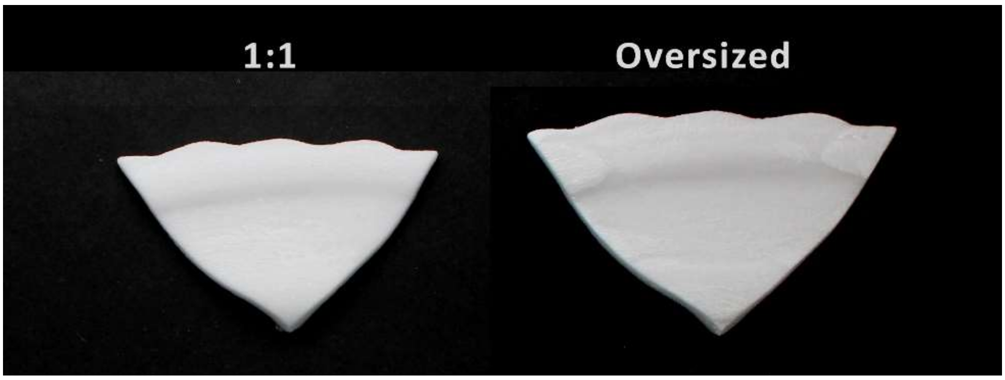

Figure 3.13 - Size comparison between a 3D printed filling in a 1:1 ration and in the applied oversized ratio.

Oversizing is necessary to compensate the natural shrinkage of the porcelain clay during drying and firing. The shrinking ration of the porcelain clay used was already well known in the factory, since it needs to be considered in the production of all products, consisting of 19% (hight) and 15% (width). As such, no need for extensive shrinkage testing was required.

In retrospective, not making a new comparison of the adjusted fragments before enlarging all pieces was a misstep, as the three newly printed with a 1:1 ration still did not fit their place. Considering everybody's availability and how printing once again would increase the cost of the process, this time the adjustments were manually made by sanding the printed fragments (Figure 3.14). Firstly, the 1:1 pieces were adapted and directly compared with the object to understand where material needed to be removed, and then, by transposition, the process was repeated for the enlarged versions.

Figure 3.14 - Comparison between a 3D printed filling before and after sanding.

The oversized fragments were what was used for the subsequent processes.

3.4.4 Mould-making

For the next process in the production of fillings, the printed elements were moved to the mould-making section at the VA, where plaster piece-moulds were manufactured by specialists. Afterward, porcelain slip was poured into such moulds to obtain the porcelain fillings (see 3.4.5 Casting). Besides moulding the fillings, in order for them to retain their natural curvature during drying and firing, it also became necessary to manufacture an underlaying support that could accompany the fillings during such steps.

- Moulds of the printed fragments

To minimize the amount of material and time needed to produce these moulds, the number of fragments per mould was adapted to fit a base tile. One mould could have between one to five fragments, depending on their size. The sequence of steps made to manufacture these moulds is summarized in Figure 3.15. In total, five of these bivalved moulds were produced.

Figure 3.15 - Mould-making process.

Besides this process, as two of the fillings would be placed in areas of relief in the MSCV PP90 dish, an attempt was made to manually adapt their volumetry to match the original object. This involved creating a plaster version of the two fragments that could then be shaped with modelling tools and plasticine and compared with a stencil of the dish’s volumetry (Figure 3.16). Unsure if this method would have a successful outcome, a decision was made to produce two moulds (using the methodology described in Figure 3.15), one where they were unaltered, and one after having been hand-modelled.

Figure 3.16 - Manual adaptation of the volumetry of the fillings.

- Moulds of the underlaying supports

As previously mentioned, to avoid significant distortion of the fillings during drying and firing, underlaying supports were created. In Portuguese, these are called “calço cama” and for them to have a similar shrinkage rate to the pieces being supported they are also manufactured in the same material, in this case porcelain.

Models of the supports were manufactured by pouring thick plaster onto a marble table and lightly pressing the fillings on top, which created a slight depression where the fillings could fit (Figure 3.17).

Figure 3.17 - Pressing a filling on poured plaster to create an underlaying support.

From these models bivalved moulds were produced as described before (Figure 3.18).

Figure 3.18 - Example of a mould of a group of fillings (right), and the respective mould (left) of their support model (below).

In the end, four moulds of the supports were developed. After letting all plaster moulds dry for two days at 60 °C, the moulds were ready for the next phase – casting.

3.4.5 Casting

Casting consists of forming a ceramic objects by pouring a slip into a porous mould, in this case of plaster (Figure 3.19) (Walker Ceramics, 2021).


Figure 3.19 – Slip casting of a filling.

Both the filling fragments and the underneath supports were casted in porcelain slip, however, for the fragments, two types of slip were tested, a white porcelain slip and a second one that VA calls a “Chinese slip”. “Chinese slip” differs from the white slip due to the addition of iron (III) chromate ($Fe_2(CrO_4)_3$) into the composition, giving it a bluish tint. Visually, this porcelain closely matches the MSCV PP90 dish (Figure 3.20), unlike the white slip. Nevertheless, casting was made with both materials, only choosing one after firing the fillings (see 3.4.7 Testing and Adjustments). For the supports only white porcelain was used, which is the most abundant material in the factory.
Immediately after casting, the fragments were placed on top of their respective supports (Figure 3.21), to ensure the curvature was not significantly altered while they dried for a day, at 60 °C.


Figure 3.20 - Visual comparison between the dish's colour and the "Chinese slip".


Figure 3.21 - Example of two fillings casted in "Chinese slip" (left) and white slip (right), both placed in their respective casted supports.

3.4.6 Firing

Before firing, the dried fillings and supports (Figure 3.22) excess material resultant from the casting process was removed with a scalpel by the conservators and the surface was smoothed with a Dual Angle Micro-Mesh® Fine file. Taking advantage of the workability of the material in this state, an incision - "2021"- was carved in the back of all fragments to ensure their recognition as posterior additions to the original object (Figure 3.23). Once this step was completed, the casted pieces were ready for firing (Figure 3.24).

Figure 3.22 - Group of dried fillings and supports.

Figure 3.23 - "2021" inscription in the back of one fragment

In the VA factory, biscuit objects tend to be fired twice to avoid damage occurrence. Nevertheless, as the MSCV PP90 dish would, traditionally, only have been fired once (Buys & Oakley, 2011; Larsson, 2008; Sentance, 2004) and this would be less time consuming, the possibility of only firing the fillings once was discussed with specialists. As long as the pieces were carefully dried, they informed us that this method shouldn't be a problem, therefore the fillings were fired once at a maximum of 1380°C for seven hours. Before firing, a layer of alumina was applied over the porcelain supports, which ensured they wouldn't get stuck to the fillings.

Figure 3.24 - Placement of the fillings in the oven.

3.4.7 Testing and Adjustments

Once the fillings had been fired, it was necessary to see how they looked on the dish and if they provided the structural stability desired.

The first aspect analysed was on a visual level and consisted in comparing the fillings in “Chinese slip” with the ones in white slip. As expected, the “Chinese slip” fillings were the ones that best matched the original object’s colour, improving the appreciation of the MSCV PP90 (although the lack of iconography was still distracting, as will later be approached in 3.5 Re-touching).

The second aspect was related to how the fillings fitted in their intended places, mostly in terms of shape, curvature and thickness. Looking at the relief of the two fillings that had been achieved via hand-modelling (see “3.4.4 Mould-making”) it was determined that this did not accurately match with the object’s surface, therefore a decision was made to use the unaltered fillings. It was also concluded that almost all fragments would benefit from having extra material in certain areas (Figure 3.25). This discrepancy in shape was partly from the original printed models not being perfect from the start, the increase in rigour from the conservators, and a consequence from removing the pouring cone in the slip casting process.

Figure 3.25 - Detail of a porcelain filling in need of extra material.

The better the fillings fitted the dish the more structural stability they could provide, which was one of the main goals of this intervention. Therefore, it was crucial to improve the fillings shape. The opted method involved a VA specialist carving out the fragments’ moulds to increase the amount of material casted, as well as the conservator grinding excess material from the fired fragments (Figure 3.26). This methodology was considered less time-consuming and required the least amount of handling compared to improving the digital models and having to repeat the mould-making process.

Figure 3.26 - Adjustment of a fragment's mould (left) and grinding of the fired fragment (right).

After the moulds were adapted, slip casting and firing were performed as described before, only using “Chinese slip” for the fragments. Before firing, the fragment’s supports were manually adapted to better fit the new shapes. Afterwards, the biscuit porcelain was grinded to perfect the final fit. Alternatively to grinding fired porcelain, which is a laborious task, the fragments could have been sanded in the dry stage. Grinding was preferred due to the possibility of adapting the fillings when they have their final dimensions, allowing for a direct comparison between fillings and the areas of material loss in the MSCV PP90 dish.

Unlike contemporary materials that can be sanded in-situ to match the volumetry of the object, the use of porcelain fillings has the disadvantage that no adjustment can be made after bonding them. In this sense, the original dish had to be temporarily inverted onto an adapted support, to ensure that the fillings fitted properly both in the front and in the back. In the end it was possible to improve the shape of the 13 fragments to one that confers the dish more stability (Figure 3.27).

Figure 3.27 - Example of a filling's first try (left) and second try, after adjusting the mould and grinding the surface (right).

3.4.8 Bonding the Fillings

Bonding of the fillings was performed by the conservator with Paraloid® B-72 at 40% in acetone. Instead of moving the unstable object to a position in which gravity helps the bonding process, the dish was maintained in its transportation support while the fillings were kept in place using plasticine and adhesive-tape. As the fillings were bonded, so were the fragments that had been left separate from the object due to their instability. Once this was accomplished, it was possible to scan the object one last time to model and manufacture the 14th filling, concluding the production of the structural fillings (Figure 3.28).

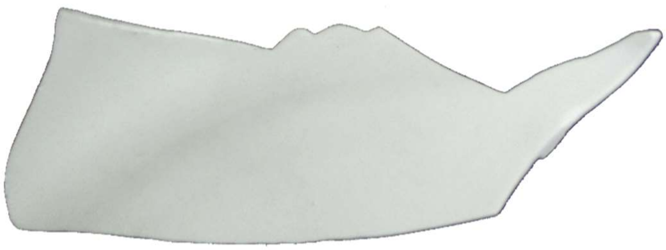

Figure 3.28 - 14th filling after firing.

3.4.9 Filling Small Gaps

Despite the successful production of structural porcelain fillings, the methodology did not allow to produce perfect fillings, leaving visible small gaps. These can lead to dirt accumulation, and will attract the viewer's eyes, hindering the overall aesthetical appreciation. It was therefore decided that such areas should also be filled in, conferring also greater physical stability.

As one participant from the survey had mentioned the use of "grinded porcelain with the addition of epoxy resin", the author considered interesting to explore the use of grinded porcelain in Paraloid® B-72, as these were the two materials that had been used for bonding and producing the structural fillings. Although possible, this methodology was discarded because of the risk of the grinded porcelain abrading the original dish's glaze. Instead, the use of Paraloid® B-72 with microballoons was considered, since it allows for a filling that can be sanded, coloured with pigments or paints, and will not yellow with age (Government of Western Australia, 2017). Oakley (2002) mentions that a mixture of Paraloid® (25-35% in a 50:50 solution of acetone and ethanol) with an aggregate (kaolin, talc or barium sulphate) should provide an appropriate reversible filling material with an opaquer look to match the ceramic body. The used solution of Paraloid® B-72 described in the literature varies from 15% in acetone or ethanol (Government of Western Australia, 2017) to 25% in a 50:50 mix of acetone and industrial methylated spirits (Kemp, 2009). For this case-study three solutions of Paraloid® B-72 were tested: 30% in acetone, 10% in acetone, and 10% in a mix of 50:50 acetone and ethanol. Besides combining the solutions with microballoons, dry pigments from Kremer® ("Cobalt Blue Dark", "Raw Sienna, French" and "Chrome Oxide Green") were used to obtain a similar tonality to the porcelain fillings (Figure 3.29). Considering the need to blend all these materials together, the Paraloid® B-72 solution had to allow for a good workability time, which was possible by using 10% Paraloid® B-72 in a mix of 50:50 acetone and ethanol. Having decided on the adequate solution and made several tests to get the colour and texture right, areas where the putty was going to be applied were prepared. This involved covering the surrounding areas with adhesive tape (Figure 3.30) to facilitate posterior cleaning and protect the glaze from subsequent sanding of the fillings.

Figure 3.29 - Colour matching the acrylic putty to the porcelain fillings.

Figure 3.30 - Application of acrylic putty.

To fill a small area in the rim section, instead of applying the mentioned mixture, an unused porcelain filling was grinded until it fitted the shape and bonded, allowing for a more robust filling (Figure 3.31). Although it could have been made in conjunction with the other porcelain fillings, its small size and simple triangular shape did not justify manufacturing it through the already described methodology. Grinding was made in a way that ensured the "21" of the original "2021" inscription was maintained.

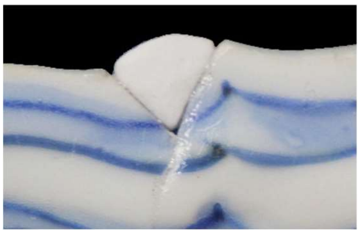

Figure 3.31 - Porcelain filling adapted to fit a small area of material loss.

Figure 3.32 shows the results upon having finished filling the front of the MSCV PP90 dish.

Figure 3.32 - Front view of the MSCV PP90 dish after filling.

3.5 Re-touching

Re-touching was not necessary for the stability of the MSCV PP90 dish. However, considering that this object is intended to go on exhibition, its restoration was debated. It's important to clarify that, at the moment, the MSCV does not have a standard approach when it comes to the re-touching of its objects. In this sense, the author reflected on the most adequate methodology for the present case-study only, and not necessarily for the collection as a whole.

Unlike the restoration of decorative objects, archaeological ceramics are generally associated with non-mimetic approaches, such as matching the fill with a "background colour" slightly lighter than the original (Bouyer, 2016). This kind of aesthetic had already been achieved without re-touching the fillings, since the used "Chinese slip" of VA did not perfectly replicate the original's colour and grinding them, when making the final adjustments, had also unintentionally resulted in a lighter tone. Nevertheless, it was considered that the solid colour of the fillings heavily contrasted with the complex iconography of the dish. It was therefore investigated whether it was possible to reintegrate the missing iconography, which would allow for a more cohesive look.

The critical ethical principle here considered is that restoration "(…) must stop at the point where conjecture begins" (Venice Charter (1964), Article 9)(Bouyer, 2016; ICATHM, 1964). Following this logic, repetitive patterns on the plate, such as the imbricated scales and diaper/trellis segments, on the front, and the *liangzhi* and peaches motives, on the back, can be predicted and therefore are suitable for reintegration. Besides this, except for one, the wide panels on the cavetto are symmetrical to the ones on the opposite side, providing enough information to reintegrate the missing parts. Finally, on the centre medallion most of the missing areas can be inferred by the available connecting areas. This meant that almost all motives could be reintegrated if so wished. The partial restoration of only the geometrical patterns or the rim and the cavetto area seems arbitrary and as such was discarded. Instead, it was decided that total reintegration of the iconography, where possible, would allow for a more unified aesthetic. All these scenarios were visualized through digital restoration in Photoshop® software (Appendix H).

According to the literature, typical materials for re-touching porcelain include tinted epoxy resins and acrylic paints (Oakley & Jain, 2002). Epoxy resins produce a hard surface that can be polished to imitate the original glaze, but will eventually yellow, making them a less than ideal medium. In contrast, the main problem of acrylic paints (or a mixture of dry-pigments and clear acrylic varnishes) is that they tend to dry to a soft plastic finish difficult to polish (Oakley & Jain, 2002). In the international survey's results (Figure 3.33), a preference for the use of acrylic paint was detected.

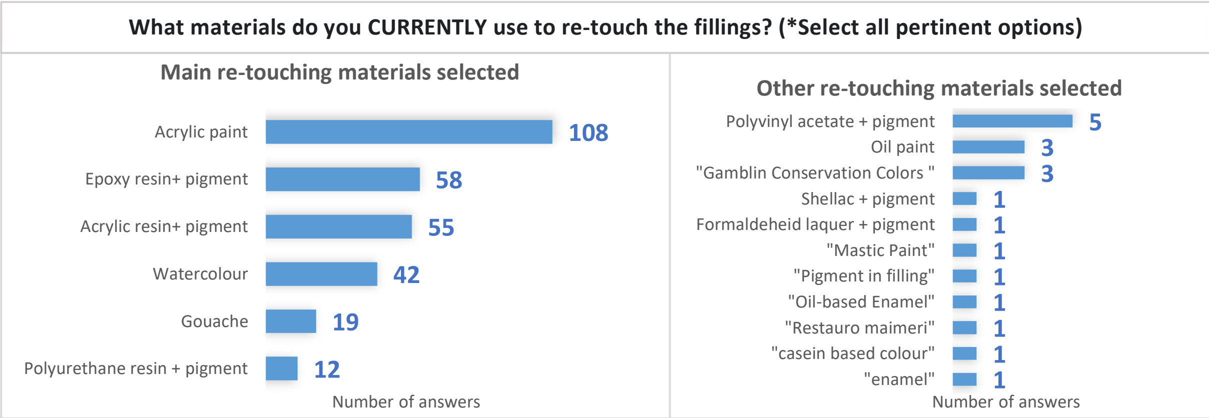

Figure 3.33 - Survey's participants answers related to the re-touching materials they use in porcelain conservation.

For the present case-study, the different texture of acrylic paints is not a negative aspect, since the detection of the porcelain fillings as later additions was always intended, to respect ethical guidelines. Their ease of use (Oakley & Jain, 2002), high stability, especially when considering acrylics classified as "Lightfastness I" (Golden Artist Colors Inc., 2017a) led to choosing to use acrylic paints for re-touching the fillings surface.

Before starting to apply the paint, an initial barrier layer was applied over the fillings surface to ensure that if, in the future, the MSCV decides on a different re-touching approach, it will be possible to remove this reintegration, without leaving traces on the porcelain fillings. For this purpose, both Paraloid® B-72 (10% in acetone and 5% in acetone and ethanol (9:1) p/v) and GOLDEN® Porcelain Restoration Glaze (with and without adding water) were tested. Paraloid® B-72 5% in acetone and ethanol and GOLDEN® Glaze diluted in water allowed for the most uniform application (Figure 3.34). However, the GOLDEN® Glaze is susceptible to being removed by water when applying acrylic washes, unlike Paraloid® B-72. In the end, Paraloid® B-72 5% in acetone and ethanol was preferred and applied as the barrier material.

Figure 3.34 - Testing of different materials for creating a barrier layer.

After the barrier dried, GOLDEN® fluid acrylics paints were applied. Firstly, a yellow wash (obtained from mixing "Naples Yellow Hue" with "Cobalt Blue") was used on the fillings to better match their background tone with the one of the dish. This step was of less importance on the front of the dish, as the iconographic motives would be more noticeable, but was particularly important for the back. To be consistent it was made on both sides. Once the base tone had dried, the motives were reintegrated. The necessary tonalities of blue were obtained by mixing "Burnt Sienna", "Cobalt Blue" and "Ultramarine Violet", which was found through experimentation. Due to the acrylics tendency to dry faster than wanted, a GOLDEN® Retarder was combined

with the paint mixture. The re-touching methodology involved applying the paint in washes, with a brush, to progressively build the tones. As already explained re-touching was purposely made in a lighter tone than the original dish.
Finally, a protective layer was applied over the re-touched surface to isolate the paint from dirt deposition and abrasion damage while simultaneously creating a more homogeneous final texture (Hartin & Baker, 2018). GOLDEN® Porcelain Restoration Glaze, a reversible water-based coating (Golden Artist Colors Inc., 2017b) was considered adequate for such task and also a material that approximated the gloss of the re-touched fillings to the dish's glaze.
Figure 3.35 and Figure 3.36 show the front and back of the MSCV PP90 after its conservation and restoration.

Figure 3.35 - Front view of the MSCV PP90 after the conservation and restoration treatment.

Figure 3.36 - Back view of the MSCV PP90 after the conservation and restoration treatment.

Conclusion

The aim of this thesis was the preservation of a fragmented Ming dynasty porcelain dish – MSCV PP90 – from the Monastery of Santa Clara-a-Velha in such a way that it would become a unified stable object that could be fully appreciated.

The decision-making process was informed by a bibliographic review and an international survey. The gathered information allowed to identify several materials currently used for bonding, filling, and re-touching porcelain objects and, to some extent, the survey allowed to detect geographical trends in the preferred methodologies. Both in the literature and survey, epoxy resins stood out as bonding and filling materials for porcelain objects. Despite this, Paraloid® B-72 was argued to be a more suitable adhesive for this case-study due to its reversibility, stability and thermoplasticity. It is this type of comparative critical discussion that enriches the present thesis.

In terms of addressing the object's inherent instability caused by significant material loss, the development of structural fillings became crucial. Although porcelain is not commonly mentioned as a conservation material in the literature and survey, it was considered a viable option to create durable detachable fillings with a similar materiality, thermal expansion/contraction, and aesthetic to the dish. This thesis focused on developing a methodology to produce porcelain fillings, in collaboration with the Vista Alegre® Factory. It involved: 3D scanning, modeling, and printing; traditional mould-making; slip casting; firing and final adjustments. Despite having succeeded in producing structural porcelain fillings for the case-study, the process was extremely time-consuming, with the need of specialized workmanship and equipment, and frequently required finishing manual adjustments. Porcelain is, therefore, unlikely to come to replace synthetic filling materials (*e.g.* bulked acrylic and epoxy resin), in a near future, due to its practical challenges, and might only be considered for very specific cases. Nevertheless, the successful results achieved may open new perspectives on incorporating the original materiality of the object in the conservation treatment and as 3D technology evolves and becomes more easily available, this methodology has room for improvement. Vista Alegre®, being a porcelain factory with a full-time conservator-restorer provides a unique environment for the further development of this methodology.

Besides the conservation treatment of the MSCV PP90 dish, this thesis also addressed its restoration since it was intended to go on exhibition. Having concluded that enough information was available to reintegrate the missing iconography, the fillings were re-touched in a lighter tone, for the object's archaeological condition to remain perceptible, highlighting the original painted decoration and not the work of the conservator. In consistence with the survey results, acrylic paints and varnishes were used as re-touching materials.

This thesis case-study presented diverse and fascinating challenges, both in terms of conservation as well as restoration. This led to a complex discussion and integrated application of ethical guidelines. A distinctive feature of the work was the successful exploration of 3D techniques, combined with traditional porcelain crafting techniques, in a multidisciplinary industrial environment. Although obtaining porcelain fillings may be complex, it involves a very stable material that respects the original object's materiality and a methodology completely reversible.
In the end the MSCV PP90 dish successfully became a stable object which can be appreciated by current and future generations.

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Appendix A

List of Materials used In Porcelain and other ceramics conservation

Table A.1 - List of Materials used In Porcelain and other ceramics conservation.

Bonding	Filling	Re-touching	Surface coating
Acrylic emulsions;	Acrylic Resin + bulking agent;	Acrylic paint;	Acrylic resin;
Acrylic resins;	Alien fragments;	Acrylic resin + pigment;	Acrylic varnish;
Animal Glues;	Animal Glue + bulking agents;	Epoxy resin + pigment;	Epoxy resin;
Cellulose nitrate;	Cellulose nitrate + bulking agent;	Formaldehyde lacquer + pigment;	Polyurethane varnish;
Cyanoacrylates;	Clay;	Gouache;	Waxes;
Epoxy resins;	Epoxy putty;	Oil paint;	
Glaze (and refiring);	Epoxy resin + bulking agent;	Polyurethane resin + pigment;	
Metal or wood dowels;	Metal mounts;	Polyvinyl acetate + pigment;	
Molten glass;	Plaster;	Shellac + pigment;	
Polyester resin;	Polyester resin + bulking agent;	Watercolour;	
Polyvinyl acetate;	Polyfilla®;		
Polyvinyl alcohol;	Poly-urea putty;		
Polyvinyl butyral;	Polyvinyl acetate putty;		
Rivets;	Replacements made in ceramic;		
Rosin;	Sawdust + resin;		
Rubber-based adhesives;	Shellac + bulking agent;		
Shellac;	Urushi;		
Silicone-based adhesives;	Wood replacements;		
Solder;	Wood;		
Urushi;			

Appendix B

STRUCTURE OF THE INTERNATIONAL SURVEY

Conservation Principles

1. During treatment of MUSEUM porcelain objects what conservation principles would be generally followed ? (*Select all pertinent options)

Tick all that apply.

- [ ] Minimal Intervention
- [ ] Reversibility
- [ ] Retreatability
- [ ] Discernible Restoration
- [ ] Use of contemporary techniques and materials
- [ ] Use of traditional crafting techniques
- [ ] Respect the patina of time

Other: [ ] ____________________

Methodologies and Materials

Fragment Bonding

2. Have you ever bonded porcelain fragments?

Mark only one oval.

( ) Yes *Skip to question 3*

( ) No *Skip to question 6*

3. What materials do you CURRENTLY use for fragment bonding? (*Select all pertinent options)

Tick all that apply.

- [ ] Acrylic Emulsions
- [ ] Acrylic Resins
- [ ] Animal Glues
- [ ] Cellulose Nitrate
- [ ] Cyanoacrylates
- [ ] Epoxy Resin
- [ ] Glaze and refiring
- [ ] Metal and/or wood dowels

- [ ] Molten Glass
- [ ] Polyester Resins
- [ ] Polyvinyl Acetate
- [ ] Polyvinyl Alcohol
- [ ] Polyvinyl Butyral
- [ ] Rivets
- [ ] Rosin
- [ ] Rubber-based Adhesives
- [ ] Shellac
- [ ] Silicone-based Adhesives
- [ ] Solder
- [ ] Urushi (lacquer from the resin the Asian tree Rhus vernieifera)

Other: [ ] ______________________

4. Would you use the same methodology and materials for a porcelain of European origin and a porcelain of Asian origin?

Mark only one oval.

( ) Yes *Skip to question 6*

( ) No

5. Additional Information: What would be the main differences?

____

____

Filling

6. Have you ever made fillings for a porcelain object?

Mark only one oval.

( ) Yes

( ) No *Skip to question 22*

7. What materials do you CURRENTLY use for Fillings? (*Select all pertinent options)

Tick all that apply.

- [ ] Acrylic Resin + bulking agent
- [ ] Alien Fragments (fragments from other objects)
- [ ] Animal Glue + bulking agents
- [ ] Cellulose Nitrate + bulking agents
- [ ] Clay
- [ ] Epoxy Putty
- [ ] Epoxy Resin + bulking agent
- [ ] Metal Mounts
- [ ] Plaster
- [ ] Polyester resin + bulking agent
- [ ] Polyfilla® (celullose strenghted binder)
- [ ] Poly-urea Putty
- [ ] Urushi
- [ ] Polyvinyl Acetate Puties
- [ ] Replacements made in ceramic
- [ ] Sawdust + resin
- [ ] Shellac + bulking agents
- [ ] Urushi (lacquer from the resin the Asian tree Rhus vernieifera)
- [ ] Wood replacement

Other: [ ] ______________________

8. Would you use the same methodology and materials for a porcelain of European origin and a porcelain of Asian origin?

Mark only one oval.

- Yes *Skip to question 10*
- No

9. Additional Information: What would be the main differences?

10. Have you ever used porcelain to create a filling?

Mark only one oval.

- Yes
- No *Skip to question 12*

11. Describre the used process for making fillings with porcelain.

Re-touching

12. Have you ever re-touched fillings in porcelain objects?

Mark only one oval.

- Yes
- No *Skip to question 18*

13. What materials do you CURRENTLY use to re-touch the fillings? (*Select all pertinent options)

Tick all that apply.

- [ ] Acrylic Paint
- [ ] Acrylic resin + pigment
- [ ] Epoxy resin + pigment
- [ ] Formaldehyde lacquer + pigment
- [ ] Gouache
- [ ] Oil paint
- [ ] Polyurethane resin + pigment
- [ ] Polyvinyl Acetate + pigment
- [ ] Shellac + pigment
- [ ] Watercolour

Other: [ ] ______________________

14. Would you use the same methodology and materials for a porcelain of European origin and a porcelain of Asian origin?

Mark only one oval.

- Yes *Skip to question 16*
- No

15. Additional Information: What would be the main differences?

16. Consider the following scenario: A porcelain object, of archaeological provenance, has a large fill but that area's iconography is unknown. Knowing it's going to be exhibited, how would you re-touch it?

Mark only one oval.

- ◯ I wouldn't re-touch it
- ◯ I would paint only a similar background colour
- ◯ I would attempt to recreate the missing representation by analyising similar objects
- ◯ Other: ____________

17. Please justify your answer.

____

____

Surface Finishing

18. Have you ever finished the surface of fillings in porcelain objects?

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to question 22*

19. What materials do you CURRENTLY use to finish the surface? (*Select all pertinent options)

Tick all that apply.

- ☐ Acrylic Varnishes (Gloss or Matte)
- ☐ Acrylic Resin
- ☐ Epoxy resin
- ☐ Fine Sanding Paper (to burnish)
- ☐ Solvol Autosol (to burnish)
- ☐ Waxes
- Other: ☐ ____________

20. Would you use the same methodology and materials for a porcelain of European origin and a porcelain of Asian origin?

Mark only one oval.

- ◯ Yes *Skip to question 22*
- ◯ No

21. Additional Information: What would be the main differences?

____

____

THANK YOU FOR YOUR TIME!

Before submitting please answear the following questions. This information might reveal important to identify regional tendencies in conservation and restoration of porcelain objects.

22. Please identify your gender.

23. Where did you underwent training on conservation and restoration? (country and/or institution name) *

24. How long was your training/education in conservation-restoration?

Mark only one oval.

- ≤3 Years
- 3-5 Years
- >5-8 Years
- >8 Years
- Other:

25. How long have you been practicing conservation-restoration

Mark only one oval.

- ≤5 years
- 5-10 years
- 11-15 years
- 16-20 years
- > 20 years
- >50 years

26. In what country do you CURRENTLY work? (IMPORTANT: if you are still studying please write "I am a student") *

27. Finally, If you accept to be further contacted for follow up questions leave here your email.

Appendix C

LIST OF THE FOLLOW-UP QUESTIONS

Table C.1 - List of the follow-up questions

Follow-up Questions	**Answered/ Questioned**
You selected "**Retreatability**" as a conservation principle you tend to follow. Do you consider this term more appropriate than "reversibility"? If yes why?	**2/7**
You have selected "**Use of traditional crafting techniques**" as a conservation principle you tend to follow. What are some of the traditional crafting techniques you use?	**0/1**
You selected "**reversibility**" as a conservation principle that you tend to follow while simultaneously selecting "**epoxy resins**" as a bonding materials. As these adhesives are extremely hard to remove how do you balance their use with the need for reversibility? (Question also formulated to include "**polyester resins**", besides or alternatively to epoxy resins)	**16/55**
You selected "**Cyanoacrylates**" as a bonding material you use for porcelain objects. Do you use this material as a permanent adhesive or as a temporary solution to keep the fragments in place while you introduce another permanent adhesive?	**4/10**
You have selected "**Cellulose nitrate**" as a bonding material. According to aging studies this material yellows and deteriorates with time. What do you feel are the advantageous characteristics of the material (ex: gloss, cost, Tg, hardness, aging etc…) that justify such choice?	**0/3**
You selected "**urushi**" as a bonding materials. Where did you learn this traditionally Asian conservation technique and in what cases do you consider this irreversible material an appropriate solution?	**0/3**
You have selected "p**olyvinyl butyral**" as a bonding material for porcelain. Compared with acrylic resins what do you feel are the advantageous characteristics of your chosen adhesive (ex: gloss, cost, Tg, hardness, aging etc…)?	**0/2**
You have selected "**animal glues**" as a bonding material. What type of animal glue do you use (ex: s gelatin, parchment size, hide glue, bone glue, fish glue etc…)?	**0/2**
In what circumstances do you prefer **glazing and refiring** broken objects as a mechanism for bonding them?	**0/1**
In what circumstances do you prefer the use of **molten glass** to bond porcelain objects and what type of glass do you use?	**0/1**
You have selected "r**osin**" as one of the bonding materials you use. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel this substance brings in terms of porcelain bonding?	**0/1**
You have selected "r**ubber-based adhesives**" as the bonding material you use for porcelain objects. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel rubber-based adhesives bring in terms of porcelain conservation?	**0/1**

When creating fillings with **"epoxy putty**" or "**epoxy resin + bulking agent**" do you make detachable fillings (bonded to the object with a reversible adhesive) or do you apply the material directly onto the surface of the object? (Question also formulated to include “**polyester resins + bulking agents**", besides or alternatively to epoxy)	**15/63**
When using "**ceramic replacements**" as fillings do you ensure they can be easily discernible from the original? If yes how?	**2/6**
You mentioned "**3D printing of missing part**s" to create fillings in porcelain. Did you print directly with ceramic powder or did you make a mould to then press porcelain slabs or slips onto?	**0/1**
You have selected "**clay**" as one of the filling materials you use. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel clay brings in terms of porcelain conservation?	**1/3**
You selected "**wood replacements**" as a type of fillings you use for porcelain objects. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel wood brings in terms of porcelain conservation?	**0/1**
You selected "**sawdust + resin**" as a type of fillings you use for porcelain objects. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel sawdust brings in terms of porcelain conservation and what resin do you usually combine it with?	**0/1**
You have selected “**Cellulose nitrate + bulking agent**” as a filling material. According to aging studies cellulose nitrate yellows and deteriorates with time. What do you feel are the advantageous characteristics of the material (ex: gloss, cost, Tg, hardness, aging etc…) that justify its use in porcelain conservation?	**1/1**
You have written "**Chalk putty** (2 parts champagne chalk, 1 part kaolin and 3% Methocel A4C (methylcellulose) in deionised water)" as a material you use for filling porcelain objects. What do you feel are the advantageous characteristics of chalk putty in terms of porcelain conservation (ex: gloss, cost, Tg, hardness, aging etc…)?	**1/1**
You have selected “**polyurethane + pigment**” and/or “**polyurethane varnish**” as a retouching and finishing materials, respectively. According to aging studies this material yellows and deteriorates with time. What do you feel are the advantageous characteristics of the material (ex: gloss, cost, Tg, hardness, aging etc…) that justify such choice?	**2/9**
You have selected "**shellac + pigment**" as a retouching material you use. According to aging studies shellac tens to yellow and deteriorates with time. What do you feel are the advantageous characteristics of shellac as a medium (ex: gloss, cost, Tg, hardness, aging etc…) that justify such choice?	**0/1**
You have selected "**Formaldehyde lacquer + pigment**" as one of the coating materials you use to retouch porcelain. What do you consider advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) of using formaldehyde lacquer as a medium?	**0/1**
As an example of a retouching material you have written "**Oil-based Enamel**". Could you provide us with the commercial name of the enamel(s) you use?	**0/1**
You have written "**casein based colours**" as your chosen material for retouching porcelain objects. Compared with acrylic paints or gouache what do you feel are the advantageous characteristics of casein based colours (ex: gloss, cost, Tg, hardness, aging etc…)?	**0/1**
You have selected "**waxes**" as one of the coating materials you use to finish the surface of fillings. What are the advantageous characteristics (ex: gloss, cost, Tg, hardness, aging etc…) you feel waxes brings in terms of porcelain conservation?	**2/11**
You have written that "Fillings of Asian porcelain are usually finished with **waxes**". Why do you think that is?	**0/1**

Appendix D

PRESENTATION AND ANALYSIS OF THE SURVEY'S RESULTS

Introduction

As mentioned in - "1.2 An International Survey - Current Practices in Porcelain Conservation" - a questionnaire was developed to understand what methodologies conservators currently use for porcelain objects (Appendix B), based on a list of materials and techniques compiled from a bibliographic review (Appendix A). The survey was divided into five main topics - conservation principles; fragment bonding, filling, re-touching and finishing. The first topic was thought-out as a way to ascertain whether the answers from the remaining topics were coherent with the chosen ethical guidelines and, if not, what principles are compromised in real life interventions. The other four topics were chosen for being the most common conservation steps directly related with the treatment of the MSCV PP90 dish. Methodologies for the removal of old restorations were not approached as they are extremely dependent on what was used previously and the condition of the object, while cleaning was not incorporated due to it being frequently straightforward for porcelain objects.

Answers were collected from January until October of 2021, reaching a total of 139 conservators that work in 39 different countries[8], most of which European. The author does not consider this a representative sample of the existing international conservators experienced in porcelain conservation. However, determining how many answers, per country, were needed to reach representativity was considered an impossible task, as many conservators are unregistered in their local associations, if these even exist. Choosing English as the survey's language and creating it in Google Forms[9] might have also impacted the answers distribution. These limitations do not diminish the importance of the survey as a first approach.

Upon gathering and analysing all answers, a more personalized approach was made through open follow-up questions, reaching out to 86 participants via E-mail. This line of questioning was only capable of obtaining more information from 20 conservators.

[8] Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Croatia, Czech Republic, Denmark, Egypt, France, Germany, Greece, Hungary, Iran, Iraq, Israel, Italy, Japan, Latvia, Lithuania, Mexico, New Zealand, Norway, Poland, Portugal, Republic of South Africa, Russia, Slovenia, Spain, Sweden, Switzerland, Taiwan, The Netherlands, Turkey, United Kingdom, United States of America, Vietnam.

[9] As it was thought that the Google Forms format could limit answers from China, museum and conservators were directly contacted via Yahoo e-mail to directly provide them with the written questions.

Sample characterization

Conservators could come across the survey in professional conservation platforms (Global Conservation Forum, ICOM-CC Glass and Ceramics, Fórum de Conservadores-restauradores and Instituto de Conservação e Restauro Pachamama) or be directly contacted via e-mail. These last ones were found in conservation associations directories[10], museums' websites[11], universities[12] and private ateliers. The direct contact complemented the previously mentioned one, allowing to purposely force the sample in countries where few answers were indirectly obtained and also force the sample in countries of interest for having a strong connection with ceramic conservation and/or porcelain objects (such as Belgium, China, Germany, Japan, The Netherlands and The United Kingdom). Geographical distribution of the participants changes slightly when comparing the country in which they currently work with their place of learning (Figure D.1). The most significate change occurs in the number of conservators that have studied in The United Kingdom (27) and Italy (13) versus those who now work in those countries (15 and 7, respectively).

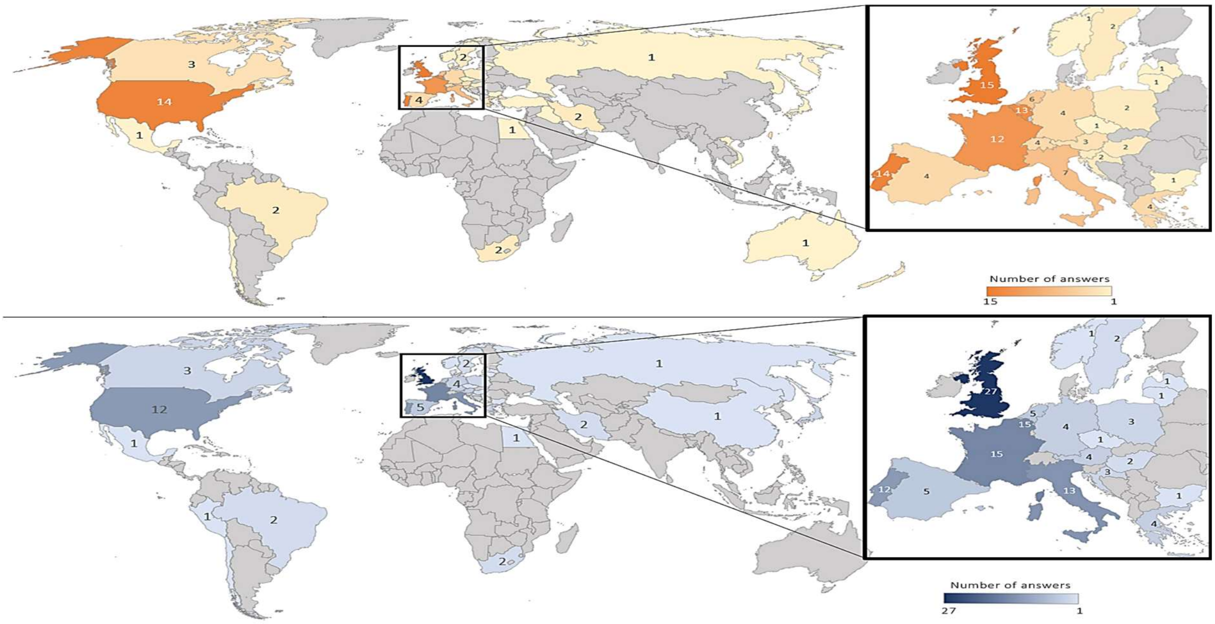

Figure D.1 - Participants' country of work (above) their place of learning (below).

Respondents were not required to have a specific educational background, however the survey's terminology required them to have a general understanding of ethical principles in conservation and materials chemical compositions. In July 2021, upon making a preliminary analysis of the responses,

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[10] *E.g.* Association Suisse de Conservation et Restauration SCR; American Institute for Conservation; Restauratoren Nederland; Nordisk Konservator Forbund Danmark; Romoe Conservators Network; Fédération Française des Professionnels de la Conservation-Restauration; Australian Institute for the Conservation of Cultural Material; Asociación Profesional de Conservadores Restauradores de España; Associação Profissional de Conservadores-restauradores de Portugal.

[11] *E.g*. Real Ontario Museum, Laboratory for Metals and Ceramics of the Vatican Museums, Harvard University Art Museums; Museum of Fine Arts, Boston; Swiss National Museum; Basel Historical Museum; Israel Museum, Penn Museum, The Regional Museum of History - Veliko Tarnovo; Muzeum Narodowe w Warszawie; The Staatliche Kunstsammlungen Dresden.

[12] *E.g.* University of Antwerp, Okinawa Institute of Science and Technology Graduate University, Art University of Isfahan, Fayoum University, Haute Ecole Arc, The Eugeniusz Geppert Academy of Art and Design; Università di Bologna.

it was thought beneficial to this research to obtain more information about the conservators' path, which led to adding two questions to the survey ("How long was your training/education in conservation-restoration?" and "How long have you been practicing conservation-restoration?"). As they were a later addition, most conservators did not provide us with such information, as seen in Figure D.2, although in some instances online curriculums were used to complement the data.

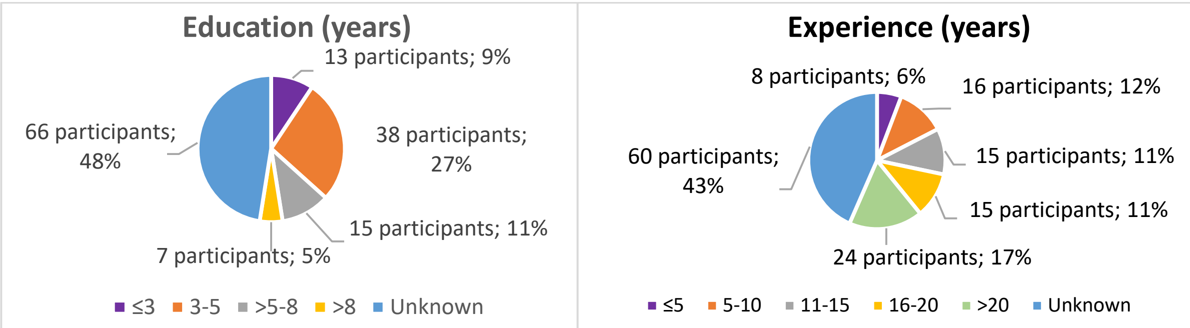

Figure D.2 - Participant's background information in terms of their education duration (left) and experience in conservation (right).

Results and discussion

This analysis will follow the survey's division into five topics, although they will be cross-referenced throughout.

To identify geographical tendencies, the discussion mostly considers the current country of work of the participants, as it would be significantly harder and subjective to connect certain practices with a "school" (particularly in cases where conservators have worked and learned in multiple contexts). Besides a global comparison, the tendencies in seven countries are discussed more in-depth as they had the highest participation rate of all – The United Kingdom (15 answers), The United States of America (14 answers), Portugal (14 answers), Belgium (13 answers), France (12 answers), Italy (7 answers), The Netherlands (6 answers)[13]. The last two countries, although below 10 submissions, were included in the list due to Italy having been a historical starting point for today's conservation, and The Netherlands for having a strong connection with porcelain objects. Germany, although also related to an incredible tradition of porcelain making, was not included in this more specific discussion, as it was only represented by four answers, which would create a precedent for other countries with fewer submissions to be incorporated, thus dispersing the analysis.

For closed-answer questions, a space was left for participants to submit options that were not considered. These contributions are differentiated in the graphics by using quotation marks.

Questions 4,8,14 and 20 of the survey (Appendix B) will not be analysed since they were unproperly formulated and remained too vague, as the answers suggested.

[13] These countries will be identified through their ISO 3166 international standard Alpha-3 codes.

- **Conservation Principles**

The Athens Charter (1931) was the first international document (although composed mostly by European countries) to set out principles for preservation and restoration (Kwanda, 2009). Since then, other documents, like The Venice Charter (1964), The Murray Pease Report (1964), The AIC Code of Ethics and Guidelines for Practice" (1994) and E.C.C.O. Professional Guidelines (II): Code of Ethics (2003), have established important principles for conservators to consider in their decision-making process. However, as any conservator will be able to concur, an equilibrium between theoretical guidelines, the values of the patrimony in question and its stakeholder's[14] wishes, frequently, requires a compromise. To analyse this, participants were asked to select conservation principles they tend to follow when treating museum's porcelain objects (
Figure D.3 and Figure D.4) as private practice have more "blurred lines". The goal of this section was not to individually analyse the selected conservation principles but have them in regard when discussing the materials and methodologies mentioned in the next sections.

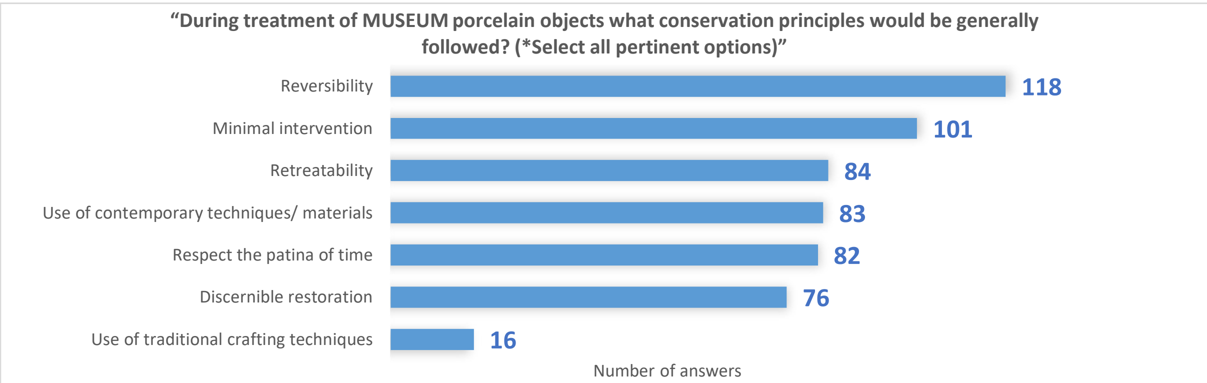

Figure D.3 - Conservation principles selected by the participants.

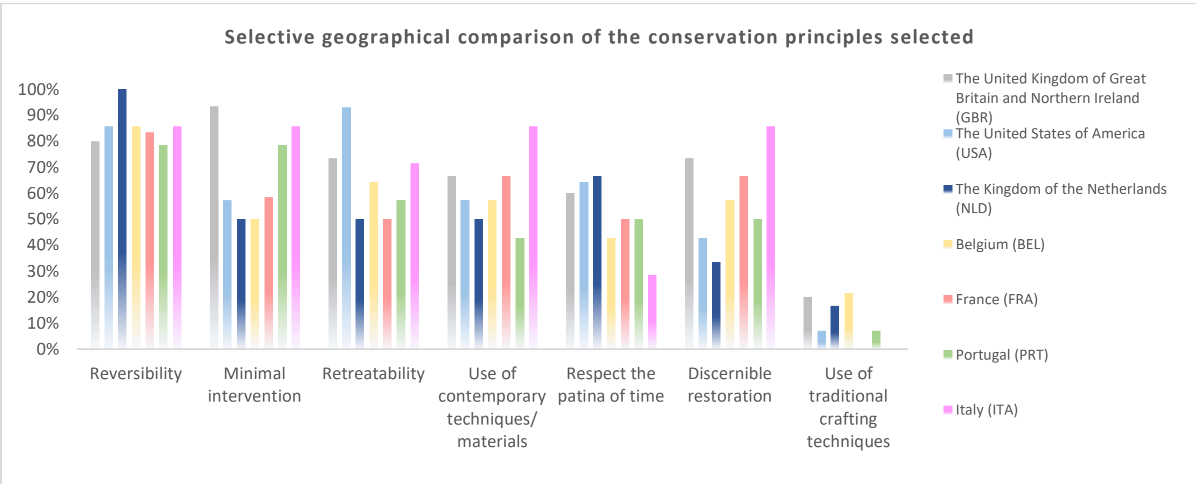

Figure D.4 - Geographical comparison of the selected conservation principles.

[14] Stakeholders: "(...)professionals, academics, and community members who value the object or place" (citation from "Values and Heritage Conservation" (2000)).

Reversibility (118 answers) and minimal intervention (101 answers) were, globally, the most selected principles while the use of traditional crafting techniques was the least selected (16 answers) (
Figure D.3). Comparing the use of traditional crafting techniques with the use of contemporary techniques (83 answers), current conservators seem to considerably value more modern-day methodologies.

It's noteworthy to reflect that, even though, according to Casanova (2011) several authors have questioned the term reversibility and have replaced it with retreatability, this survey's results demonstrates that reversibility is still most often preferred by conservators. In the selective geographical comparison[15] (Figure D.4) this tendency is only inverted in conservators working in the USA. To further this discussion, conservators that selected retreatability instead of reversibility were questioned why they considered this a more appropriate term. The following answers exemplify the justifications given: "(…) we use many different materials and methods in ceramic conservation that cannot be totally reversible but the whole method should make the future treats possible … is also obvious that the process of object cleaning is not reversible (…)" and "Sometimes, reversibility may cause damage or impact on the integrity of the ceramic so retreatability would be desirable.". These are indeed strong arguments in favour of the term retreatability.

Discernible restoration, a principle already defended by Camillo Boito (1835-1914) and built on by Cesare Brandi (1906-1988) in his "Teoria del Restauro" (1996), was unexpectedly chosen by less than half of the conservators working in the USA and the NLD, especially considering that the question was related to museum objects. However it is interesting to note that this principle seems to remain an important idea in ITA, the country where it was born.

- **Bonding**

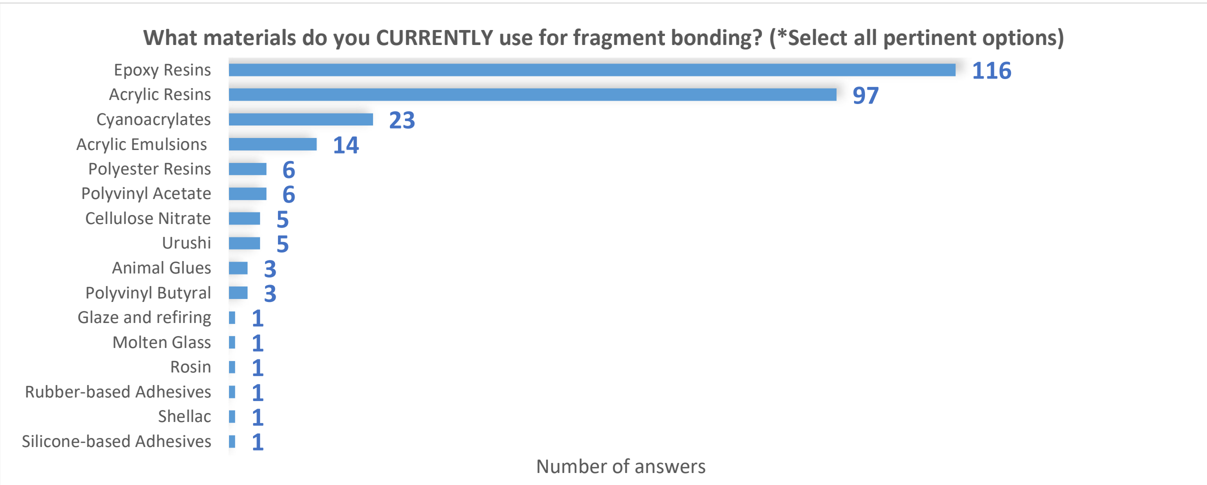

Figure D.5 - Bonding materials selected by the participants.

[15] In order to compare geographical trends from countries with a different number of submissions, each country's answers were converted into a percentage that takes into account the total amount of participants from said country (*E.g* 12, out of 14 USA participants, selected "reversibility", which is equivalent to (12/14)*100 = 86%; while 12, out of 15 GBR participants, is equivalent to 80%).

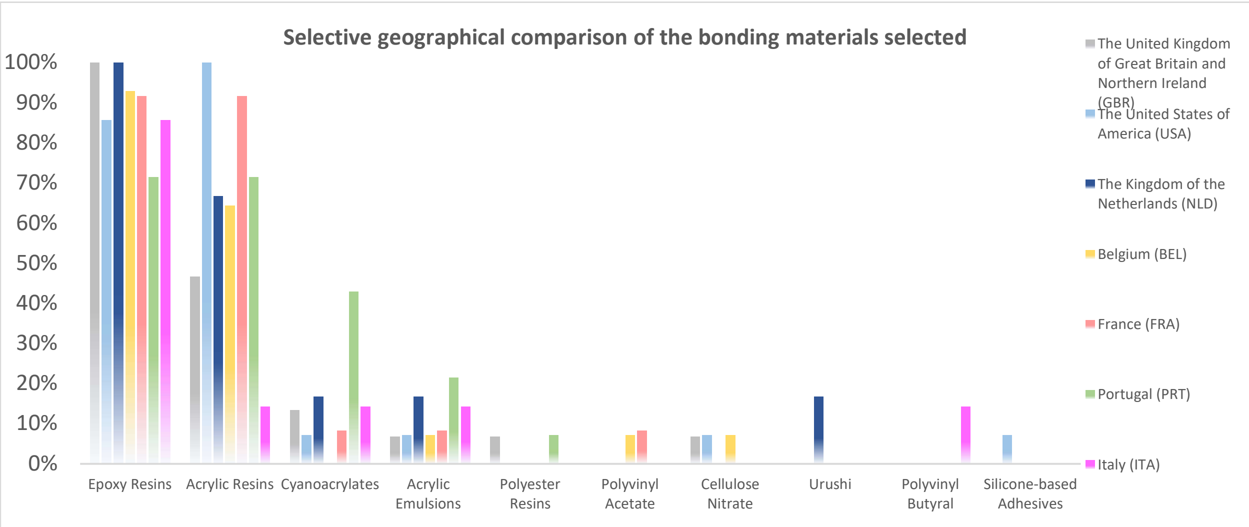

Figure D.6 - Geographical comparison of the selected bonding materials.

As expected, and in accordance with the literature (Bidarra et al., 2015; Ćurković, 2014; Hawkins, 2020; Hyoyun, 2014; S. P. Koob, 1997; Moncrieff, 1975; Oakley & Jain, 2002; Tennent, 2014), epoxy (116 answers) and acrylic (97 answers) resins are currently the favoured adhesives to bond porcelain objects (Figure D.5). Between the two, conservators working in the GBR and ITA show a clear preference for epoxy resins (Figure D.6). Interestingly, a participant from BEL notes that "Porcelain and glass, for those materials we use an epoxy resin = we learned that in our training (…)". This predefined notion is also frequently seen in the literature.

Initially, the fact that epoxy resins were, internationally, the most selected bonding material and that reversibility was also the most chosen conservation principle seemed inconsistent, as epoxy resins are insoluble and can be hard to remove (Coutinho, 2008; Horie, 2010). This led to a follow-up question of how conservators balanced the need for reversibility with the use of epoxies. Several respondents noted that "Epoxy resins are hard to remove but not impossible" and that "Most of times it is reversible just with some heat otherwise with suitable solvents", which was indeed what was experienced in this thesis, while disassembling the MSCV PP90 dish. A complementary methodology that five follow-up answers mentioned (out of 16) is the application of a barrier layer of Paraloid® B-72 (an acrylic resin) before bonding the fragments with epoxies. This technique has been evaluated by Podany (2001) in marble and by Schuck (2019) in glass, being considered to provide a significant degree of reversibility to either epoxy or polyester structural adhesives, and is considered to provide a significant degree of reversibility to either epoxy or polyester structural adhesives.

Of the less predominantly selected materials for bonding, cyanoacrylates stand out (23 answers). Little is known of their aging characteristics (Horie, 2010) therefore it's use in conservation should be carefully thought out. The survey's structure did not allow to determine if the participants use cyanoacrylates as a temporary solution to achieve instant tack, followed by the application of another adhesive, or as a permanent bonding material. This aspect was therefore asked in a follow-up question. Two of four follow-up respondents have used it as a permanent adhesive.

Another material of questionable durability that was surprisingly found in the answers of the survey is cellulose nitrate. This was one of the first synthetic polymers to be widely used and creates weak, rather brittle joints (Horie, 2010). It is considered, by Koob (1982), as a unstable compound and no longer the best choice, compared with other available adhesives. This material was also detected in the filling section of the survey, combined with bulking agents, as will be discussed later on. Conservators that had selected cellulose nitrate were asked what characteristics they considered advantageous in its use as an adhesive, however no answers were obtained.

The current use of animal glues for porcelain conservation was also unexpected. Follow-up answers to what type of glues are used and why have not yet been obtained.

In terms of a geographical standpoint, the detection of the urushi technique (which has a long history in Japanese restoration) in the NLD, Austria, Australia, and Germany, is proof of international transmission of restoration techniques. The transmission of this technique was also identified in the filling section of the survey, being detected in Russia and Germany. To better determine why and where conservators had learned this technique a follow-up question was made, but no answers have been obtained till now.

Finally, it was interesting to notice that molten glass and glassy fluxes (glazing and refiring), although vestigial, are still used in the world to conserve porcelain. These methods were considered by Koob (1998) as obsolete.

- **Filling**

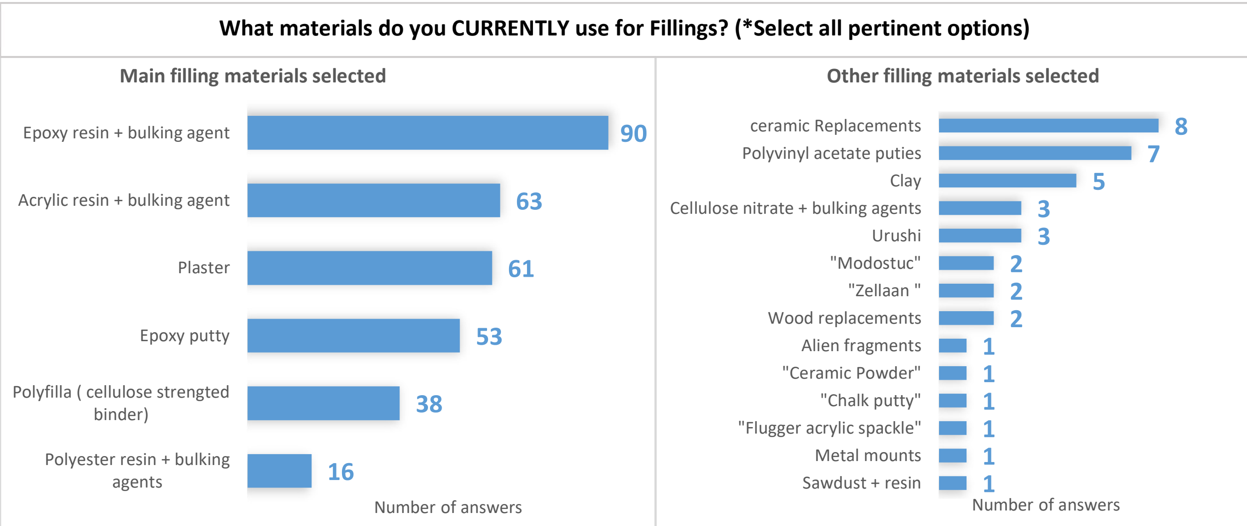

Figure D.7 - Filling materials selected by the participants.

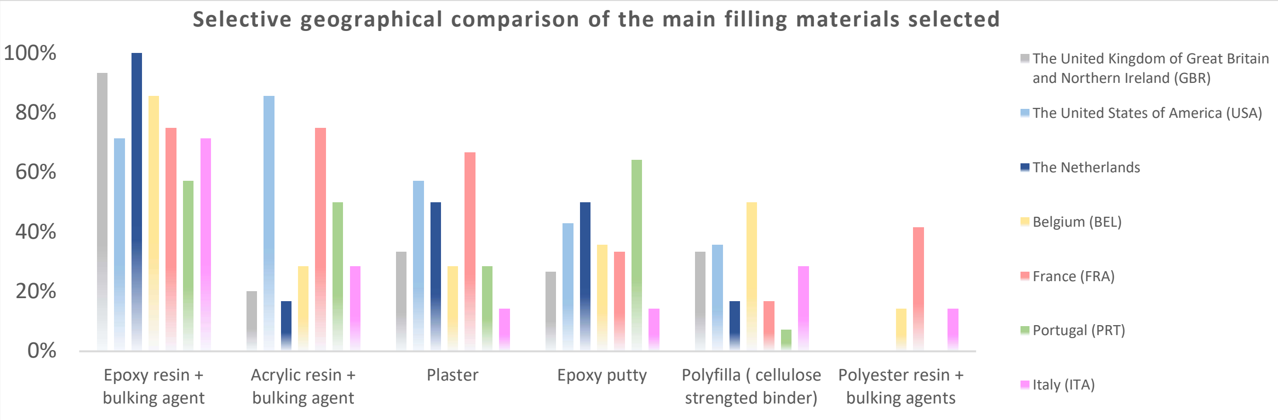

Figure D.8 - Geographical comparison of the selected filling materials.

"Epoxy resins + bulking agents"[16] (90 answers) stand out as a preferred material for filling porcelain objects (Figure D.7) which is in accordance with the literature, followed by "Acrylic resins + bulking agents" (63 answers), plaster (61 answers) and epoxy putties (53 answers). This preference for epoxy materials, just like in terms of bonding, is once again seen in conservators that work in the GBR and IT, but also in the NLD and BEL (Figure D.8). On the contrary, in the USA the tendency seems to switch in favour of acrylic resins. Epoxy resins are frequently used due to their ability to closely match the vitrified aspect of porcelain objects, allowing for an almost invisible approach. Considering that almost all conservators working in ITA had selected discernible restoration as an important principle when treating museum objects (Figure D.4), their preference for epoxy resins was unexpected. This can however be explained if their working experience involves predominantly the private client.

For "epoxy resins + bulking agents" and epoxy putties the survey's general question did not allow to understand if conservators applied the materials directly onto the surface or if they made detachable fillings, later bonded with a reversible adhesive. In order to fill in this gap of knowledge, a follow-up question was made to participants who had chosen such materials. Several answers mentioned they did both methodologies, depending on the case, so no conclusion was taken from here.

Plaster (calcium sulphate hemihydrate) is a material that has been used in conservation for many years, due to its availability, low cost and ease to use (Oakley & Jain, 2002), and clearly continues to be pertinent for filling till this date. Its shortcoming, in terms of salt contamination of ceramics, might be less significant in porcelain conservation, as porcelain has a very low porosity that limits this effect. Although vestigial, the selection of wood as a possible material for fillings in porcelain conservation was unexpected, as wood, unlike porcelain, is highly affected by humidity, which can cause new tensions. Also surprising was finding that alien fragments were used by one participant as fillings. This is an ancient practice that according to Koob (1998) dates back, at least, to the 6th century B.C..

[16] Although "epoxy resins + bulking agents" could be considered an epoxy putties this terminology was used to differentiate it from ready-available putties (e.g Milliput).

As previously mentioned, cellulose nitrate, was detected in both bonding and filling. In terms of its advantageous use as filling, a respondent answered its "main advantage is a low viscosity, which allows for precise and accurate filling, as well as the following cleaning which is much easier". To counteract the known instability of the material the conservator keeps strict storage conditions for the treated objects.

Considering this thesis theme, the use of ceramic materials for fillings was of particular interest for the author, in particular the use of porcelain. Seven conservators answered they had used porcelain for fillings (Figure D.9), out of which three described their method as involving 3D printing technology, two incorporated traditional methods of porcelain manufacture; one mentioned the use for porcelain only for elements separated to the object (e.g. lids); and, finally, one mentioned the use of grounded porcelain mixed with epoxy resin.

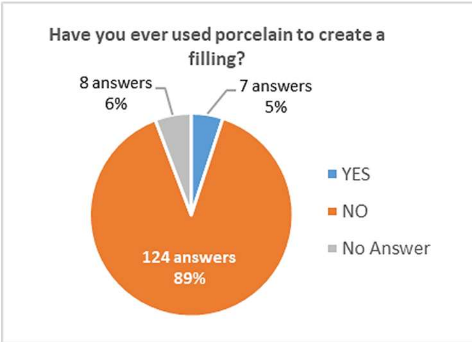

Figure D.9 - Participants' answers to if they have used porcelain for fillings.

As ceramic replacements can often be difficult to discern from the original object, due to their similar materiality (depending on the chosen clay), participants that had selected "ceramic replacements" (8 answers) were asked in the follow-up if they ensured such fillings could be discernible, as was demonstrated in this thesis conservation treatment. While one of the two replies, currently submitted, answered affirmatively in terms of the ceramic replacements being discernible, the other stated that "Generally not, most of my work calls for 'invisible' repairs as these are mostly not museum objects", demonstrating, once again, that discernible restoration, although considered for museum's objects, is frequently compromised in treating private clients' porcelains.

- **Re-touching**

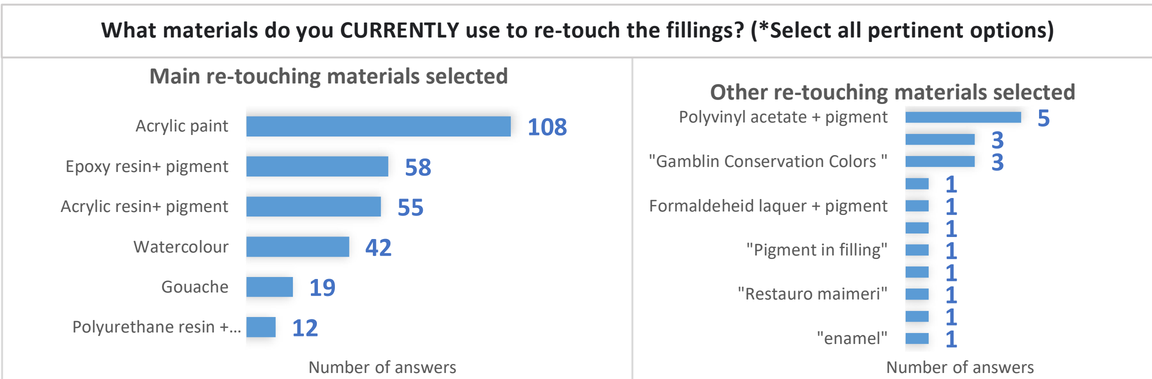

Figure D.10 -Re-touching materials selected by the participants.

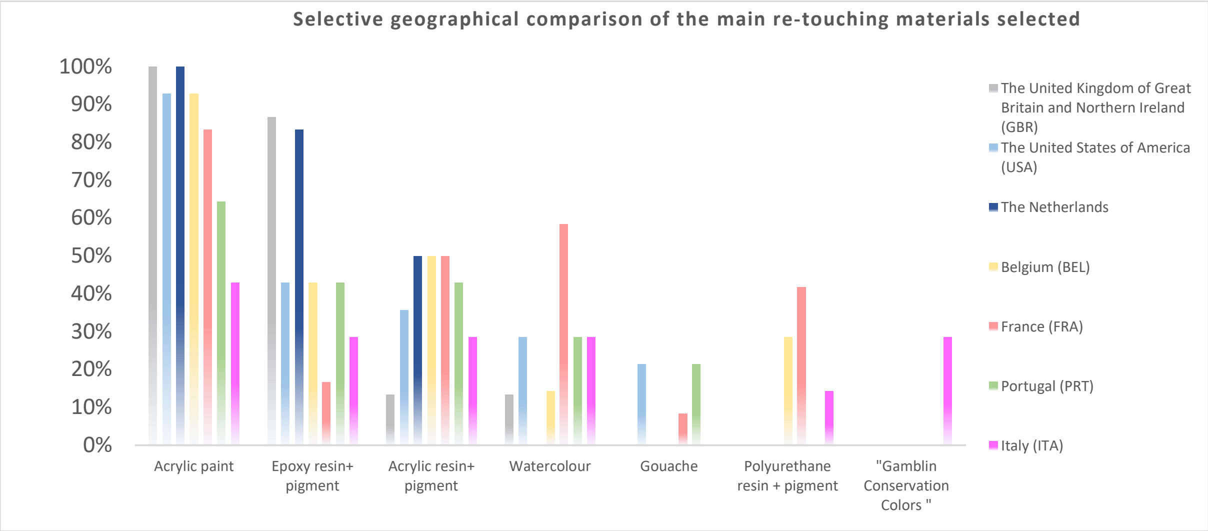

Figure D.11 - Geographical comparison of the selected re-touching materials.

Unlike bonding and filling of porcelain, where epoxy materials were predominant, acrylic paints (108 answers) seem to be preferred for re-touching (Figure D.10), despite Oakley (2002) mentioning that "on fine porcelain the results may be disappointing" and Hyoyun (2014) discussing "the colour of celadon and white porcelain are difficult to express" with acrylic paint. In terms of the selective geographical comparison (Figure D.11), the preference for acrylic paints is observed in all countries, however the use of epoxy resins (in this case as a medium), remains quite relevant in the GBR and the NLD.
The identification of polyurethane resin as a medium, mostly in FRA (5 answers) and BEL (4 answers), was extremely unexpected as they are known to have a poor resistance to ageing (Oakley & Jain, 2002). One conservator mentioned polyurethane's ability to create a "(…) perfect smooth surface … shiny and hard (…)". Through a follow-up question another noted that objects conserved 40 years ago with this material remain in a good condition.
Different approaches to re-touching are available to the conservator, from painting a background colour to blocking out certain areas of colour, pointillism or even mimetic restoration. To better understand which restoration methodologies conservators consider for porcelain objects, and in order to further bridge this section of the survey with the thesis case-study, a hypothetical scenario was presented to the conservators ("A porcelain object, of archaeological provenance, has a large fill but that area's iconography is unknown. Knowing it's going to be exhibited, how would you re-touch it?"). Ultimately, this question was formulated inappropriately and remained too vague, as several conservators noted, therefore its answers won't be here analysed. Nevertheless the difference between treating an object for a private client and for a museum exhibition was once again commented on. Future studies that intend to develop this topic might be benefited from presenting a more concrete case-study (with an image, specification on the clients wishes, and the object's context), but nevertheless this is an extremely subjective topic that is hard to approach.

- **Surface Finishing**

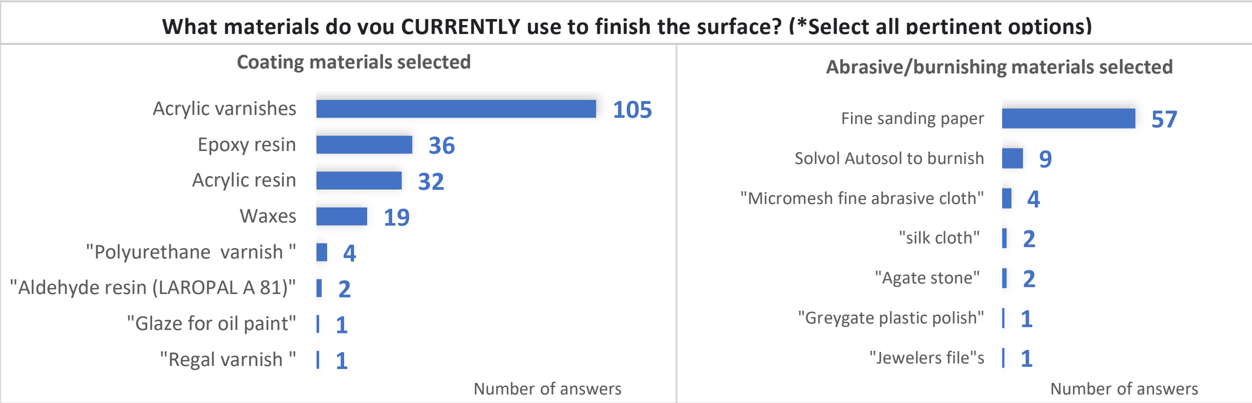

Figure D.12 - Coating and abrasive/burnishing materials selected by participants.

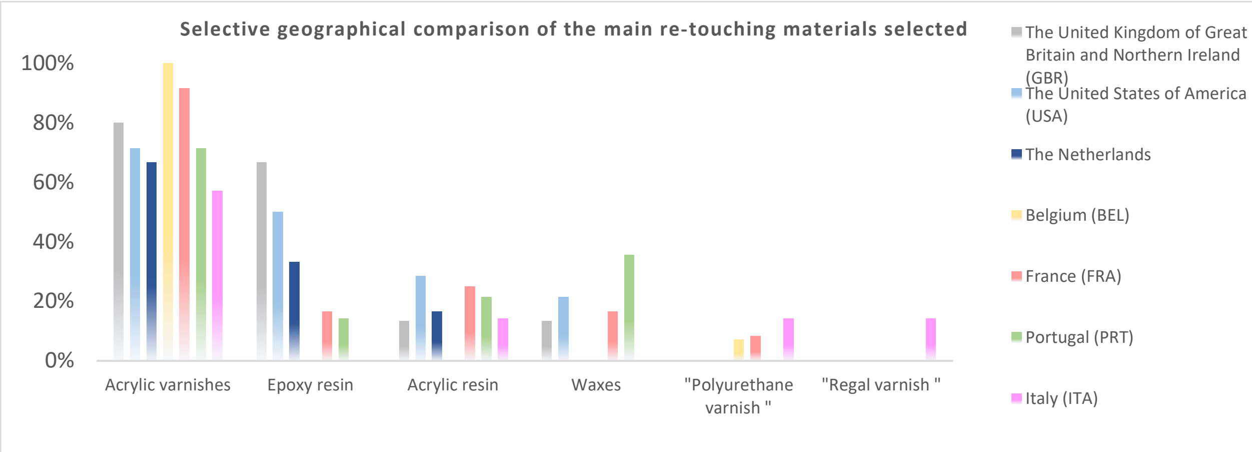

Figure D.13 - Geographical comparison of the coating and abrasive/burnishing materials selected.

Just like what was previously seen in the re-touching section, acrylic materials, more specifically acrylic varnishes (105 answers), are more predominantly used by conservators as a surface coating (Figure D.12). Acrylic varnishes are water-based and easy to use, and can provide different finishes (gloss, matt and satin) (Oakley & Jain, 2002).

When compared with other countries, conservators in the GBR are the ones that most select epoxy resins as a coating material, while its presence was not registered in BEL and ITA (Figure D.13). This relatively higher selection of epoxy resins in the GBR was seen in all previous sections, only being over-taken in the filling section by conservators working in the NDL.

For the author, an unexpected coating material that was detected, with a higher incidence in Portugal, was wax, since it usually does not allow for a hard surface that resembles the porcelain glaze. Conser-vators were therefore asked, in a follow-up question what they considered advantageous in the use of this material for finishing the fills. Two responses were obtaining mentioning its “Gloss, easy to gain a homogenous surface with polishing. Easy to apply compared with spraying.", as well as "Particularly if objects are going back to a private client (versus museum) where handling/cleaning protocols are un-known, it provides some extra protection especially towards cleaning solutions (water, some detergents and solvents, etc).". Their ease of purchase was also commented on. It's also interesting to point out that on the survey, a conservator wrote that "Fillings of Asian porcelain are usually finished with waxes". Desiring to understand this nuance a follow-up question was made to said respondent, however no answer has been obtained till this point.

Despite being an unstable material, polyurethane was here detected as a varnish, having been previously mentioned in the re-touching section.

Besides coating materials, several materials to burnish and abrade the fills surface were detected (Figure D.12). Fine sanding paper was the most prevalent (57 answers), but these results may be influenced by not having included many abrasive methods in the initial survey (only Fine Sanding Paper and Solvol Autosol® had originally been included).

Conclusion

A survey to understand techniques and materials used in porcelain conservation was developed as a way to inform the conservation treatment of a porcelain dish from the Monastery of Santa Clara-a-Velha. The research did not intend to obtain representativity, but it did wish to achieve a great diversity in the geographical location of the participants, which was successfully accomplished with 139 respondents from thirty-nine countries.

Although treatment options should be determined on a case-by-case basis, the gathered information allowed for the identification of several materials currently used for bonding, filling and re-touching porcelain objects. For bonding and filling porcelain object, epoxy resins were, globally, the most selected materials, while for re-touching and coating the fillings, acrylic materials were predominant. Techniques thought by Koob (1998) to be obsolete, such as using molten glass to bond fragments and creating material replacements in wood, were surprisingly found to still be in use, although vestigial, demonstrating the relevance of the current study.

Geographical tendencies were analysed in seven countries with a higher answer rate (BEL, FRA, GBR, ITA, NDL, PRT, USA), six of which European. GBR and NLD were the two countries where epoxy resins were most selected for bonding, filling and re-touching. On the other hand, acrylic resins for bonding and filling were most selected in the USA and FRA. Waxes as a coating material were most mentioned by conservators working in PRT.

Overall, this research revealed the need for conservators to share their methodologies with peers, not only to globally document the evolution of the profession, but also to learn from the experience of one another, further enriching the field. Future research might involve tackling the difference between conservation methodologies for private clients or for museum. Considering the present analysis as a first contact with professionals on the field, this line of research has the potential to be complemented by a series of interviews. On a last remark, the author wishes to sincerely thank all participants for taking their time to participate in this survey and providing positive feedback.

Appendix E

ICONOGRAPHY FOUND ON THE MSCV PP90 DISH

Figure E.1 - Iconographic found on the case-study.

Appendix F

DETERIORATION MAPPING

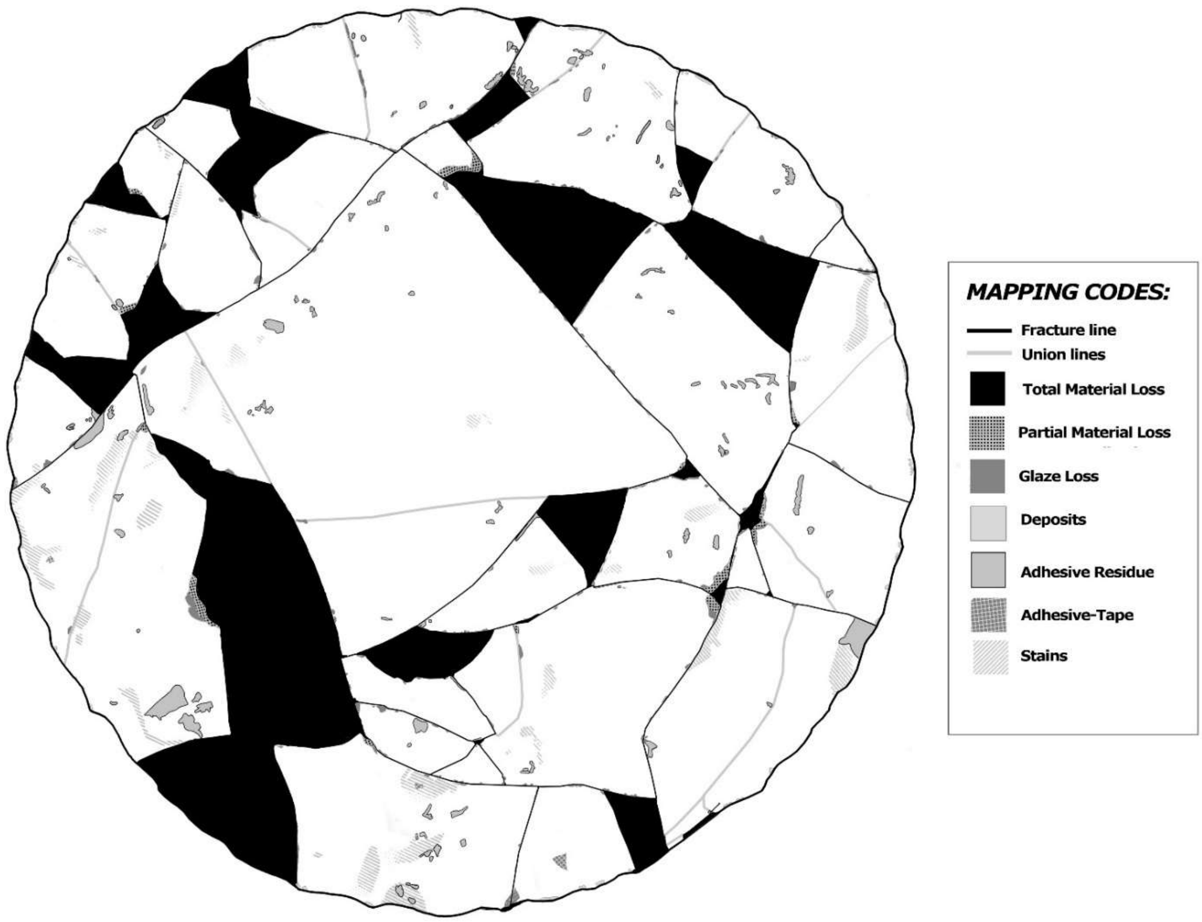

Figure F.1 - Deterioration mapping of the front side of the case-study

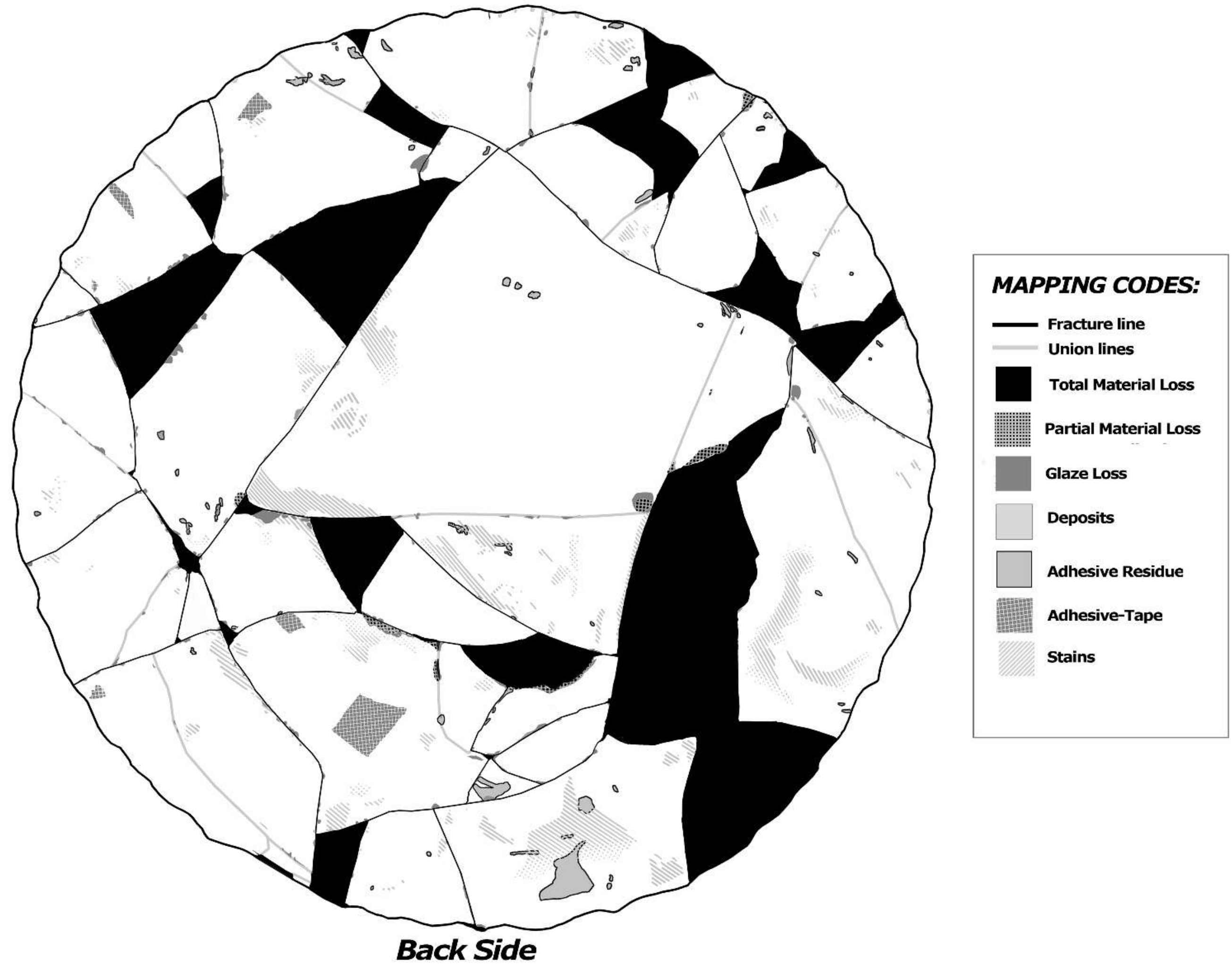

Figure F.2 - Deterioration mapping of the back side of the case-study

Appendix G

IDENTIFICATION OF THE ADHESIVE-RESIDUES

G.1 Observation Under UV light

Date of analysis: 02-12-2020

Equipment and conditions of the analysis: Black-Ray® Lamp, model UVL-56, U.V. wave of 365nm.

Results and Discussion: Through UV light observation it was determined that the adhesive residues fluoresce in an intense blue tone (Figure G.1)

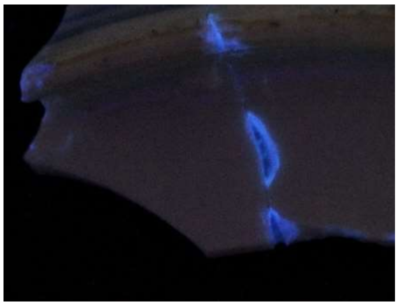

Figure G.1 - Detail of the adhesive-residues fluorescing under U.V light.

G.2 ATR-FTIR

Date of analysis: 24-11-2020

Equipment and conditions of the analysis: ATR-FTIR was used to identify the adhesive present in the dish from the Monastery of Santa Clara-a-Velha. Two samples were removed from the object: Sample A from a fracture line of a fragment and Sample B between the union of two fragments (Figure G.2). For the ATR-FTIR measurements, the used equipped was an Agilent® Handheld 4300 spectrophotometer, equipped with a ZnSe beam splitter, a Michelson interferometer and a thermoelectrically cooled DTGS (deuterated triglycine sulfate) detector, coupled to a diamond ATR sample interface.

Figure G.2 - ATR-FTIR sampled locations.

The FTIR spectra were acquired between 4000-650cm^{-1} with a resolution of 4cm^{-1} and 64 scans. Suspecting the presence of an epoxy resin, as these are frequently used in the conservation of porcelain objects and fluoresce, the bands of the ATR-FTIR spectra obtained (Figure G.3) were compared with the ones found in the literature (Table G.1). ATR-FTIR was performed in two samples, one from a fracture line (Sample A) and one from a join between two fragments (Sample B)

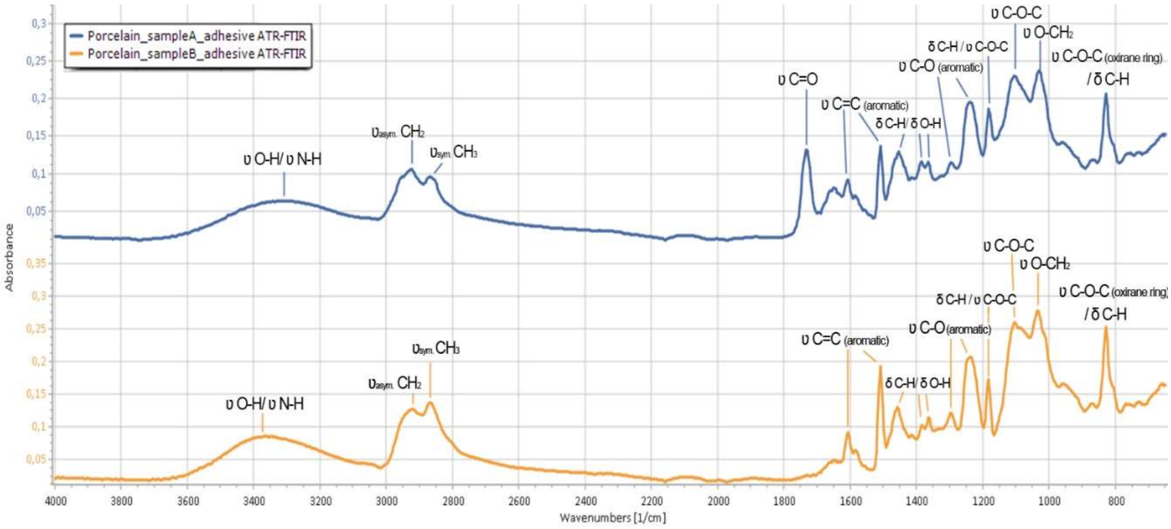

Figure G.3 - ATR-FTIR spectra of adhesive samples A and B.

Table G.1 - Proposed IR absorption assignment (υ: stretching; δ: deformation; sym.: symmetric; asym.: asymmetric vs: very strong; s: strong; m: medium, w: weak)

Assignments	IR Band (cm^{-1})	Bibliography
υ O-H/ υ N-H	3510-3179 (w)	(Achilias et al., 2012; Carvalho, 2016; Coutinho, 2008; Karayannidou et al., 2006; Li et al., 2008; Zhang et al., 1994)
$υ_{asym.}$ CH_2	2921 (m)	(Coutinho, 2008; Doménech-Carbó et al., 2001; Karayannidou et al., 2006; Li et al., 2008; Nikolic et al., 2010; Zhang et al., 1994)
$υ_{sym.}$ CH_3	2869 (m)	(Coutinho, 2008; Li et al., 2008; Nikolic et al., 2010; Zhang et al., 1994)
υ C=O	1724 (s) – Only present in sample A	(Carvalho, 2016; Coutinho, 2008; Meiser et al., 2010)
υ C=C (aromatic)	1607 (w);	(Carvalho, 2016; Doménech-Carbó et al., 2001; González et al., 2012; Zhang et al., 1994)
υ C=C (aromatic)	1508 (s);	(Carvalho, 2016; Coutinho, 2008; Doménech-Carbó et al., 2001; Zhang et al., 1994)
δ C-H/ δ O-H	1456 (m); 1384 (w); 1367 (w)	(Carvalho, 2016; Coutinho, 2008; Doménech-Carbó et al., 2001; Nikolic et al., 2010; Zhang et al., 1994)
υ C-O (aromatic)	1294 (w); 1237(s);	(Carvalho, 2016; Coutinho, 2008; Karayannidou et al., 2006)
δ C-H / υ C-O-C	1182 (m);	(Doménech-Carbó et al., 2001) / (Carvalho, 2016; Nikolic et al., 2010)
υ C-O-C	1101 (s):	(Carvalho, 2016; Coutinho, 2008; Zhang et al., 1994)
υ O-CH_2	1035 (s);	(Doménech-Carbó et al., 2001; Karayannidou et al., 2006; Zhang et al., 1994)
υ C-O-C (oxirane ring) / δ C-H	828(s);	(Carvalho, 2016; González et al., 2012; Karayannidou et al., 2006; Nikolic et al., 2010) / (Doménech-Carbó et al., 2001; Zhang et al., 1994)

There are mainly two families of epoxies - glycidyl epoxies and non-glycidyl epoxies (also called aliphatic) (González et al., 2012). The most common monomer of the first family is diglycidylether of bisphenol A (DGEBA), and products based in this compound have a strong absorption at 1510cm^{-1} and a weaker band at 1610cm^{-1} (Carvalho, 2016; Derrick et al., 2000; González et al., 2012). Since these bands were detected in the obtained spectra, the possibility of the sampled material being an epoxy resin of the first family was reinforced. Most bands found are consistent with the ones mentioned in the literature, however, two characteristic bands of the epoxydic group, that according to Carvalho

(2016) and Li (2008) should appear at around 3040 and 911cm^{-1} were not detected. Still worth mentioning is an intense band at around 1724cm^{-1}, detected on one of the two samples analysed - sample A. This was attributed to the carbonyl formation that occurs as a result from radical oxidation mechanisms of the adhesive, which is also coherent with the yellowed appearance of the material (Carvalho, 2016; Coutinho, 2008; Meiser et al., 2010). The slight shift in the OH band (at 3300-3150cm^{-1}) can also be explained by the aging process (Meiser et al., 2010). As the goal of this analysis was to provide insight into what kind of adhesive would be dealt with during the conservation treatment, the hypothesis of it being an epoxy resin undergoing deterioration was considered enough to inform the decision-making process.

Appendix H

DIGITAL RESTORATION OF THE DISH

Figure H.1- Digital scenarios of the MSCV PP90 dish without re-touching (a), with repetitive patterns reintegrated (b), with the rim and cavetto areas reintegrated (c) and with all motives reintegrated (d)

2022

Leonor Correia Conceição

FILLING IN THE GAPS: The conservation and restoration of a Ming dynasty porcelain dish from the Monastery of Santa Clara-a-Velha

NOVA SCHOOL OF SCIENCE & TECHNOLOGY