Winterthur Museum

Department of Conservation

Technical Study

Proposal for a Technical Study of a Creamware Jug from the Winterthur Museum Collection

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Abstract

Technical analysis of ceramic objects can inform both provenance and possibilities for treatment. This study focuses on a prime example of early 19th century Liverpool wares, an oversized creamware jug from the Winterthur Museum collection. Characterization of original materials and problematic additions from a restoration campaign are pursued through elemental, molecular, and phase identification. The composition of the ceramic body is characterized qualitatively using X-ray fluorescence spectroscopy (XRF), scanning electron microscopy-energy dispersive spectrometry (SEM-EDS), and x-ray diffraction (XRD). Enamel colorants are characterized using XRD, SEM-EDS, and Raman spectroscopy. Restoration materials and organic components are assessed for stability and reversibility with Fourier transmission infrared spectroscopy (FTIR) and Raman spectroscopy, as well as ultraviolet light examination. This study presents analytical results that are consistent with historical accounts of methods in Liverpool's Herculaneum Factory. A lead-glaze and metal oxide colorants in the enamels were identified, as well as insoluble epoxy resins in the joins.

I. Introduction

This distinctive creamware jug immediately poses several questions. While its unique polychrome designs and imposing size are readily apparent, closer inspection reveals incongruous repairs made under the pouring lip (fig. 1). The history of the object, its manufacture, damage, and restoration are not fully understood. This study aims to use a range of analytical techniques to better comprehend the materials and manufacture of the object, as well as its current state and potential for treatment.

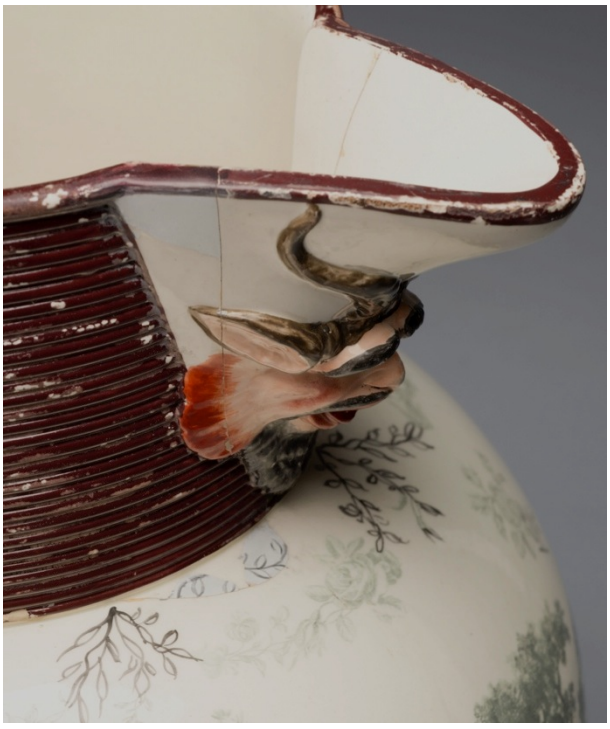


Fig. 1. Fills in large losses on pouring lip of 2009.0017 (AL6049).

The body and lid of the jug are mostly complete, and larger losses to the body have

been the subject of previous repairs. The pouring lip and the proper right side of the neck have significant cracking and break lines that indicate where pieces were previously detached. Detachment was likely caused by a physical impact to the area. Many of these cracks and losses contain yellowed adhesive residues and light colored fill material, which was shaped, smoothed, and inpainted previously. Prominent fills include the proper right edge of the pouring lip, narrow segments in the vertical cracks, and two areas inside of a semicircular crack in the shoulder. The latter two fill areas feature painterly black leaf designs that do not align with leaf designs on the main body. Cracks appear in a ring with adhesive residue around the base of the acorn finial, which indicates it was likely repaired or otherwise affixed at some point post-firing. It is unknown whether the acorn finial is original, as the enamel colors are unique to this element.

Liverpool ceramics

The manufacture and trade of ceramic wares in Liverpool is well documented. The port city facilitated both the import of high quality raw materials and the export of finished goods. The thriving ceramic industry began growing in the early 1700s, when utilitarian objects with lead and tin-opacified glazes first appear in the record (Brown and Lockett 1993, 17). White creamwares were introduced by Thomas Whieldon and Josiah Wedgewood by the mid 18th century (Magetti, Rosen, and Serneels 2011). The increasing demand for porcelain and earthenware in the 1800s fueled fine ceramic factories such as Herculaneum in south Liverpool, which increasingly competed with Staffordshire potters. Herculaneum was established in 1796 and continually produced a broad range of high quality wares until 1840 (Brown and Lockett 1993, 20). The factory was developed by three investors, Samuel Worthington, Samuel Holland, and Michael Humble, who valued international trade and reputation (Brown and Lockett 1993, 43). Herculaneum conducted a "huge volume of business with America" and specialized in transfer printed creamwares geared towards the American consumer (Arman and Arman 1998, 15). An object such as this jug would have appealed to both British and US merchants, but shipping challenges suggest that it most likely stayed in the United Kingdom. Herculaneum's works, particularly those made for the American market, are often unmarked (Brown and Lockett 1993, 41). Factory marks such as the impressed name of the factory, a crown, and/or a Liver bird, which is a large mythical bird representative of Liverpool, were occasionally included

on objects (Smith, 1970, 108). Though the Winterthur example is unmarked, there is little question that it was produced at Herculaneum.

While Herculaneum produced a range of tableware and beverage ware types, “the manufacture of extremely large jugs seems to have been a specialty” at the workshop (Smith 1970, 39). Creamwares from the region were normally under 30 cm tall, although several “giant” pitchers are known (Arman and Arman 1998, 48). One oversized blue transferware with a similar morphology to the subject of the study, 2009.0017, is purported to be for serving ale and cider while harvesting in the fields (Halliday and Halliday 2012, 219). Winterthur curator Leslie Grigsby notes that heavy, unwieldy jugs were comparatively uncommon and likely used for ceremonies as opposed to daily life (2015). Comparable large transferware jugs from the Herculaneum factory include similar details such as faux riveting, a “reeded” neck, engine-turned base, and printed floral sprays (Smith 1970, 39). A blue-enameled jug honoring Lord Nelson is notable for its striking similarity in form and technique to 2009.0017. An example of a similar stoneware jug and cover has a significantly different finial in the shape of a recumbent lion and does not feature printed ornament (Smith 1970, Plate 37).

Transfer printing was a fast and effective method for decorating ceramic wares and was most successfully developed by John Sadler and Guy Green of Liverpool in the 1750s (Smith 1925, 25). This technique contributed to the mass production and assembly line manufacturing style described in a contemporary account by local reporters for The Liverpool Albion (1827). Overglaze transfer printing is most common in black ink, but examples of sepia, lavender, green, and other colors exist (Arman and Arman 1998, 13). Print subjects ranged from popular figures to genre scenes in a “bewilderingly large” range (Brown and Lockett 1993, 45). Individual printers and designers gained popularity, such as Richard Abbey for his series of Aesop’s fables (Smith 1925, 31). Transferwares were often further embellished with hand-painted polychrome enamels (Arman and Arman 1998, 13).

The earthenware clay body typically used at the Herculaneum factory consisted of a light-firing clay from Northern Ireland (Brown and Lockett 1993, 19). Contemporary workplace accounts describe a thorough process of clay refining and thinning (Brown and Lockett 1993, 11). The

object appears to be mold-made in separate components, as evidenced by faint mold lines under the handle and pouring lip. The neck, body, handle and pouring lip were likely molded as separates and joined together before smoothing and finishing on a wheel. These observations are consistent with the description of assembly line production in The Liverpool Albion (1827). Detailed molded reliefs, such as the satyr mask pouring lip, were often used for multiple objects (Smith 1970). The personal papers of Herculaneum's Mr. Joseph Tomkinson offer insights into many recipes, including a translucent "cream colored glaze" that reveals the cream-colored body of the clay beneath and consists of lead, stone, and flint components (Smith 1970, 123). At Herculaneum, the enameling process most often consisted of hand painting or transfer printing designs onto an already glazed surface. Successive firings were used for multiple colors. Colorants would be mixed with networking agents such as silicates, fluxing agents such as aluminum oxide, and opacifying agents such as lead to create a glassy structure (Torok 2012, 4). The Tomkinson papers point to some specific recipes, and brown enamel, for instance, was described as a mixture of litharge, antimony, and manganese (Smith 1970, 124). The print designs on the object have the crisp lines and slight texture expected in overglaze transfer printing (Grigsby 2015). This method required an oil-based colorant to be printed from an engraved copper plate onto a thin piece of tissue paper, which was then pressed and scrubbed onto a glazed ceramic surface before the tissue was removed. The enamels, which consisted of various colorants ground with a flux, could be added directly to the ink before printing, or the ground enamel powders could be added to the wet printed designs by pouncing directly onto the ceramic surface (Smith 1925, 25).

Technical analyses of similar materials

Various analytical techniques have been successfully applied to the characterization of materials and methods that make up a wide range of ceramic wares. Non-destructive techniques have been used preferentially for cultural material. Raman spectroscopy and XRF have been used extensively to paint a picture of the colorants found in enamel decorations. Colomban, Sagon, and Faurel demonstrated the use of micro-Raman spectroscopy to discriminate between glazes and painting enamels with different compositions or phases (2001). By comparing colorless and colored zones of a Sèvres Factory glazed bisque palette, the authors created a set of standards, with particular success identifying white, green, yellow, brown, and red colorants. The

prevalence of TiO_2 opacifiers was also noted in Sèvres case studies. Colomban, Tournie, and Bellot-Gurlet compiled 700 Raman spectra in a database of glassy materials and were able to characterize distinct groups (2006). Using the Si-O stretching peak and polymerization index as their key components, the authors created a system of seven glassy material and enamel types. Colomban also explored the use of portable Raman instrumentation (2008). In 2010, Caggiani and Colomban addressed a range of Raman instruments for their applicability to highly absorbent black pigments and found that high-sensitivity equipment was preferred to high-resolution capability. Raman spectroscopy methods were applied specifically to the study of early English porcelain compositions and decorative methods by Jay and Orwa (2011). Authors note that the black colorant in the two lead-silicate wares studied could not be determined, although they successfully identified a red color deriving from an iron mixture. The significant compositional differences between the ceramics in the study supported the conclusion that they were manufactured in different factories. XRF has also been used in the non-destructive characterization of colorants, with studies such as Rohrs and Stege using qualitative results as indicators for dating (2004).

Destructive techniques using small cross-section samples have been used to study the layer structure and composition of ceramics and glazes. The study of ceramic body compositions has benefitted greatly from the use of SEM-EDS. Mirti applied this technique to demonstrate interaction between ceramic body and slip or glaze in examples of Greek and Roman pottery (2000). Schleicher, Miller, Watkins-Kenney et al. were able to characterize the chemical compositions of red earthenware sherds from a shipwreck excavation, noting that the ease of operation and minimal destructiveness was central to the choice of technique (2008). The authors suggested that similar type vessels that had originated from different manufacturing sites or had been subjected to different environments could be distinguished. The analytical team also used XRD to provide further distinctions of phase type in the ceramic body. Magetti, Rosen, and Serneels, chose a combination of techniques, XRF, XRD and SEM-EDS to study white earthenware bodies from Lorraine, France (2011). The study concluded that materials could be divided into calcareous and siliceous type bodies, and authors observed agreement between analytical results and contemporary technical treatises of the early 19th century. Owen and Hillis focused on porcelain sherds from the mid 18th century Liverpool factory, Bronlow Hill, and used

SEM-EDS qualitatively to trace trade patterns of ceramic pastes mixtures (2003). The ratios of silica-alumna-calcium within a ceramic body merited comparisons to London and Pomona wares. SEM-EDS has also been used to focus on colorant composition, as in Domoney, Shortland, and Kuhn's study of 18th century Meissen porcelains (2012). Characteristic elements helped to create a baseline data set of materials for the Meissen factory.

Analytical methods in the studies reviewed were appropriately employed and offered informative results. A question often left unaddressed is the characterization of restoration material, which is of central importance to the current study. Assessing and comparing the composition of restoration materials can help clarify the timeline of the object's past interventive treatments and inform a plan for reversing aged materials. Confirming the unmarked jug's consistency with reported Herculaneum techniques is also possible through elemental, molecular, and phase identification. The composition of the ceramic body can be characterized qualitatively using X-ray fluorescence spectroscopy (XRF), scanning electron microscopy-energy dispersive spectrometry (SEM-EDS), and x-ray diffraction (XRD). Enamel colorants can be characterized using XRD, SEM-EDS, and Raman spectroscopy. Restoration materials and organic components can be studied more in depth with Fourier transmission infrared spectroscopy (FTIR) and Raman spectroscopy, as well as ultraviolet light examination. While ceramic materials have been studied extensively with these techniques, there is a dearth of data regarding Herculaneum and associated factories. Many studies geared towards a conservation audience seek to characterize outdated ceramic repair materials, but this information is rarely presented in the context of technical analyses of the original material. By bringing these two perspectives together, this study can offer new insights into the character of Liverpool ceramics and future treatment possibilities for similar objects.

II. Experimental Procedures

Analysis sought to address the materials and methods from the jug's period of manufacture and its previous restoration campaign. Procedures began with non-destructive methods and FTIR analysis that would facilitate treatment progress. Cross-section samples of original material were used for both SEM-EDS and XRD.

Ultraviolet light radiation (UV)

In order to observe previous repairs, the jug and lid were examined in a dark room with a handheld ultraviolet light source, Mineral Light model UVGL-58 (115 V, 60 Hz, 0.16 A). Both long-wave (366 nm) and short-wave (254 nm) settings were used for observations. Known adhesive materials on ceramic tile were used under the same light source to provide comparison.

X-Radiography

Structural features and previous repairs, particularly the acorn finial and pouring lip break, were examined with this technique. A portable Pantak-Seifert Eresco 65 MF2 X-Ray Unit (5-300 KV, 0.5-6 mA) with a 3 mm focal spot was used in conjunction with Rhythm Review software. The lid was positioned perpendicular to the negative plate, 39 inches away from the tube. Appropriate voltage and current were determined by comparison to previously recorded object procedures. At 50 KV and 2.5 mA with 60 second exposure, 40 μm resolution, and low gain, structural details were clear. The breaks around the pouring lip were also examined. The jug was placed upright with the plate positioned vertically, 30 inches from the tube. The same settings were used to capture the image of the neck and pouring lip.

Energy dispersive X-ray fluorescence spectroscopy (XRF)

XRF was used to qualitatively characterize the elemental composition of the clay body and various polychrome enamels. No sample preparation was required for this non-invasive technique. A stationary Bruker ArTAX microXRF spectrometer with rhodium target X-ray tube (600microA current, 50kV voltage, 100 seconds live time irradiation) was used in conjunction with Intax v. 7.6 software. The spot size is approximately 70-100 microns. Exact sample locations and target accuracy are imaged with a CCD camera. Thirteen sample areas were analyzed, including unglazed ceramic body, uncolored glaze, and representative examples of each enamel color to provide a basis for comparisons. Sample areas were selected to accommodate the geometry of the object and the instrument. See Appendix I for detailed sample locations.

Fourier transmission infrared spectroscopy (FTIR)

FTIR was used to examine repair adhesives and fill materials in order to inform the treatment steps and methodology. Four areas of restoration material were sampled, including two fills and two adhesive residues near joins. Sample areas were selected to compare restoration materials from different places on the object, and choices were limited by accessibility. See Appendix I for detailed sample locations. Samples were gathered by minimal scraping with a scalpel blade and transferred using glass slides. Samples were then flattened on a diamond cell in preparation for analysis. FTIR analysis was performed on a Thermo Scientific Nicolet 6700 FTIR Spectrometer equipped with a Nicolet Continuum FTIR microscope and Omnic 8.0 software.

Scanning electron microscopy/energy dispersive spectrometry (SEM-EDS)

SEM-EDS was used to further inform elemental characterization and examine the layer structure of cross-section samples. The two samples were taken from the break edge of the polychrome satyr mask, representing light pink and gray enamel areas. See Appendix I for detailed sample locations. Samples were removed by a diamond blade scalpel pressed into the edge to create a chip containing the complete stratigraphy. The samples were placed perpendicularly using 3M 415 polyester double-sided tape in Buehler SamplKups after coating the molds with Buehler silicone release agent. Epokwik resin was mixed in a 5:1 ratio with the catalyst, resulting in 20 g of resin to fill two molds. The resin was left to cure in a fume hood for six days, however, a fully hardened state was not achieved and the casts were deformable under pressure. Since the resin was still able to take a polish, it was decided to move forward with these cast samples for analysis. Resin casts were wet polished with silicon carbide rolls up to 600 grit on a Buehler HandiMet® two roll grinder. Fine polishing was continued on a South Bay Technology Model 900 grinder/polisher with 1200 grit. At this point, samples were observed with a Nikon AZ100 compound microscope with Nikon Intensilight C-HGFI reflected light source, and photomicrographs were taken using a Nikon DS-Ri-U3 camera and processed in Nikon Elements D software. Resin surrounding the sample was then thinned and attached to a Zeiss slot head mounting stub (SPI Supplies® #01519-MB) using a conductive carbon double sided adhesive disc (12mm, SPI Supplies® #5077-BA). The sample was coated with SPI Supplies conductive carbon paint (colloidal graphite in isopropanol, 20% solids).

SEM-EDS was conducted with a Zeiss EVO MA15 scanning electron microscope with a lanthanum hexaboride (LaB_6) crystal and a Bruker Nano X-flash detector 6|30, processed through Quantax 200 and Esprit v. 1.9. The instrument was set to variable pressure mode with a working distance of approximately 8.4 mm. Accelerating voltage of 20 keV and 0 degree stage tilt were used. Instrument was calibrated using a standard of gold flakes on a copper grid. Back-scattered electron images of each sample were collected initially to visualize areas of interest for EDS false-color mapping and spot analysis.

III. Results

Under long-wave UV light, a greenish-yellow fluorescence was observed around break edges, highlighting aged adhesive residues. The fill materials, particularly the small fill in the enamel to the proper right of the pouring lip, fluoresced slightly white against the dark body that appeared to absorb light. In short-wave UV, the creamware fluoresced a bright yellow-white, consistent with a lead glaze, as shown in figure 2.

The x-radiograph of the lid showed a clean break edge between the acorn finial and the bell-shaped dome (fig. 3). In the x-radiograph of the jug's neck, voided spaces were observed along the break edges. No inserts or metal rivets, which were commonly used in ceramic repairs, were observed (Koob 1998). The ceramic body appeared to be a similar density throughout.

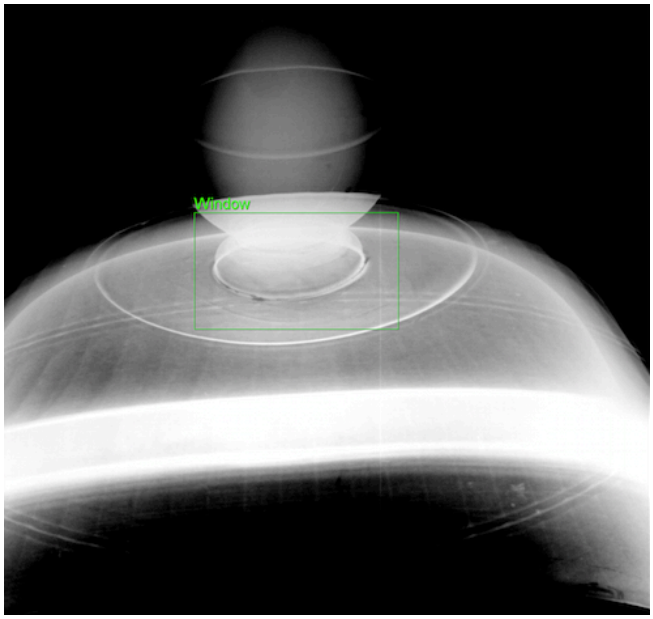


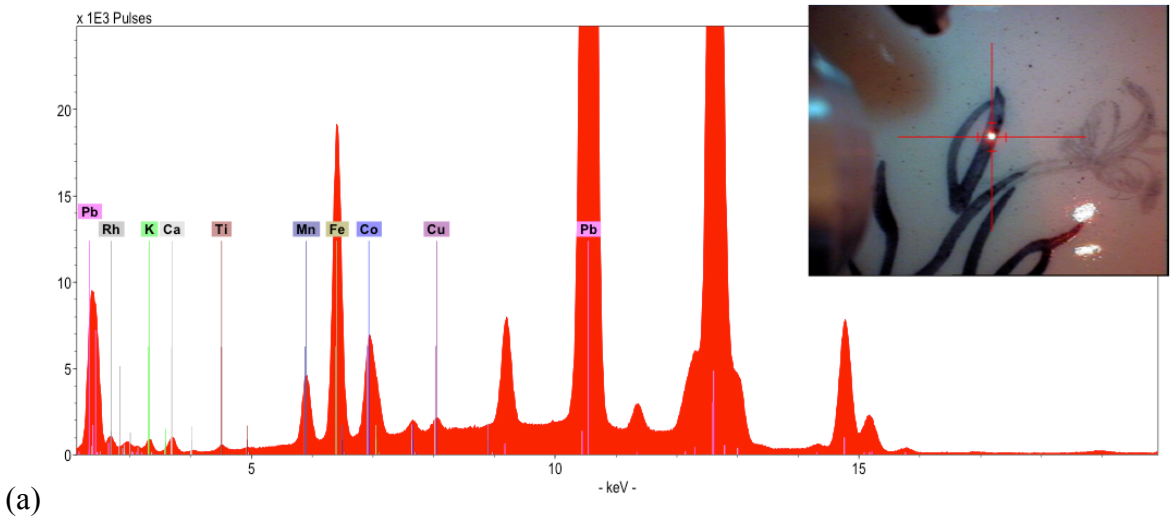
Fig. 2. Short-wave (254 nm) ultraviolet illumination showing fluorescence of lead glaze

Fig. 3. X-radiograph of lid detail and acorn finial, 50 KV and 2.5 mA with 60 second exposure

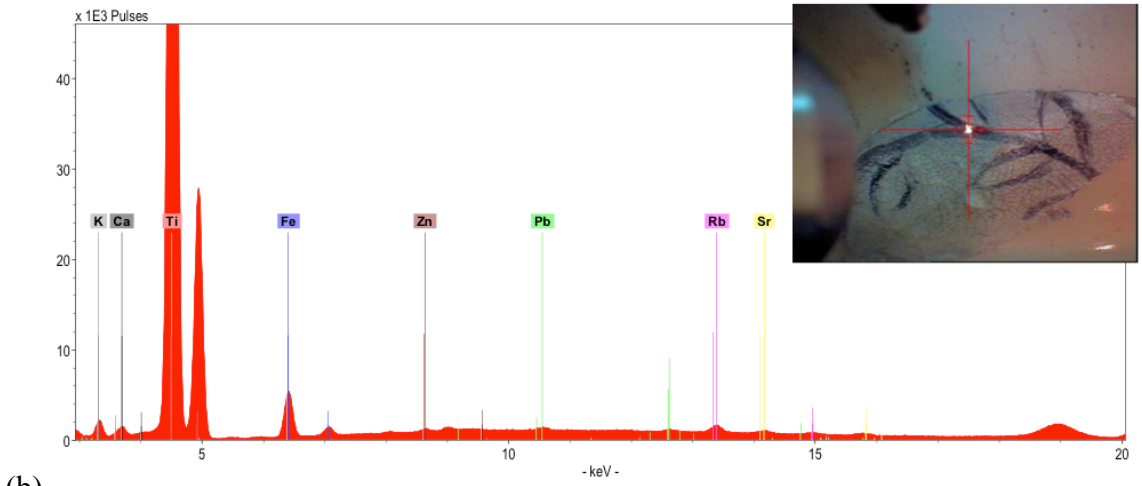
XRF results are summarized in Table 1. Primary components of the ceramic body are calcium, potassium, titanium, and iron. The glaze consistently shows a strong lead component and transition metals varying in proportion. The iron peaks in the colored enamel spectra are generally high intensity, except in samples XRF11 and XRF12 where iron levels are comparable to the unglazed body. Antimony appears in both the light and dark ochre enamel spectra, XRF13 and XRF14, but not in the other polychrome samples. Representative spectra, showing samples XRF4 and XRF6, are included in figure 4. Sample XRF6, which shows fill material, has a higher intensity peak for titanium and zinc appears as a minor element.

Table 1. Summary of stationary XRF data, elemental analysis of 2009.0017 (AL6049)

Sample	Area/Color	Major and (Minor) Elements
XRF1	break, unglazed body	Ca, K, Ti, Fe, (Zr), (Rb), (Sr) (Cr) and (Mn), possibly due to diffraction
XRF2	glazed body	Pb, Fe, (Ca), (K), (Ti), (Cu)
XRF3	print, green enamel	Pb, Cu, Fe, (Ca), (K), (Ti), (Mn), (Co)
XRF4	shoulder, black floral	Pb, Fe, Mn, Co, (Ca), (K), (Ti), (Cu)
XRF5	neck, blue discoloration	Pb, (Ca), (K), (Ti), (Fe)
XRF6	fill, black floral	Ti, Fe, (Ca), (K), (Zn), (Pb), (Rb), (Sr)
XRF7	rim, brown enamel	Pb, Fe, (Ca), (K), (Ti), (Cu)
XRF8	satyr beard, gray enamel	Pb, Fe, Mn, Co, (Ca), (K), (Ti), (Cu)
XRF9	satyr lip, red enamel	Pb, Fe, (Ca), (K), (Ti), (Cu)
XRF10	satyr tongue, red enamel	Pb, Fe, (Ca), (K), (Ti), (Cu)
XRF11	satyr nose, flesh enamel	Pb, Fe, (Ca), (K), (Ti), (Cu)
XRF12	satyr horn, gray enamel	Pb, Fe, (Mn), (Ca), (K), (Ti), (Cu)
XRF13	acorn, light ochre enamel	Pb, Fe, Sb, Mn, (Ca), (K), (Ti), (Cu)
XRF14	acorn, dark ochre enamel	Pb, Fe, Sb, Mn, (Ca), (K), (Ti), (Cu)



(a)



(b)

Fig. 4. Sample areas **(a)** XRF4 black colorant over glazed body and **(b)** XRF6 black colorant on painted fill material. Elements identified using Intax v. 7.6.

SEM-EDS results were consistent with preliminary findings from XRF. Images of cross-section X1, from the pink enamel area, is shown below in figure 5. The body and the glaze appear clearly delineated at lower magnification, but the backscattered electron image shows an interactive zone. The EDS false color maps show the division between the silica and aluminum rich body versus the lead rich glaze. Figure 5c also shows a slightly higher density of iron localized in the glaze compared to the body. Other findings from SEM-EDS included chlorine rich areas in the glaze of X1, potentially from environmental contamination. Sodium did not appear in the glaze in high proportions, and the content of tin versus calcium was not conclusive.

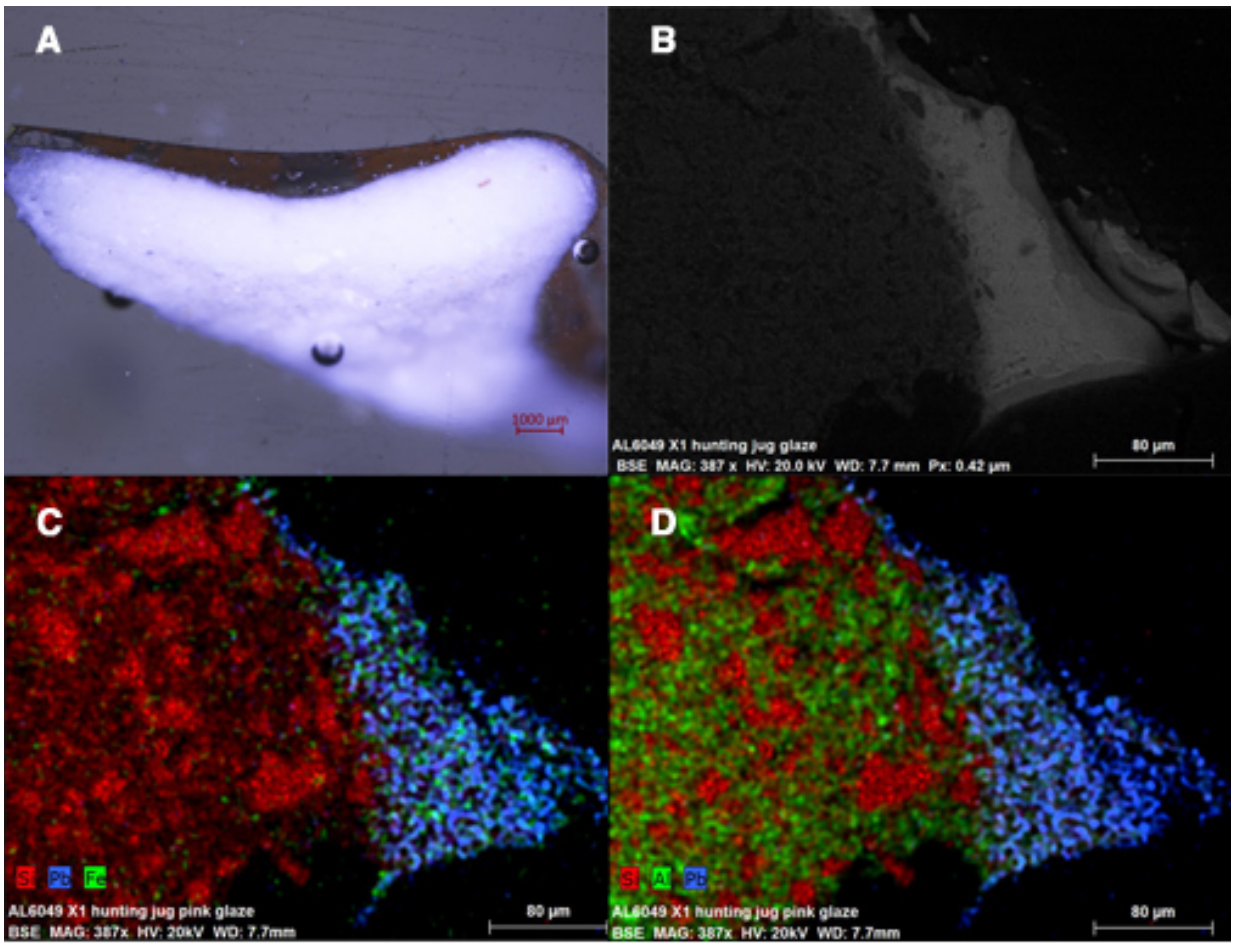


Fig. 5. Sample X1, pink enamel **A.** 40x total magnification, 2 ms exposure **B.** back-scattered electron image, right outer edge of sample **C.** EDS false color map showing Si (red), Pb (blue), and Fe (green) **D.** EDS false color map showing Si (red), Al (green), and Pb (blue)

FTIR spectra for both fill material samples, F1 and F2, indicated the presence of fumed silica. The spectra most closely matched a reference spectrum for Aerosil 200 fumed silica. F1 also showed peaks near 3000 cm^{-1} and 1700 cm^{-1} that correspond to a reference spectrum for Acryloid QR-746, an acrylic resin. The absorbance sharply increase from approximately 1000 cm^{-1} to 650 cm^{-1}, suggesting that titanium may be present. The adhesive sample from the pouring lip, F3, contained fumed silica as seen in the fill material. Additionally, distinct peaks in the F3 spectra align with the strongest peaks of an epoxy resin ester (fig. 6). The second adhesive sample, F4, has a spectrum aligning with a polystyrene material and two strong epoxy resins, Koreapox 49, and Araldite.

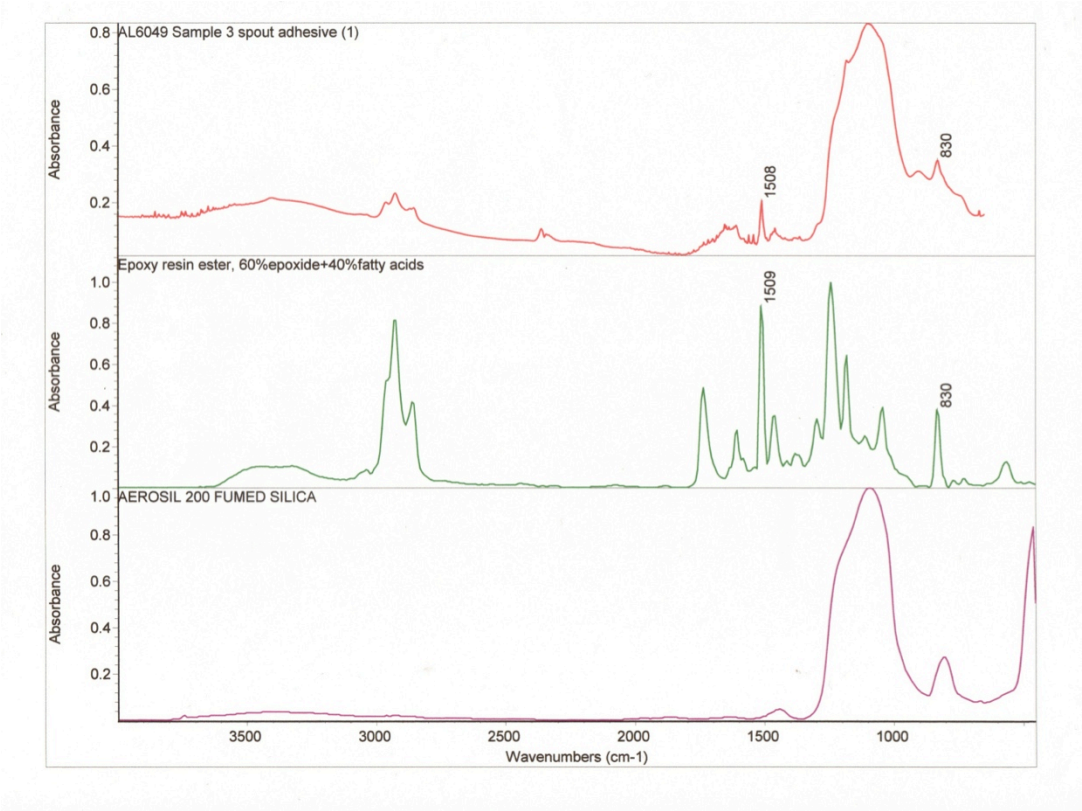


Fig. 6. Sample F3, adhesive residue from interior of pouring lip on 2009.0017 (AL6049), shown in red, with reference spectra. Strong peaks in the epoxy resin ester spectrum, 1509 cm $^{-1}$ and 830 cm $^{-1}$, are visible in the sample spectrum.

IV. Discussion

Results thus far offer insights into the materials used during manufacture as well as the restoration process.

Original material

The silicon, aluminum, and calcium based body with a titanium component is consistent with white earthenwares and creamwares (Magetti, Rosen, and Serneels 2011). In the mid 18th century, lime-rich fluxes gave way to potassium-rich fluxes, which were likely used at Herculaneum (Domoney, Shortland, and Kuhn 2012). The glaze and polychrome enamels show evidence of being silicon oxide networks modified by the addition of potassium oxides and lead oxides (Columban 2008; Owen and Hillis 2003). The proportion of lead observed in the glazes suggests a higher concentration than the moderate intensities used in earlier period Liverpool wares as described by Owen and Hillis in (2003). Common enamel colorants from the late 18th

century and onward are corroborated by historical accounts as well as past and present analyses. The Sèvres collection demonstrates blacks from spinel structures of metal oxides, cobalt blues, copper greens, iron oxide reds, and additions of zinc and manganese for browns (Colomban, Sagon, and Faurel 2001). Similarly, technical recipes indicate copper greens, iron oxide reds, and antimony and manganese within browns (Smith 1970, 124). The current study found copper associated with green color areas as well as pervasive potential sites of iron oxides in the red, pink, and red-brown enamel. The yellower brown tones used in the acorn finial appear to have the antimony and manganese content as expected.

Restoration material

The UV examination, x-radiograph, and FTIR data helped clarify the techniques and general classes of materials used to repair the jug. The acorn finial and lid appear to be joined at a clean break with no mechanical attachment, suggesting that the acorn is the original decoration despite its unique coloration. Fumed silica is commonly used as a bulking agent in fills and could potentially be combined with acrylic adhesives and white pigments and paints. The epoxy resin residues along break edges are consistent with repair solutions used to create strong joins. The polystyrene material at the finial break edge may suggest an acrylic paint or Rhoplex used during inpainting.

V. Conclusion

VI. Acknowledgements

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Supplementary Information

Time Line

Completed analyses include x-radiography, FTIR, XRF, and SEM-EDS. Each analytical session took approximately 3 hours, with a minimum of 3 additional hours for data interpretation. Research, synthesis, and summary took approximately 1-2 hours per week, spread over the course of the fall semester.

Further analyses, 6 hours each for experiment and interpretation:

- Raman spectroscopy
- X-ray diffraction spectroscopy (XRD)
- Gas chromatography-mass spectroscopy (GCMS)

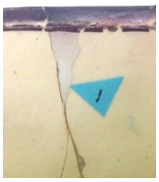
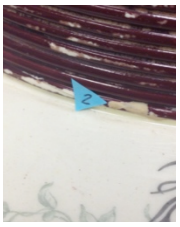
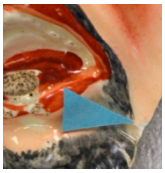
Sample preparation is expected to take minimal time due to the reuse of cross-section samples or the application of non-destructive methods.

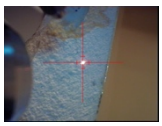
Personnel and Facilities

This study will be supervised generally by the members of the Scientific Research and Analytical Laboratory (SRAL) at Winterthur Museum, and Catherine Matsen (Associate Scientist and Affiliated Assistant Professor) will directly oversee the project. All necessary equipment is located in SRAL, and access is available by appointment. Time is limited to approximately 3-4 official sessions per semester. Some equipment (XRF) is available to use with less direct

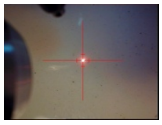
supervision or appointment scheduling. Data interpretation will be conducted through research and additional meetings with supervisors including Catherine Matsen, Dr. Jennifer Mass, Dr. Jocelyn Alcantara-Garcia, and Dr. Christian Peterson.

Appendix I: Sampling Locations for 2009.0017 (AL6049)

Image	Number	Description
	F1	Interior of pouing lip, proper right side, discolored fill material
	F2	Exterior neck, proper right side, small white fill in enamel
	F3	Interior of pouring lip, proper left side, yellow adhesive residue
	F4	Lid, base of acorn, dark adhesive area near loss
	X1	Satyr mask, proper left break edge, pink/flesh tone enamel
	X2	Satyr mask, proper left break edge, beard, gray enamel

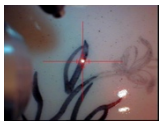


XRF1 Body, break edge, proper left side between adhesive residues

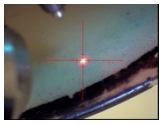


XRF2 Uncolored glaze, shoulder above fox print, proper left side

XRF3 Hunting dog print, top tree, green enamel

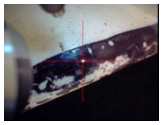


XRF4 Shoulder, proper right, black floral design

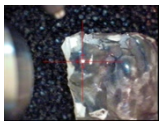


XRF5 Interior neck, blue discoloration

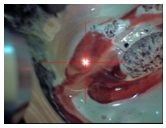
XRF6 Shoulder, proper right, black floral design on fill material



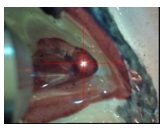
XRF7 Pouring lip, rim, brown/aubergine enamel



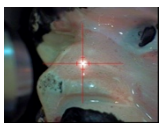
XRF8 Satyr mask, tip of beard, gray enamel



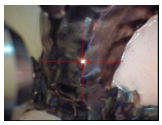
XRF9 Satyr mask, lower lip, red enamel



XRF10 Satyr mask, tongue, red enamel



XRF11 Satyr mask, nose, flesh tone enamel



XRF12 Satyr mask, proper left horn, gray enamel

XRF13 Lid, acorn finial, light ochre enamel

XRF14 Lid, acorn finial, dark ochre enamel