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An Analysis of Unidentified Dark Materials Between Inlaid Motifs on Andean Wooden Qeros

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An Analysis of Unidentified Dark Materials Between Inlaid Motifs on Andean Wooden *Qeros*

A thesis submitted in partial satisfaction

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in Conservation of Archaeological and Ethnographic Materials

by

Heather Marie White

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ABSTRACT OF THE THESIS

An Analysis of Unidentified Dark Materials

Between Inlaid Motifs on Andean Wooden *Qeros*

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Heather Marie White

Masters of Arts in Conservation of Archaeological and Ethnographic Materials

University of California, Los Angeles, 2016

Professor Ellen J. Pearlstein, Chair

Paramount in the study of Andean civilizations, past and present, are the rituals and ceremonial customs practiced through the Inka and post-Inka periods. Decorated wooden cups called *qeros* have facilitated these customs through the centuries, experiencing long use-lives as they are passed down from generation to generation, holding libations to the gods in rituals and celebrations that ensure the community's prosperity and good health. It is from here that *qeros* enter museum and private collections, their use-life ends, and their preservation as vestiges of Andean culture begins. Decorated by brilliantly colored organic inlay, commonly known as *mopa mopa,* there is currently a lack of information concerning dark material that often surrounds the *mopa mopa* polychromy. This dark "background" at times exhibits peculiar and substantial loss on *qeros* in many collections, sometimes as though it has been purposely scraped off. For this study, dark materials on a group of *qeros* belonging to the Fowler Museum at the University of California-Los Angeles were investigated in an effort to characterize them and potentially explain their presence and causes for loss. Several documentation and analytical techniques were employed, including visual analysis, digital photography, UV-induced visible fluorescence, Reflectance Transformation Imaging (RTI), portable X-ray Fluorescence (pXRF) spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, and Gas Chromatography-Mass Spectrometry (GC/MS). Results showed this dark material to be a mixture of organic components—fatty acids, oils, and possible natural resins—most likely deposited on the surface from the cups' ethnographic use. A couple instances of dark inlay decoration were found to be a chemically similar material, and another similar oil-based mixture was found to be used as a type of surface application. Obvious tool marks targeting the removal of the dark material suggest there were mechanical interventions meant to clean the cups of dark ethnographic accretions so that their polychrome imagery showed unobscured. Identifying these materials, understanding their origin and explaining their loss, contributes to our knowledge of *qero* history and guides our custodianship over these artifacts of Andean traditions.

The thesis of Heather Marie White is approved.

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Table of Contents

List of Figures

List of Tables

Supplemental Materials

Appendix A: Fowler Museum Records

Appendix B: Survey Forms and Annotated Maps

Appendix C: Dark Material Visual Glossary

Appendix D: Condition Visual Glossary

Appendix E: Reflectance Transformation Imaging

Appendix F: UV-induced Visible Fluorescence

Appendix G: Portable X-ray Fluorescence Spectroscopy

Appendix H: Sampling Locations

Appendix I: FTIR GCI Report

Appendix J: FTIR MFA Report

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Further, I must acknowledge Prof. Mora Rivera for generously sharing his ethnographic photographs of the local use of *qeros* by the ayllu Soraga community (Avaroa province, Department of Oruro, Bolivia). This documentation has the authorization of the ayllu's authorities and is part of a project lead by Prof. José Luis Martínez of the Universidad de Chile. Project information: "Sistemas andinos de registro y de comunicación y semiosis andina colonial." Project contact: Ethnographer, Gerardo Mora Rivera (gamora@uc.cl), FONDECYT 1130431.

I credit all researchers and collaborators responsible for the breadth of information already established on qero technology for providing the foundation for this work.

1. Introduction

The Spanish conquest in South America in the early sixteenth century was not a simple matter of one invading culture swiftly dominating and seizing the lands of another; rather, it was a period of political, social, cultural, and religious upheaval of the Inka empire, aided by the devastation of European-introduced disease, that wrought dramatic change to Andean populations in the course of a mere generation. The new order established in the Colonial era began a struggle for indigenous Andeans defined by cultural suppression and the challenges of a shattered identity that continue to this day. Defiant, surviving peoples have worked to resist European influence and continue their culture's traditions; staying connected to their ancestors while living in a new sociopolitical and religious environment that discourages ties to their past. This "politically-charged and culturally mixed" atmosphere (Stone-Miller 2002) has been documented by Andean artistic works over the generations, none as captivating or narrative as the brilliantly colored drinking vessels known as *qeros*, which depict changing social dynamics while embodying surviving Inka traditions (fig. 1).

Fig. 1. Stylistic progression of *qeros* in the Colonial Period (ca. 1530-1780 C.E.). Pictured left to right: Museo Inka in Cuzco, (MoMa 229) (Courtesy Museo Inka, Cuzco), Metropolitan Museum of Art (1994.35.14) <www.metmuseum.org/art/collection/search/316824>, and National Museum of the American Indian, Smithsonian Institution (10/5635). Photo by Ernest Amoroso.

Qeros are made in pairs for use in ritual activities and have been made from a variety of materials, including gourd, wood, ceramic, and precious metals. Though there are variations in spelling and dialect,[1] the term "*qero*" will be used in this study to only refer to wooden drinking vessels. The use of *qeros* in Andean culture dates to over a millennium ago, and their continued use has remarkably survived Spanish colonization despite efforts to ban them and drinking altogether (Stone-Miller 2002). Artistically they have changed from minimally decorated cups incised with linear, geometric motifs during the Inka Empire, to sparse Early Colonial animal and insect motifs in horizontal patterns, to complex narrative scenes executed in a broad palette (Howe 2001) (fig. 1). These Late Colonial scenes reflect a blend of European and indigenous Andean imagery, culminating in a cultural commentary that often echoes the cups' use at occasions involving the consumption of a fermented beverage called *chicha*,[2] or in some communities the libation of blood.[3] Few *qeros* have been excavated from archaeological contexts; rather, most have survived as heirlooms passed down through many generations, continually used in Andean celebrations and rituals: "The bright colors [on *qeros*] are in a sort of mastic lacquer, inlaid in a modified cloisonné technique. Most of those now known have probably been preserved in Peruvian houses since the day of their manufacture" (Bushell 1956, 137).

Study thus far has focused on the polychrome iconography of *qeros*, often thought to be rendered with paint or described as "lacquered" (Bushell 1956, 137; Mason 1957, 271; Metraux 1965, 37-38;

[1] Also spelt *kero*, *quero*, *q'ero,* or *qquero.* In early Quechua-Spanish dictionaries, *quero vicchi* is used for "wooden cup" though regional variations in dialect also account for *k'ullu qero*, as well as just *quero* translating as "wooden cup for drinking" (Bolin 1998; Cummins 2002; Kirsop 2013). Also, *qespe qero* is used for cups made of glass in the Peruvian highlands (Bolin 1998), and *aquillas* refers to cups made from precious metals like gold or silver (Cummins 2002). For this study, the spelling "*qero*" is used throughout to refer to wooden drinking vessels.

[2] *Chicha* is the Spanish word for a fermented beverage that can be made from a variety of raw materials, such as maize, fruit or mandioc (Cutler and Cardenas 1947). The Quechua words *aqha* and *asua* are similarly used (Bolin 1998; Kirsop 2013).

[3] The use of *qeros* for blood libations is documented in Bolin (1998).

Rowe 1961), but which in fact consists of an inlayed, pigmented organic resin derived from small buds from species of trees of the *Elaegia* genus (Howe 2001; Newman, Kaplan, and Derrick 2015; Newman and Derrick 2002; Pearlstein et al. 1999). This resin, locally known as *mopa mopa*, has fascinating physical properties which have revealed *qero* manufacture to be a complex and labor intensive technology. While recent technical studies have advanced our understanding of *qero* materials and manufacture, questions remain about their decoration and maintenance. Notably,

Fig. 2. Examples of *qeros* exhibiting a dark material in "background" areas around polychromy. Pictured left to right: Minneapolis Institute of Art (98.163.2) <collections.artsmia.org/art/9380/qero>, and Metropolitan Museum of Art (1994.35.12) <www.metmuseum.org/art/collection/search/316840>.

many *qeros* exhibit a dark "background" which surrounds the inlaid polychrome decoration on the exterior and seems to travel over the rim and into the cups' interiors (fig. 2). Anthropologist John Rowe, who devised the first chronology for *qeros*, describes one cup as having a "brown lacquer" background, implying that there was indeed an intentional dark *mopa mopa* layer between the polychrome imagery (1961, 330). However, there is a lack of information and analysis concerning this "background" material, partly because it is curiously absent or has substantial loss on many *qeros* held in collections. In some instances conservators refer to it as looking "scraped off". In addition, little is known about how the cups are maintained in Andean communities and how they are treated once they enter the art market, both of which could influence the surfaces of *qeros* and any materials present.

1.1 Purpose of the Study

This study was designed to address questions concerning dark material on *qeros* using a group of six Colonial *qeros* belonging to the Fowler Museum at the University of California-Los Angeles (fig. 3). Research and analysis aimed to identify all dark materials present on their surfaces, and to discuss their potential origins or purpose. Questions included: is this material an intended background decoration made of colored *mopa mopa*, as Rowe implied; a material applied ethnographically as a type of maintenance or aesthetic addition, or accumulated as result of use; or finally, is it related to treatment practices after they have entered collections? Further, patterns of loss were investigated to explain why the dark material is so variably present.

1.2 Description of the Fowler *Qeros*

Like most *qeros* held in collections, little is known of the provenance of the Fowler Museum cups other than they were accessioned in 1999 as a gift from the Helen Kuhn Family Trust (Appendix A). While at the Fowler Museum, they have not undergone any treatment or analysis and nothing is known of their specific manufacture, though it is clear that most contain repairs to counter radial cracking in the wood—likely multiple campaigns and ethnographic in origin. Out of the Museum's collection of fifteen *qeros*, the six chosen for this study (X99.22. [1, 3, 5, 9, 10, 11]) exhibit varying amounts of dark material with different physical characteristics, and with potentially different causes of loss; it is hoped that the diversity between the cups in this sample contributes to a more accurate and complete study representative of the possible dark materials present on *qeros* in general.

Fig. 3. Group of *qeros* studied, belonging to the Fowler Museum at the University of California-Los Angeles (X99.22. [1, 3, 5, 9, 10, 11]).

All of the Fowler *qeros* are wooden, with a narrow waist and flaring rims; one is footed (X99.22.10). Initially fabricated in pairs, each is an unpaired cup, having been separated from their counterpart, likely when sold in the art market, as is often the case. The polychrome decorations are presumed in this study to be colored *mopa mopa* inlay, as has been established on many Colonial period *qeros* in four other collections (Kaplan et al. 1999; Newman and Derrick 2002; Pearlstein et al. 1999). Their motifs are generally divided into horizontal registers containing figural scenes with Andean natives surrounded by floral/vegetal elements, rainbows, animals and insects; some cups also contain bands of repetitive geometric forms, such as concentric rectangles called *tocapu*, and one cup is entirely decorated with geometric shapes (X99.22.11). Dating is based on style and is thus speculative, though the five figural cups (X99.22. [1, 3, 5, 9, 10]) suggest dating in the Colonial period (c. 1530-1780 C.E.) given their narratives and broad color schemes. One *qero* (X99.22.5) is included in a publication by Cummins (2002), in which he dates the iconography to the late sixteenth or early seventeenth century. The footed cup is possibly later seventeenth century due to the colonial style of dress on one of the figures, and the cup whose decoration is only comprised of sharp geometric designs may date earliest, around the time of Spanish conquest in the early to mid-sixteenth century.

Though the Fowler *qeros* have little in the way of records, save for *qero* X99.22.5's chronological assignment by Cummins in 2002, research and analysis of their dark surface materials presents an opportunity to contribute to our understanding of *qero* decoration, use and lifecycle.

2. *Qero* Use and Significance

Aside from scholarly works devoted to *qeros*, there are some earlier sources about Peruvian civilizations and the Inka Empire which contain brief excerpts describing *qeros* (Brundage 1967, 184; Bushell 1956, 137; Mason 1957, 271; Menzel 1977, 7; Owens 1963, 21). More foundational works include *Toasts with the Inca: Andean Abstraction and Colonial Images on Quero Vessels* (Cummins 2002) and *Qeros: Arte Inka En Vasos Ceremoniales* (Ochoa, Arce, and Argumendo 1998), which comprehensively delve into *qero* history, use, and iconography. Other publications (Allen 2002; Bolin 1998) recount their current use in detail through ethnographic observation. In *Rituals of Respect: The Secret of Survival in the High Peruvian Andes* (Bolin 1998), several intimate family and community-based rituals are described where *qeros* are used for libations of *chicha* or blood in ceremonies that pay tribute to the gods to ensure the people's economic prosperity, good health, and love:

> Gregoria collects the blood from her llama in a *qero*. She sprinkles some onto the ground in honor of Pachamama.[4] Then, facing the mighty mountain, she whispers "Apu Ausangate, make this beloved animal return and let my herd multiply." Her family stands by watching solemnly, absorbed in the significance of the ritual. (54)

> Young people cluster around a *mesarumi*,[5] holding *qeros* in their hands and hoping that they will fall in love or make the one they secretly love accept them. A young man in a striking poncho sprinkles *chicha* from his *qero* onto the four corners of the sacred table of stone while he confides, "I very much love this young woman with whom I meet. Pachamama, please help to make her love me too." (107)

> More *chicha* is poured from the *urpu*[6] into the *qero*. Again and again, Pachamama and the Apus are implored to grant the couple health, youth, prosperity, many animals,

[4] Pachamama: Mother Earth, or the Great Mother (Bolin 1998).

[5] *Mesarumi*: a table (*mesa*) of stone (*rumi*) that serves as an altar for sacred rituals (Bolin 1998).

[6] *Urpu* (also known as *arybalo*): an earthen container used to store *chicha* (Bolin 1998).

> and good harvests in return for their offerings. It is a common belief that during weddings and other celebrations in the Andes, drinking and drunkenness prevail. During this wedding, although offering and accepting drinks are important elements in the rituals . . . no one was drunk. Throughout the days of ceremonies, the wedding party performed all rituals in full control and with utmost dignity. (144-45)

Other sources (Jennings and Bowser 2008; Moseley et al. 2005) discuss alcohol production, consumption, and practices in Andean societies. Ethnohistorical and archaeological records suggest a strong continuity between pre-conquest and post-conquest (including contemporary) ritual and celebratory use of *qeros* (figs. 4-5). Their use in pairs has remained constant, fostering social bonds and expressing a duality believed to represent opposing forces and partnerships: "The custom of toasting others with drink was a common practice, the giver of the toast making his way over to the favored one with two full [*qeros*], one of which he offered and one of which he drank himself" (Brundage 1967, 184). If one were to decline an offered *qero*, it is considered a deep insult warranting no further contact with that individual.

Fig. 4. A pair of *qeros* being used in a ritual libation in the *ayllu* Soraga community in Bolivia. *Photo courtesy of Gerardo A. Mora Rivera, October 2014.*

Fig. 5. Communities like the *ayllu* Soraga utilize *qeros* in ritual celebrations to share drink in an act of reciprocity. *Photos courtesy of Gerardo A. Mora Rivera, October 2014.*

As an individual drinks from a *qero*, their hand generally wraps around the lower half, obscuring the more simple design elements while leaving the more meaningful narrative scenes in the upper register visible to the participants sharing in drink (Allen 2002; Cummins 2002). The collective sharing of *chicha* and offerings of libations constitute acts of reciprocity fundamental to the people, linking the people's way of life—families, unions, harvests—to their Inka ancestors (Allen 2002; Cummins 2002; Jennings and Bowser 2008; Kirsop 2013).

As well documented and understood as their use seems to be, there is a surprising dearth of information regarding their maintenance in communities and over the generations. In personal written correspondence with several anthropologists and specialists, it became clear that few ever witnessed or heard of their care or upkeep in the communities. The most useful accounts suggest there may be differences between local cleaning practices. Anthropologist Dr. Inge Bolin[7] of Vancouver

Fig. 6. *Qeros* in the *ayllu* Soraga community being rinsed with water.
Photo courtesy of Gerardo A. Mora Rivera, October 2014.

[7] Dr. Bolin is an Honorary Research Associate in the Anthropology Department at Vancouver Island University in Nanaimo, British Columbia, and has done ethnographic work in the Andean highlands with the pastoralist community of Chillihuani.

Fig. 7. The *qero* pair used in celebrations in the *ayllu* Soraga community show surfaces heavily deposited with dark materials, undoubtedly from their regular use over many years. *Photos courtesy of Gerardo A. Mora Rivera, October 2014.*

Island University studies pastoralists in the Andes, and she describes witnessing a piece of cloth being used to vigorously scrub *qeros* and other dishes with water and sandy sediment when they needed cleaning; a group of Yachaq volunteers she works with inquired in the communities as well, and the people could also only refer to the fact that they and their ancestors used sand or sandy earth to clean them.[8] Working with communities in Bolivia, anthropologist Gerardo A. Mora Rivera[9] notes that people say it is forbidden to wash *qeros*, though that they in fact get rinsed with fresh water every now and again,[10] almost ritualistically pouring the water from cup to cup (fig. 6); Dr. Bill Sillar of the University College London offered a similar account, seeing water swirled around in them for cleaning.[11] No specialist consulted[12] observed families applying oils, fats, or other coatings for maintenance to the surfaces of *qeros*. However, pictures of their contemporary use provided by Prof. Mora Rivera show their surfaces are rough and covered in dark accumulations or accretions of some kind, which obscure their polychrome decoration (fig. 7). Though previous studies have noted surface residues and accretions, these features have never been thoroughly explored.

3. Previous Technical Studies

3.1 *Qero* Manufacture

Equally as elusive as maintenance practices is certain information concerning *qero* manufacture; currently there is little in the way of firsthand observation and documentation of *qero* fabrication,

[8] Dr. Inge Bolin, email message to author, July 13, 2015.

[9] Gerardo A. Mora Rivera is an adjunct anthropology professor at the Universidad San Sebastian and is part of an ethnographic collective named AZAPA. He records local *qero* use in the *ayllu* Soraga community in Oruro, Bolivia.

[10] Gerardo A. Mora Rivera, email message to author, March 29, 2015.

[11] Bill Sillar, email message to author, March 20, 2015.

[12] Other than those referenced in the text, consultants included anthropologist Catherine Allen (The George Washington University) and anthropologist Gary Urton (Peabody Museum).

and there is exceptionally little known about how the wood was carved or treated prior to decoration. *Qero* pairs are thought to be produced from the same block of wood[13] carved in the longitudinal direction, that is, parallel to the growth of the tree. Craftsmen called *querocamayocs*,[14] who as their name implies specialized in the production of wooden drinking cups, seem to have chosen wood from mature trees of the genera *Escallonia* (Kaplan et al. 1999), *Alnus* or *Hymenae* (Rivery and Escalera 1998). Features of manufacture can be observed on some cups, such as a small central indentation on their base which suggests they were turned on a lathe (Kaplan et al. 1999), and chisel marks on their interiors which show how they were hollowed out. Other than these features—which are not consistently found—little is known of how the wood was shaped or prepared before it was decorated, and of course specific manufacturing techniques have likely varied between artisans over the generations.[15]

3.2 *Mopa Mopa* Inlay Decoration

The predominant investigation into the materials and manufacture of wooden Andean *qeros* comes out of a research collaborative of conservation professionals from several institutions, who in 1994 began an ongoing project to understand and identify the colored inlay decoration on approximately 150 *qeros* held in four museum collections[16] (Kaplan et al. 1999; Kaplan et al. 2012; Newman and

[13] In one study, a pair of *qeros* was confirmed as having come from the same block of wood, one cut from on top of the other longitudinally, as their tree rings were superimposable (Kaplan et al. 1999). This is considered materially symbolic of their duality and the relationship/union fostered between the two individuals participating in drink.

[14] *Querocamayocs* were woodworkers or carpenters that fashioned goods for the Inka Empire, whose work principally comprised of the manufacture of wooden drinking cups, i.e. *qeros*. It is the only term known to classify a carpenter by the object they produce. A group of *querocamayoc* Indians who lived in the mountains on the eastern slopes of the Andes were simply called "Queros" by the Inka, given their location close to the wood and the venerable objects (*qeros*) they manufactured for the state (Cummins 2002).

[15] Though recent studies have indicated relatively consistent technologies for *qero* manufacture, specific surface preparations are not well understood and are purely speculative, requiring more research and analysis.

[16] The four collections include: The Brooklyn Museum, the Metropolitan Museum of Art (MMA), the American Museum of Natural History (AMNH), and the National Museum of the American Indian (NMAI).

Derrick 2002; Pearlstein et al. 1999). In addition to non-invasive portable X-ray fluorescence spectroscopy (pXRF), samples were taken from a select group of cups for destructive chemical analysis via energy dispersive spectroscopy (EDS), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and High performance liquid chromatography (HPLC); also, cross-sections were embedded for examination using polarized light microscopy (PLM).

Results from this project showed both organic and inorganic colorants responsible for the bright and broad palette of colors used for *qero* inlays; these include cinnabar, orpiment, lead white (cerussite or hydrocerrusite), indigo, cochineal, carbon black, brown earth pigments, and a number of copper salts like verdigris. As previously stated, these studies also confirmed the binder to be the organic exudate *mopa mopa*. There are two widespread and physically similar species of *mopa mopa* used on *qeros* originating from trees of the genus *Elaeagia*; these are *E. pastoensis* and *E. utilis* (Newman, Kaplan, and Derrick 2015). *Mopa mopa* is a resin exudate derived from small capsules or buds on the branches of these trees, which are collected and sold to artisans in their raw form as a hard, opaque green cake of material containing various plant particulates (Kaplan et al. 1999). A botanical specimen of *E. pastoensis*, as well as other plant resin sources potentially available to Andeans for *qero* manufacture, were chemically analyzed against several hundred inlay samples from the Colonial period *qeros* in the project; all *qero* inlay samples closely matched *E. pastoensis* as their main component (Kaplan et al. 1999; Newman and Derrick 2002). This identification was further refined in a subsequent study, see below (Newman, Kaplan, and Derrick 2015).

The use of *mopa mopa* was reported by European naturalists in the seventeenth to nineteenth centuries, who witnessed craftsmen called *barnizadores* applying the material to various organic objects in a craft known as *barniz de pasto,* which continues today in the city of Pasto in southern

Colombia (Howe 2001; Kaplan et al. 1999). A member of the research collaborative, Ellen Howe, travelled to Pasto to observe contemporary *barnizadores* working and applying the material. Processing involves boiling the *mopa mopa* in hot water, kneading, pounding, manipulating and grinding it, while mechanically removing plant impurities to achieve an elastic, malleable product. Well-worked and purified *mopa mopa* becomes quite translucent and colorless, and can be tinted and used as a glazing affect over pigmented inlay or the wood substrate (Newman, Kaplan, and Derrick 2015). Dry pigments are kneaded into the *mopa mopa* producing a range of colors. Through the use of GC/MS analysis in one of the earlier studies (Newman and Derrick 2002), a semi-drying oil or an animal fat was perhaps found to have been mixed with the *mopa mopa* binder on some Colonial *qeros*, believed to help facilitate the addition of pigment during processing.[17] After pigmentation, contemporary artisans stretch the material into large, paper-thin sheets; designs are cut from these sheets and then impressed onto surfaces using finger pressure and heat. By contrast, colored *mopa mopa* on Colonial *qeros* was applied several millimeters thick, probably also with the aid of heat, into carved recesses in the wood; no adhesive has ever been found used to adhere the material to the wood. It is also evident that the optical qualities of the material were utilized in complex ways on later *qeros* by layering different colors and adding the tinted, translucent *mopa mopa* "glazing".

Work on this unique and complex resin has continued recently in a publication by conservation scientists Richard Newman and Michele Derrick (MFA-Boston) and conservator Emily Kaplan (NMAI), who have investigated the binder further with FTIR, gas chromatography-mass spectrometry (GC/MS) and pyrolysis gas chromatography-mass spectrometry (py GC/MS) (Newman, Kaplan, and Derrick 2015). In this work, standardized analytical procedures were developed and refined to aid in the analysis of *mopa mopa* resins from both species of *Elaeagia* (*utilis*

[17] Newest studies (Newman, Kaplan, and Derrick 2015) indicate that these fatty acids could be associated with later treatment or use, rather than inlay preparation.

and pastoensis), which furthers the discussion of its use on Andean objects and *qeros* throughout history. The resulting collection of reference spectra of resin extracts from *E. pastoensis and E. utilis,* as well as samples from *qeros*, provides a foundation for comparative analysis with the dark material observed on the Fowler *qeros*.

4. Methodology

The current project involved a four-part methodology beginning with researching the contemporary use of *qeros* and their maintenance practices, obtained by consultation with anthropologists and ethnographers working with Andean communities (reported in 2. *Qero* Use and Significance). Visual assessment, documentation, and analysis followed, described below with equipment, software and procedures outlined in Table 1.

4.1 Visual Analysis and Documentation

Thorough visual examination and digital documentation of the six Fowler *qeros* was performed at the Fowler Museum and at the UCLA/Getty Conservation Training Labs in Pacific Palisades, California. Focus was placed on documenting and mapping condition phenomena and dark materials across the surfaces of the *qeros* so as to find possible relationships. All observations were organized into custom survey forms and annotated maps that connected through a unifying language of terms defined in visual glossaries. To aid in mapping, rollout photography[18] was performed for each *qero* in which a series of images taken as the *qero* rotated were stitched together using editing software programs. Microsoft Image Composite Editor (Microsoft ICE) was used for the bulk of the stitching, however a great deal of manual stitching in Photoshop CC 2015 16.0 was

[18] Thanks go to NMAI photographer, Ernest Amoroso, for advising on creating rollouts of *qeros*.

required when Microsoft ICE failed to differentiate between repetitive *qero* imagery. The conical foot on *qero* X99.22.10 was unable to produce a successful rollout image due to its sharply angled shape. Rollout maps were annotated using Photoshop, however annotations were inevitably subjective, so mapping represented significant areas of surface features more generally rather than precisely.

Reflectance Transformation Imaging (RTI) was used to further visualize and document relevant features on *qero* surfaces. RTI is a technique that blends a group of raking light images into a single digital file that can be manipulated to highlight subtle surface relief. Its interactive viewing software, RTIViewer, facilitated a greater measure of understanding of the surfaces than can be represented through still images. RTI can only be effectively utilized on relatively flat surfaces, so the flared walls of the *qeros* meant that a scaled-in, tight frame was necessary to diminish the influence of the curve. For this reason, only a few representative areas were chosen on each *qero* to be documented using RTI; a total of twelve areas were selected, one to three per *qero*. Selection was based on areas that appeared to have received surface modification or otherwise had unique features.

The UV-induced visible fluorescence of surface materials was also studied and documented. A turntable was utilized again to capture every surface in detail in a series of images, which allowed for easy navigation as the images were scrolled through post processing. Originally, these series of images were intended to become rollouts as well, however there were difficulties in maintaining their correct color values when processed in the stitching software. Therefore, an appendix was created based only on a selection of areas for each cup that showed unique or representative fluorescence.

Table 1. Equipment and Parameters

Digital Photography	
Equipment/Software	<u>Macro-</u> • Nikon D90 Digital SLR camera under Tungsten light (InterFit Halogen 1000) <u>Micro-</u> • Nikon D90 Digital SLR camera • Meiji Techno EMZ series stereo microscope (magnifications 7x – 45x) • Fiber-optic illuminator (Meiji Techno, FL 150) • Photoshop CC 2015
Procedure	Each *qero* was photographed overall, including their interiors and undersides. Details were taken to capture features of condition and document the presence of dark material. Photography under magnification was utilized for capturing minute details and documenting sites for sampling.
Rollout Images	
Equipment/Software	• Nikon D90 Digital SLR camera under Tungsten light (InterFit Halogen 1000) • Turntable • Image Composite Editor (ICE) by Microsoft Research Computational Photography Group • Photoshop CC 2015
Procedure	Each *qero* was placed on a manually rotated turntable and illuminated under even Tungsten light. The Nikon DSLR camera was positioned on a tripod and set to capture via remote; the *qero* was centered in a vertical frame. An easily recognized starting point was chosen on each *qero* to begin the series of images. From here, one hand rotated the turntable approximately every 3-5° as the other hand captured the image using the remote. The process continued until the entire surface of the *qero* was captured, taking approximately 5-10 minutes and resulting in 60-100 images (varying by the particular *qero*'s surface area). In processing, images were color corrected and cropped. The designated starting and ending points on the *qero* for the series of images were cropped from the center of the *qero* and out to either the left or right edge of the

	frame to include the *qero*'s profile. All other images in the series were cropped to a central, narrow column allowing for approximately 20% overlap between the design elements in each consecutive image. The final, edited images consisting of a series of successive narrow, columns capturing the expanse of the *qero*'s surface, as well as beginning and ending images including the *qero*'s profile, were then stitched together. The open source program, Microsoft ICE, allowed for the series of images to be imported and automatically stitched together. This process was successful as equally as it was unsuccessful, as the repetitive design elements proved to sometimes confuse the program and often resulted in misaligned images. Each qero rollout required manual editing and stitching in Photoshop to varying degrees; the entire stitching and editing process took a few hours per *qero*. Rollouts were annotated in Photoshop.
Reflectance Transformation Imaging (RTI)	
Equipment/Software	• Nikon D90 Digital SLR camera • Copy stand • Reflectance spheres (1/4" ceramic ball bearings) • Moveable light source (desk lamp with an incandescent bulb) • Photoshop CC 2015 • RTIBuilder Version 2.0.2 and RTIViewer Version 1.1 (Cultural Heritage Imaging)
Procedure	Several areas on each *qero* were documented using RTI. A stationary photographic set-up was required to eliminate any possible vibration or movement during capture for image processing to be successful. The Nikon DSLR camera was mounted to a copy stand and used with remote capture, with the *qero* placed on its side beneath the camera and the desired area of its surface positioned in frame. The areas chosen for capture were only a few inches in either direction; this tight frame, as well as angling the *qero* using sandbags to be parallel with the camera, helped reduce the influence of its curved walls. Two reflectance spheres purchased as part of the RTI Highlight Capture Starter Kit provided by Cultural Heritage Imaging (CHI) were secured in frame with the aid of plasticine molding clay and bamboo skewers. A simple desk lamp was utilized as a movable light source. It was kept at a fixed radius as it was moved around

	the object, at a distance roughly 4x the diameter of the area being captured. All light in the room was turned off leaving just the light from the movable light source. Image capture was executed by two people: one person proceeded to capture the images with the camera remote as the other moved the light source along imaginary transects of an "umbrella" or dome around the object. After roughly 20 minutes, a series of 80-120 RAW image files were obtained which highlighted the area under a diverse range of raking light angles. The series of RAW image files were first converted into jpegs using Photoshop and then imported into RTIBuilder—an open source program created by CHI which guides the user through a simple procedure to produce the final interactive RTI file. A new project is created from the imported series of jpegs, highlights are detected on the reflectance spheres, images are cropped, and the RTI file is generated. The file is then viewed and navigated in RTIViewer (created by CHI). RTIViewer allows for the file to be viewed with different rendering modes that help visualize and enhance subtle surface reliefs. For this project, Specular Enhancement mode with values of 50 (Diffuse Color), 70 (Specularity), and 75 (Highlight Size) were most favored and informative. Diffuse Gain, Normal Unsharp Masking, Luminance Unsharp Masking, and Coefficient Unsharp Masking were also useful at various "Gain" levels.
UV-induced Visible Fluorescence Photography	
Equipment/Software	• A modified Nikon D90 Digital SLR camera with IR/UV filters removed • Mini-Crimescope 400 Forensic Light Source (SPEX Forensics, HORIBA Scientific), excitation 300-400nm • Peca filter #916 (400-725nm)
Procedure	Each *qero* was placed on a manually rotated turntable, lights were turned off, and an excitation wavelength of 300-400nm was cast on their surface using a Mini-Crimescope 400 Forensic Light Source. The modified Nikon DSLR camera with Peca filter #916 was positioned on a tripod and set to capture via remote. The *qero* was centered in a vertical frame. An easily recognized starting point was picked on the *qero* to begin the series of images. From here, one hand rotated the turntable approximately every 3-5° as the other hand captured the image (in the visible, 400-725nm) using the remote. The process continued until the entire surface of the *qero* was captured, taking approximately 5-10 minutes and resulting in 60-100 images (varying by the particular *qero*'s surface area).

Portable X-ray Fluorescence Spectroscopy (pXRF)	
Equipment/Software	• TRACER III-SD portable XRF spectrometer (Bruker Instruments) • S1PXRF version 3.8.3 (Bruker Instruments)
Procedure	Acquisition parameters were: 40 kiloVolts (kV)/11 microAmps (µA), and under vacuum (LabRatMode). Spectra were acquired for two minutes and interpreted using the program S1PXRF (version 3.8.3) from Bruker Instruments.

Fourier Transform Infrared Spectroscopy (FTIR)	
Equipment/Software	<u>Getty Conservation Institute</u> • Bruker Hyperion 3000 FT-IR microscope <u>Scientific Research Lab, MFA, Boston</u> • Thermo Nicolet iS10 FTIR spectrometer with attached Nicolet 'Continuµm' IR microscope • Bruker Senterra Raman microscope with a 785nm laser and 50x objective
Procedure	Sampling was performed under binocular magnification using a #11 scalpel. Samples consisted of several particles the size of a period at the end of a printed sentence. All sample sites were assigned location numbers, photographed and described prior to sampling. Labeled sample vials were delivered by hand to the Getty Conservation Institute and shipped to the Museum of Fine Arts in Boston. <u>Getty Conservation Institute</u> Optical microscopy was first used to examine the samples appearance and composition. Representative particles were placed on a one-millimeter thick diamond window and flattened using a metal roller. Analysis was performed on the resultant translucent sample using a 15x Schwarzschild objective, attached to a Bruker Hyperion 3000 FT-IR microscope and purged with dry air. The samples were analyzed individually using a transmitted infrared beam apertured to 100 x 100 micrometers or larger area. Polarizing filters were used to enhance sample contrast and assist in targeted analysis of the various components. The spectra are the sum of 64 scans at a resolution of 4 cm^{-1}. Solvent extraction, using water and ethanol, was utilized to separate potential soluble components from the bulk material. The identification of the infrared spectral data was performed with the help of in-house generated reference libraries. Components present in low concentration (below 5%) could not be identified.

	Scientific Research Lab, MFA, Boston A representative small portion of each sample was removed from its vial and squeezed between the two diamond windows of a SpectraTech 'µ Sample Plan'. The pressed sample was analyzed on a Thermo Nicolet iS10 FTIR spectrometer with attached Nicolet 'Continuµm' IR microscope in transmittance mode; 100 scans at 4 wavenumber resolution were carried out. Spectra from the samples were searched against several digital libraries, including Hummel Polymers and Additives, IRUG 2007 edition, and in-house libraries based on previous analyses of various reference materials and samples. In a few cases, microextraction of the pressed sample was carried out on the diamond window with small amounts of chloroform and/or water. If a ring of extracted material was visible, it was then analyzed. A few samples contained visible colored particles. In these cases, additional analysis to identify the colored particles was carried out with a Bruker Senterra Raman microscope, using a 785 nm laser and 50x objective.
Gas Chromatography-Mass Spectrometry (GC/MS)	
Equipment/Software	Scientific Research Lab, MFA, Boston • Agilent 6890 capillary GC/Agilent 5973N mass selective detector • Injection port, 300°C; MS transfer line 280°C, split/splitless manual injection
Procedure	Scientific Research Lab, MFA, Boston Samples were prepared by heating at 50°C for one hour in 20 microliters of Altech 'MethPrep 2," 1:1 in toluene, usually diluted with additional reagent (10-20 microliters) after cooling. ▪ Injection volume: 0.5-1.0 microliter ▪ Instrument: Agilent 6890 capillary GC with 5973N mass selective detector ▪ Split/splitless injection port, 275C; manual injection ▪ Oven program: 50°C held for 2 minutes, ramped 15°C/minute to 300°C, held for 25 minutes ▪ Column: J+W DB-5ms, 30 m x 0.25 mm x 0.25 micrometer film thickness ▪ Carrier gas: helium, constant flow 1.3 ml/minute ▪ MSD transfer line 280C, MS source 230C, MS quad 150C. MSD scan mode, 50-550 Da, solvent delay 7.76 minutes ▪ MS libraries: in-house; Wiley 275K (2004) and NIST 98 (2004)

4.2 Analysis

Portable X-ray fluorescence spectroscopy (pXRF) was utilized at select sites over each of the *qeros* where different dark materials were observed; sixteen sites were analyzed in total. These did not correspond to sampling sites, but rather areas which had the greatest expanse of dark material to take best advantage of the pXRF window. Spectra were interpreted using S1PXRF software, and overlays were created with different spectra from the same *qero* as well as spectra between different *qeros* for comparison.

Dark material from each *qero* was sampled for FTIR spectroscopy and GC/MS. Samples were chosen based on the material's visual properties and location (i.e. between inlay, over inlay, interior of cup, etc.), as well as the appropriateness of the sample site, with the aim of having a sampling group representative of the variety of dark materials observed over the *qero* surfaces. In total, thirty-one sample sites were identified for analysis, ranging from three to seven per *qero*. Sampling was performed at the UCLA/Getty Conservation Training Labs, and each sample was given a reference number based on its location (ex. *qero* X99.22.3, sample location 4 = sample # 3-4). An initial ten samples were sent to the Getty Conservation Institute (GCI) for analysis by Assistant Scientist Herant Khanjian. Another twenty-one samples were sent to the Scientific Research Lab at the Museum of Fine Arts (MFA) in Boston for analysis by conservation scientist Richard Newman. Both institutions utilized solvent extraction to separate soluble components, and the MFA continued analysis via GC/MS with three samples chosen at their discretion, in order to gain more specific information about the components.

5. Results

The extensive terminology used here to describe dark applied or accreted materials, as well as various condition features observed on the *qeros*, illustrates a complicated array of surface phenomena. Visual analysis and documentation suggested multiple dark materials, yet analysis determined that these materials shared overall uniform compositions.

5.1 Visual Analysis and Documentation: Surface Materials

5.1.1 Categorization

Table 2. Categorization of Materials Studied

Exterior Surface	*Major Visual Distinctions*
Type #1 Dark Material	usually matte; dark color with purplish transitions
Type #2 Dark Material	glossy/resinous; dark color with reddish transitions
Type #3 Dark Material	repair material located at radial cracks; gummy/tacky
Type #4 Dark Material	inlay decoration; dark; matte
Gloss	glossy coating; largely translucent
Interior Surface	
Type #3 Dark Material	repair material located at radial cracks; gummy/tacky
Type #5 Dark Material	usually quite thick; dark; matte; wrinkled or "blistering"

Through visual examination with the aid of binocular magnification, five "types" of dark material, as well as a material I called "Gloss," were characterized on the surfaces of the *qeros* (Table 2). This classification was employed for descriptive and organizational purposes, however predicated on the understanding that analysis may determine several "types" to be the same material, and individual "types" to be a mixture of materials. Exterior surfaces contained dark material Types #1-4, as well as Gloss, and the interior of the cups were coated by Type #5 dark material, sometimes with Type #3.

These material types were mapped over each *qero* rollout following a written survey of the cup in Appendix B (figs. 8-9). All materials were profiled in a visual glossary (Appendix C), which includes a brief physical description illustrated by a photographic detail, and a list of particular condition phenomena associated with the material.

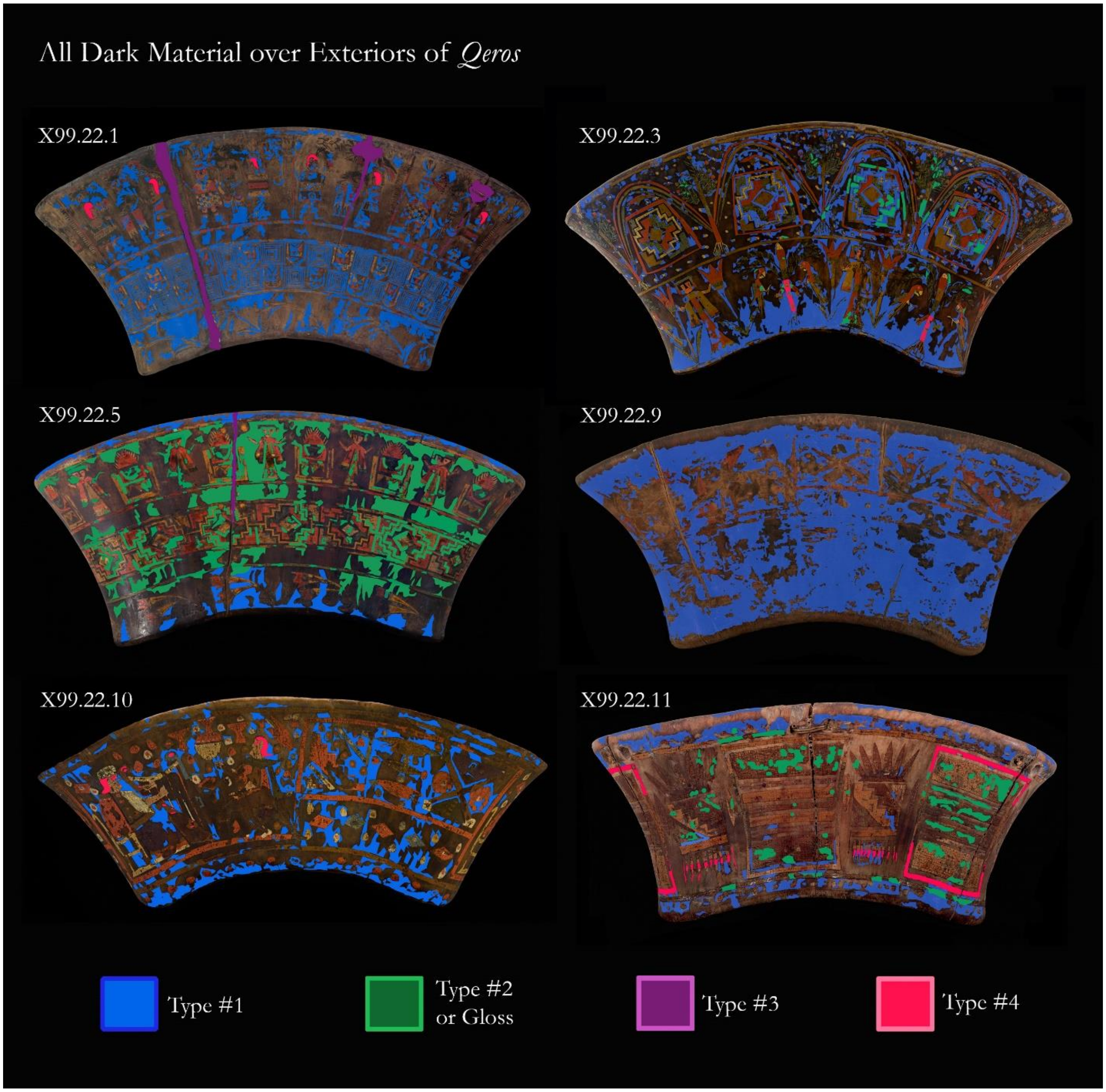


Fig. 8. Results for the distributions of all dark materials over *qero* exteriors. *Note: qeros are not depicted to scale in relation to each other.*

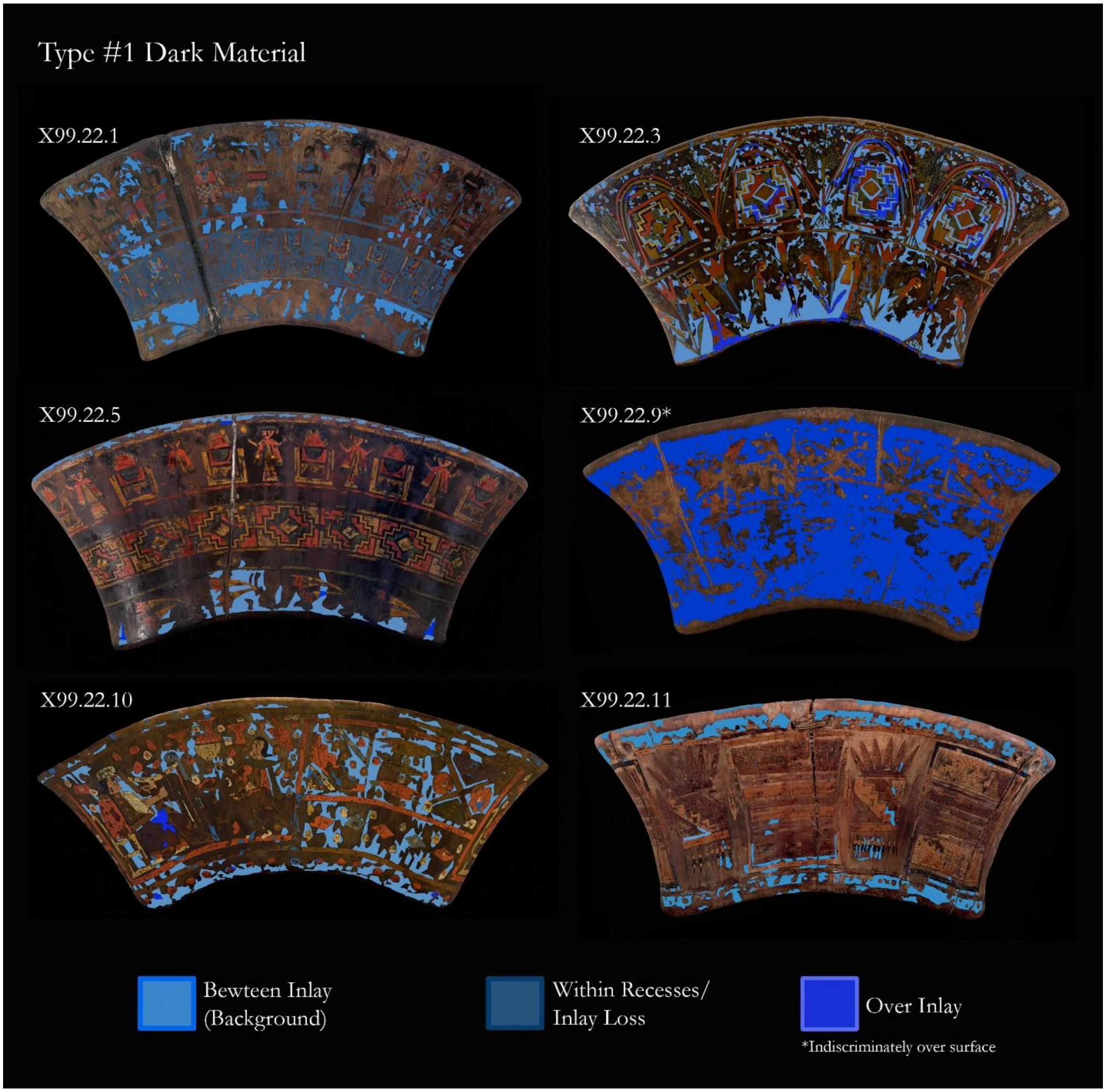


Fig. 9. Type #1 dark material was recorded between inlay, over inlay, and within areas of inlay loss. *Note: qeros are not depicted to scale in relation to each other.*

Type #1 dark material occurred most broadly over the *qeros*, and was defined by its matte and opaque appearance (figs. 9-10). This dark black or brown material sometimes had a purplish tint under magnification and actually appeared to shift towards a reddish hue where it occurred more thinly (fig. 10, right). Overall, opacity and color varied by thickness. Type #1 dark material often looked matte or hazy, though once buffed it became somewhat transparent and shiny.

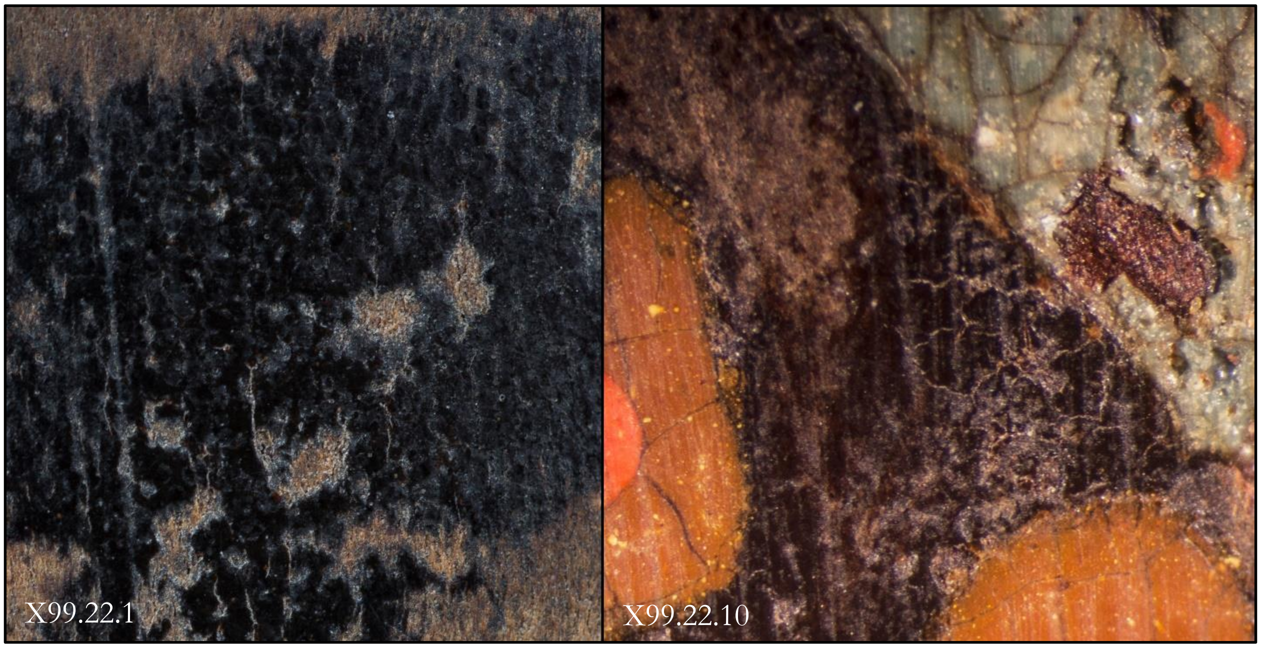


Fig. 10. Type #1 dark material was matte and generally a dark black or brown color (left), though sometimes it seemed to have a deep purplish tint and would shift towards a reddish hue where it was thinner (right).

Fig. 11. Though the majority of Type #1 dark material was recorded in background areas bordering inlay, it also occurred over inlay (left) and within recesses, such as where inlay was lost (right).

Although it was usually located in "background" areas bordering inlay decoration—and especially near the tops and bottoms of the cups—it was sometimes noted over inlay and within recessed areas of inlay loss (figs. 9, 11) In a unique example, *qero* X99.22.9 had this material broadly and indiscriminately covering the expanse of its surface, obscuring the majority of the cup's inlay decoration; RTI helped capture the thickness of the material on its surface (fig. 12).

Fig. 12. Detail of an area on *qero* X99.22.9 using RTI to show Type #1 dark material thickly covering its surface and obscuring the cup's inlay decoration. Rendering Mode: Specular Enhancement (Diffuse Color = 40; Specularity = 70; Highlight Size =75).

Type #2 dark material was a resinous, glossy material that varied from very dark black to a subtle reddish color (fig. 13). This color shift was subjective and seemed to be influenced by the material's translucency, thickness, and the angle of light under which it was viewed. Its translucency was particularly evident under magnification, and particles of color were sometimes distinguishable deep within, or perhaps below, the material (fig. 14). Type #2 dark material was nearly exclusive to *qero* X99.22.5, and was not recorded at all on *qeros* X99.22.1, X99.22.9, or X99.22.10. Again, it was found between and over inlay, and within areas of inlay loss (fig. 15); material over inlay was not easily distinguished from Gloss, leading to areas labeled as "Type #2 or Gloss".

Fig. 13. Type #2 dark material was very glossy with a translucent quality. It typically looked fairly black (top), though had an obvious reddish tint at times depending on its thickness and the angle of light (bottom).

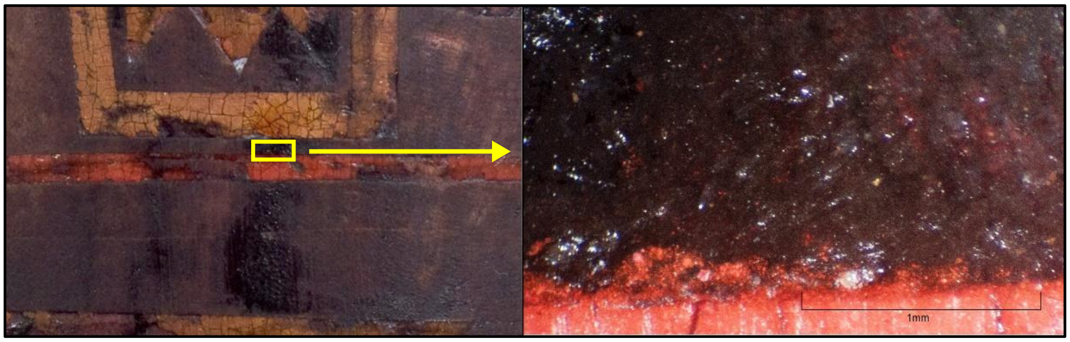


Fig. 14. Colored particles were sometimes seen within or below the material.

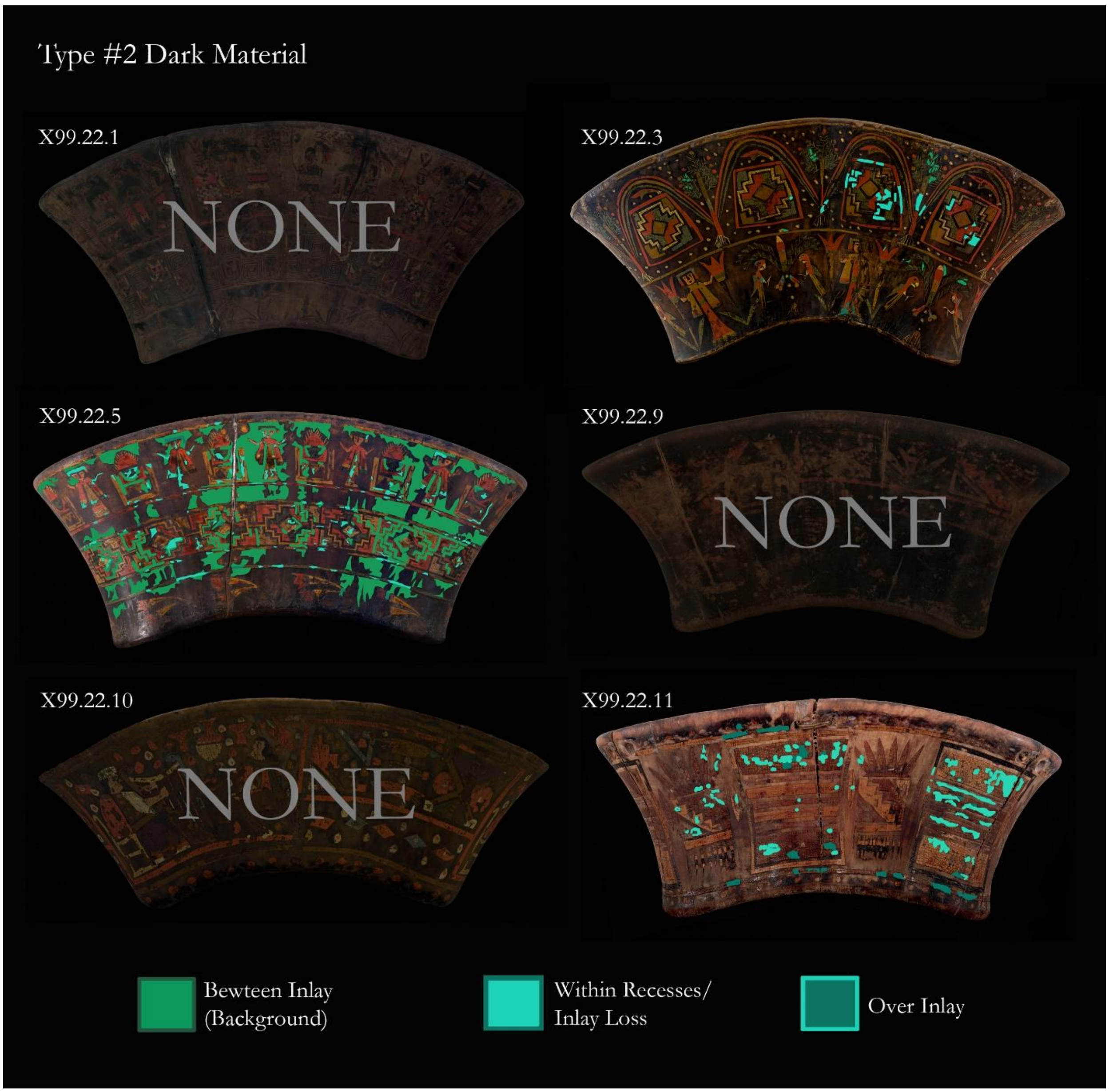


Fig. 15. Type #2 dark material was recorded between inlay, over inlay, and within areas of inlay loss. *Note: qeros are not depicted to scale in relation to each other.*

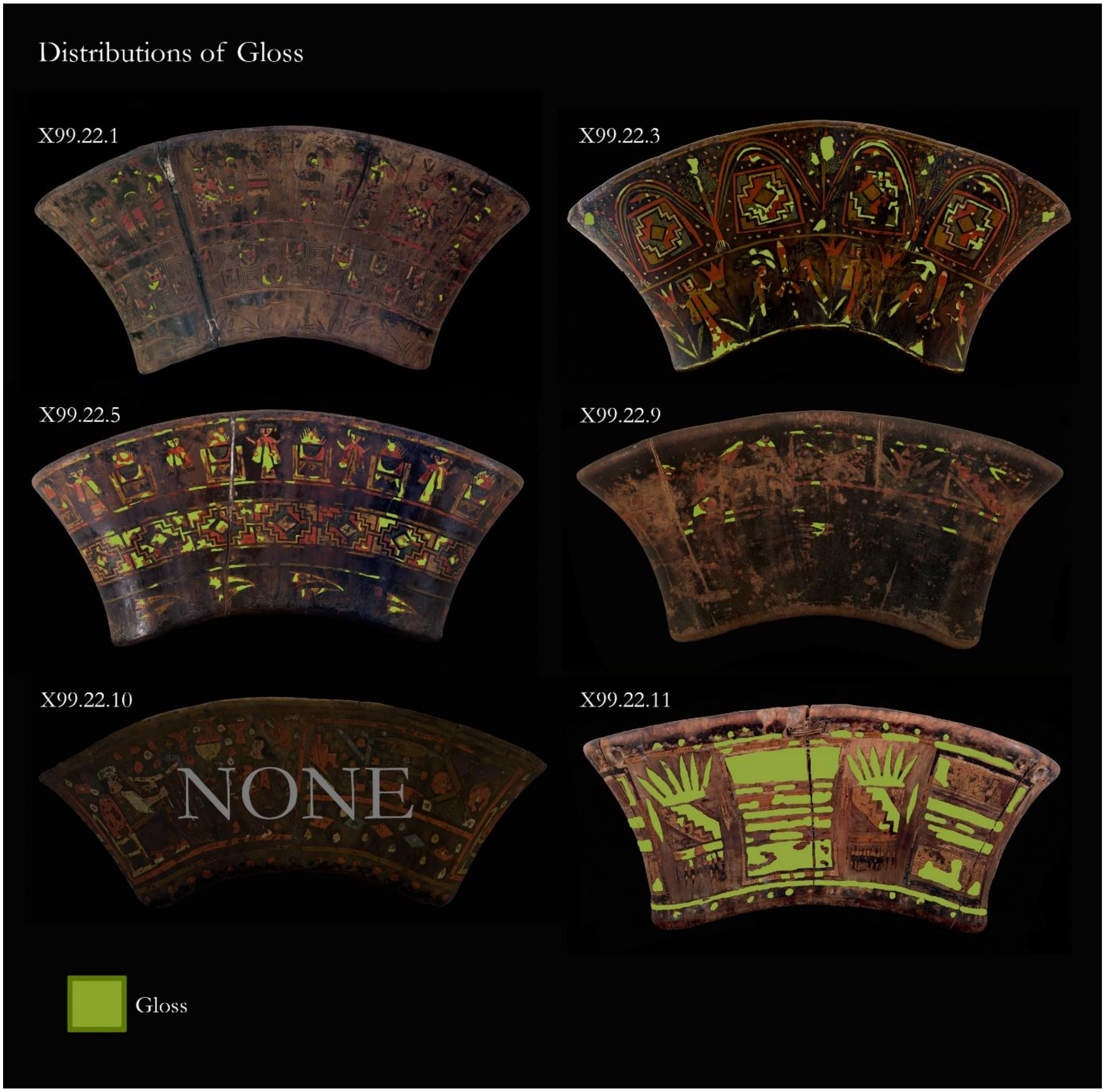


Fig. 16. Results for the distribution of material called "Gloss" on *qero* exteriors. *Note: qeros are not depicted to scale in relation to each other.*

Gloss refers to a largely colorless, transparent material which coated surfaces over polychrome inlay (fig. 16). It was most notable on *qeros* X99.22.3, X99.22.5, and X99.22.11, and observed to a lesser and more isolated degree on *qeros* X99.22.1 and X99.22.9. Areas of Gloss were not recorded on *qero* X99.22.10. Its distribution clearly suggested a relationship with Type #2 dark material (fig. 17), such as on *qeros* X99.22.5 and X99.22.11, however it was classified separately because it appeared to have

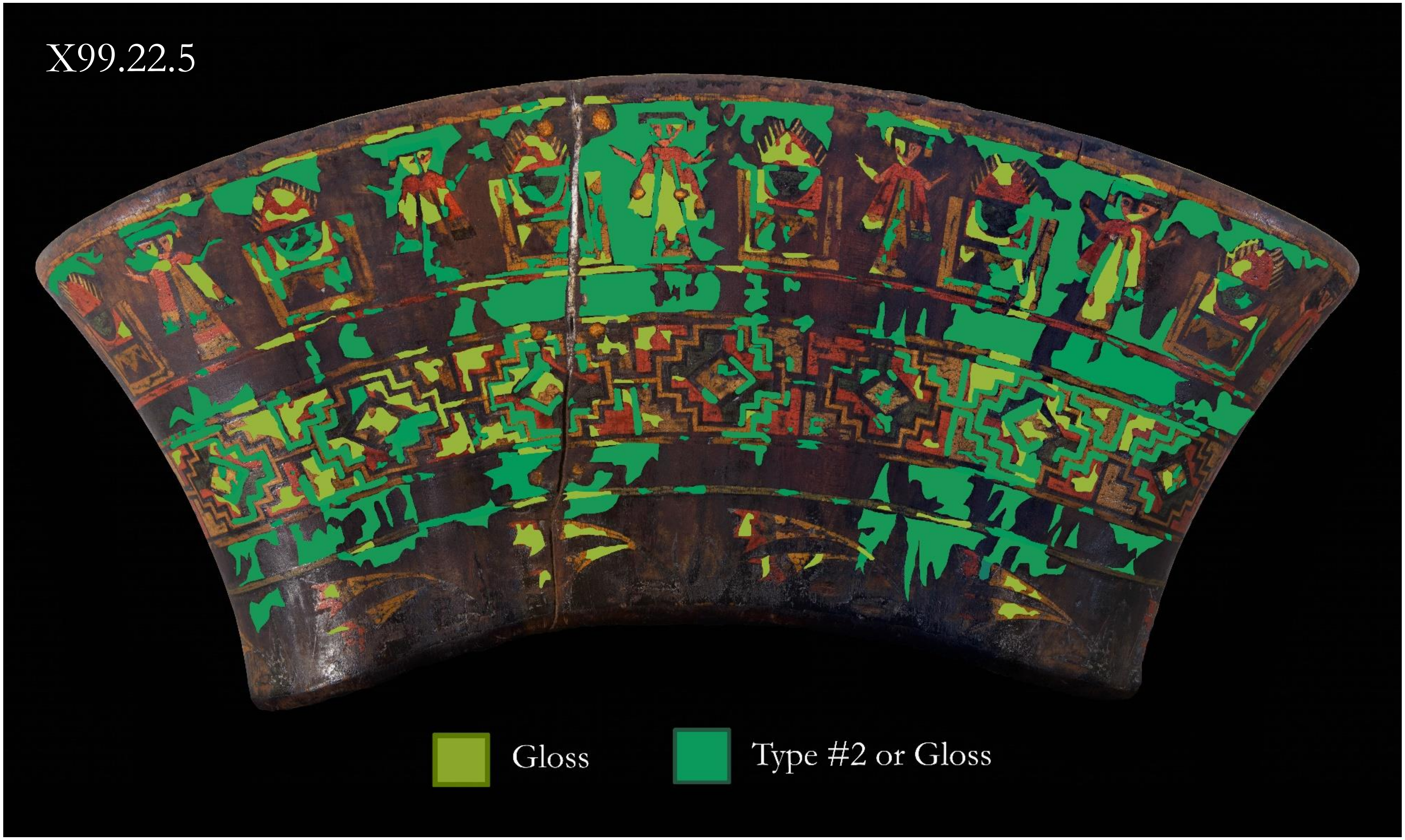


Fig. 17. Mapping showed a clear relationship between Gloss and Type #2 dark material, which was also glossy in nature.

significantly greater translucency (fig. 18, top). Given this translucency and a brownish or reddish tint at times, Gloss often visually altered the color of the polychrome inlay it covered (fig. 18, middle). It often appeared to seep out of craquelure (fig. 18, bottom) and "pool" in the middle of an inlay area, for instance making red inlay look darker in color towards the center.

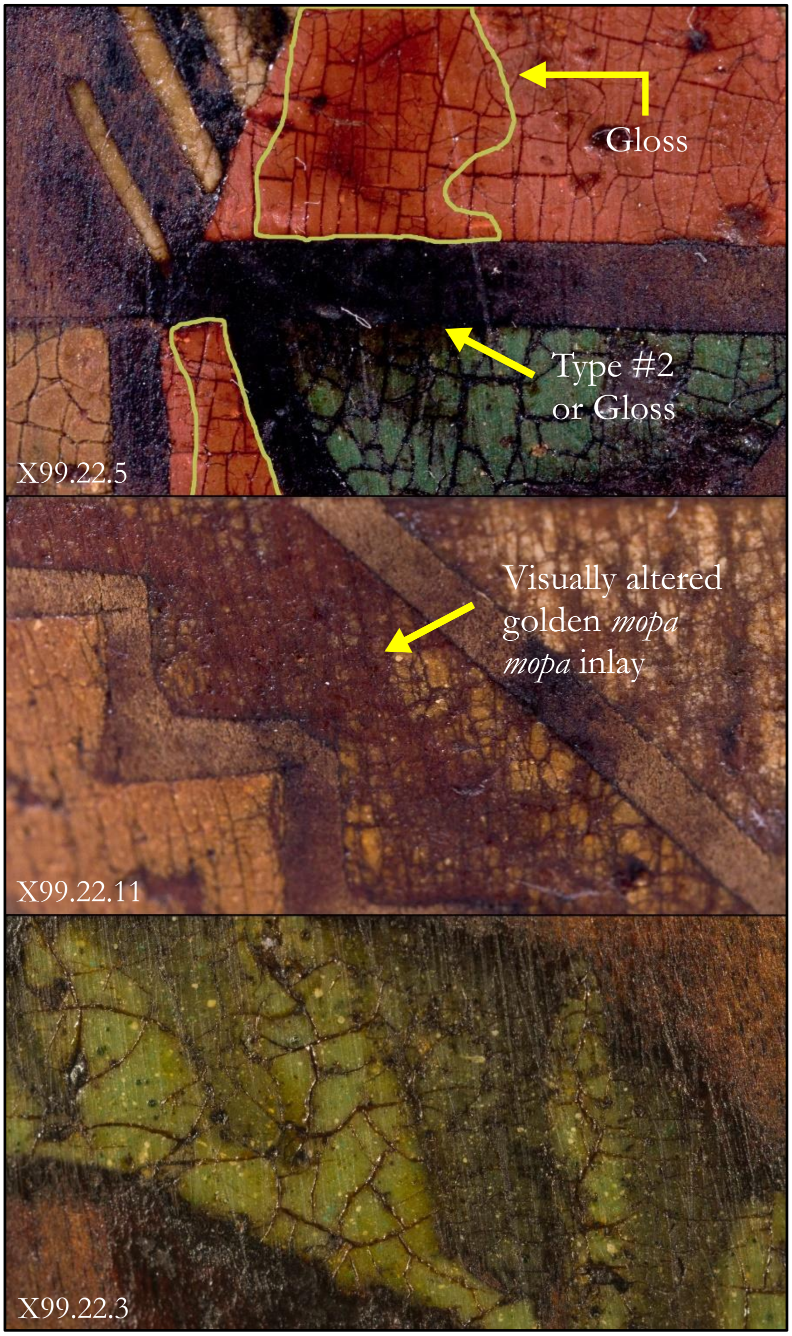


Fig. 18. Gloss material, related to Type #2, covered areas of inlay, visually altering its color and appearing to seep from cracks.

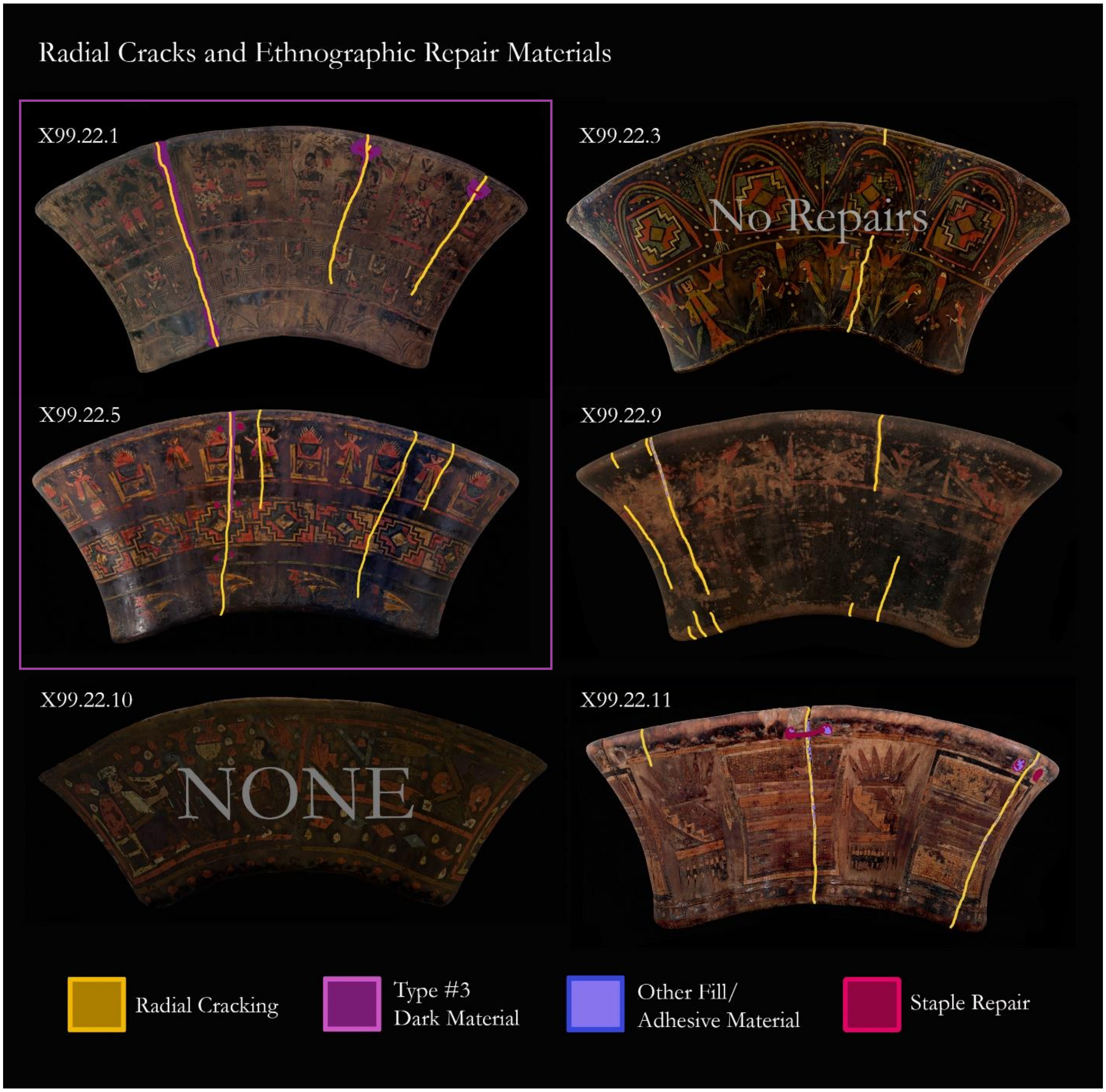


Fig. 19. Most *qeros* contained radial cracks which had received some type of repair, including Type #3 dark material on *qeros* X99.22.1 and X99.22.5. *Note: qeros are not depicted to scale in relation to each other.*

Dark ethnographic repair materials, classified as Type #3, occurred on *qeros* X99.22.1 and X99.22.5, along with other interventions across the group that addressed radial cracking in the walls of the cups (fig. 19). Type #3 was usually quite gummy and resinous, sometimes appearing bulked with plant or hair fibers, and was applied within radial cracks and around staple holes that straddled the cracks (figs. 20-21).

Fig. 20. Dark material was used on *qero* X99.22.1 to mitigate radial cracking in the wood.

Fig. 21. Repair material on *qero* X99.22.5 showed organic fibers and a white efflorescence.

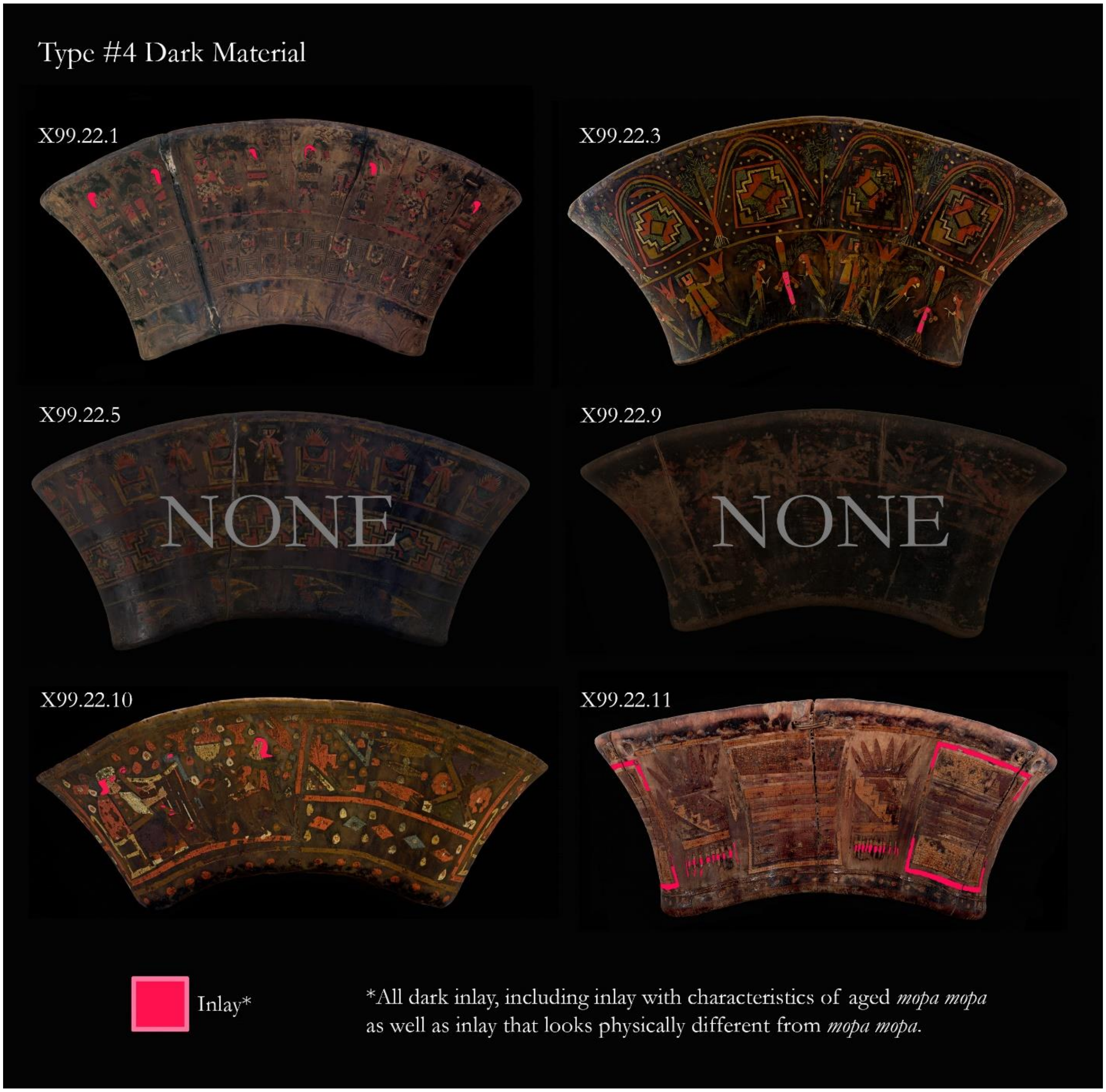


Fig. 22. There were four *qeros* that contained dark inlay; two appeared to be *mopa mopa* and the other two appeared physically different. *Note: qeros are not depicted to scale in relation to each other.*

Four *qeros* (X99.22.1, X99.22.3, X99.22.10 and X99.22.11) had inlay classified as Type #4 dark material (fig. 22). The dark inlay used for tree trunks on *qero* X99.22.3 and for figures' hair on *qero* X99.22.10, had a rectangular craquelure pattern consistent with aged *mopa mopa* (fig. 23). However, the dark inlay used for the hair of figures on *qero* X99.22.1 and in the linear designs on *qero* X99.22.11, looked more characteristic of other dark surface materials: no rectangular craquelure, a reddish tint, and a semi-translucent matrix (fig. 24). Using different rendering modes in RTI, an area was captured on *qero* X99.22.1 which contained Type #1 dark material outside of Type #4 dark inlay; both appeared to have a unique texture from the nearby *mopa mopa* inlay (fig. 24, bottom).

Fig. 23. *Qeros* X99.22.3 and X99.22.10 contained dark inlay with craquelure consistent with *mopa mopa* inlay; adjacent dark material outside of inlay did not display this rectangular cracking pattern (left).

Fig. 24. *Qeros* X99.22.1 and X99.22.11 contained dark inlay physically unlike *mopa mopa* (top), and an area imaged using RTI on *qero* X99.22.1 showed its unique surface texture (bottom). Rendering Mode: Coefficient Unsharp Masking (Gain = 60); Rendering Mode: Diffuse Gain (Gain = 40).

Finally, Type # 5 dark material referred to material that extended over the rims of the *qeros* and coated their interiors. This material was distinguished by its particular thickness and unusual "wrinkled" surface that was characterized by a raised network of cracks (see "blistering" in Appendix D) (fig. 25).

Fig. 25. Every *qero* studied had dark material coating their interiors. Interior surfaces ranged from smooth (top) to rough or "winkled" (bottom).

5.1.2 UV-induced Visible Fluorescence

The *qeros* had an overall hazy, greenish-yellow UV-induced visible fluorescence that can be attributed to their tropical wood (Lafleur et al. 2002) (Appendix F), though the presence of surface materials created nuances in this fluorescence. When studying areas between polychromy, the fluorescence of dark material in relation to the fluorescence of bare wood was not consistent across the group of cups.

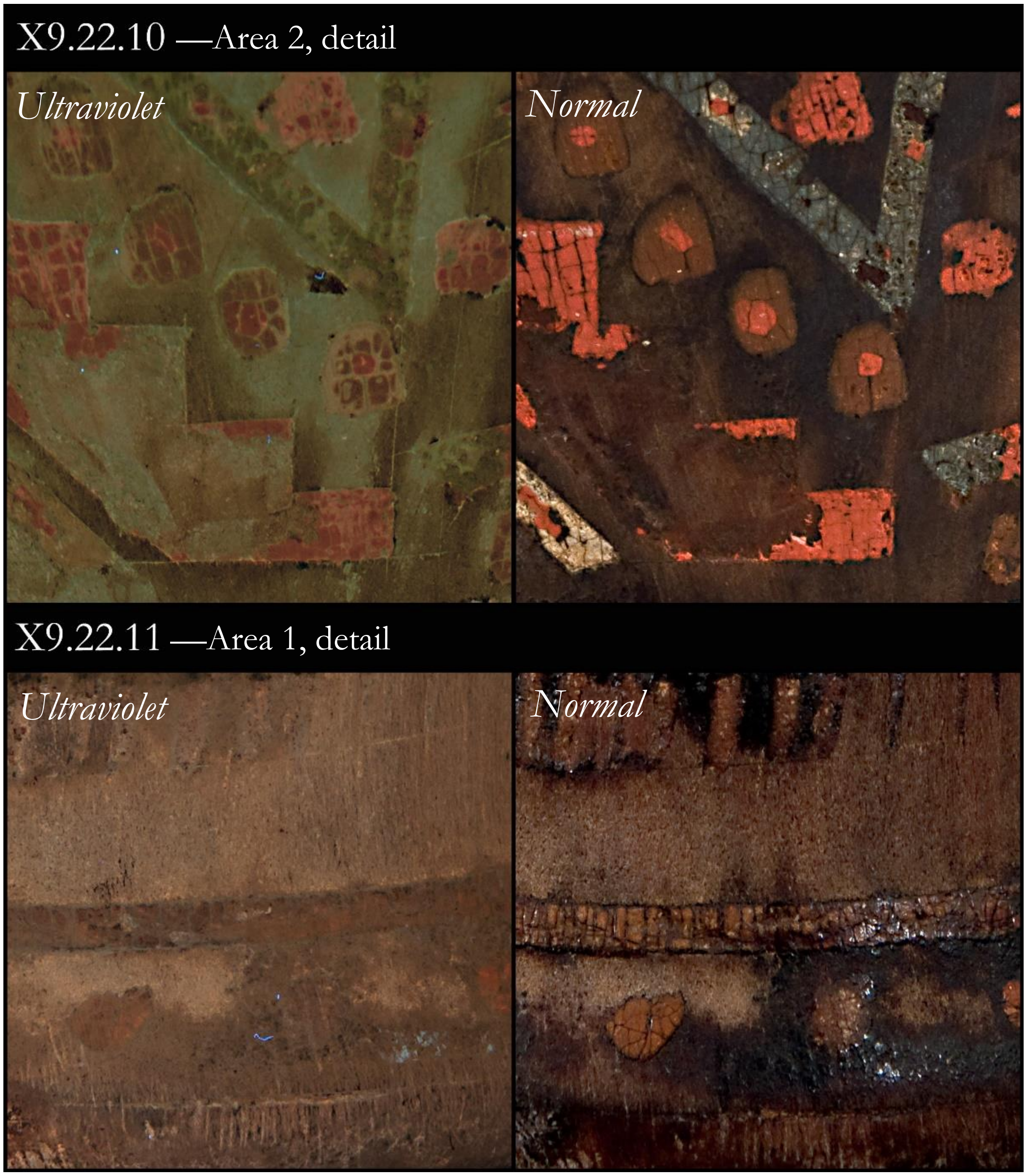


Fig. 26. On some cups, the dark material appeared more reflective and lighter than the wood under UV radiation (top) while other cups had darker, more absorbing dark material (bottom). Both instances of dark material were more fluorescent than the wood.

For *qeros* X99.22.9 and X99.22.11, the dark material appeared much darker and more absorbing than the bare wood, yet this contrast was reversed for *qeros* X99.22.3, X99.22.5, and X99.2. 10, which showed dark material to be brighter and more reflective than bare wood surfaces (fig. 26); this could be explained by differences in the woods and/or differences in the dark material.

Fig. 27. Area 3 on *qero* X99.22.1 shows the varied fluorescence of dark material in relation to the bare wood under UV radiation.

Qero X99.22.1 seemed to have variable results over its own surface: areas of both Type #1 dark material and bare wood ranged from a lighter to darker muddy, yellowish color, making the two not overwhelmingly distinct from each other (fig. 27). Areas of wood that appeared bare perhaps contained grime, skin oils, or trace amounts of dark material which may have created this inconsistent fluorescence. In some instances, there were absorptions in vertical lines that did not match areas viewed as bare wood or dark material in normal light (fig. 28); this pattern mimicked scraping marks observed over *qero* surfaces (see 5.2.3 Condition Features and the Loss of Dark

Material) and may allude to areas of the wood more deeply scraped (absorbing) versus areas that still retain remnant dark material (reflecting).

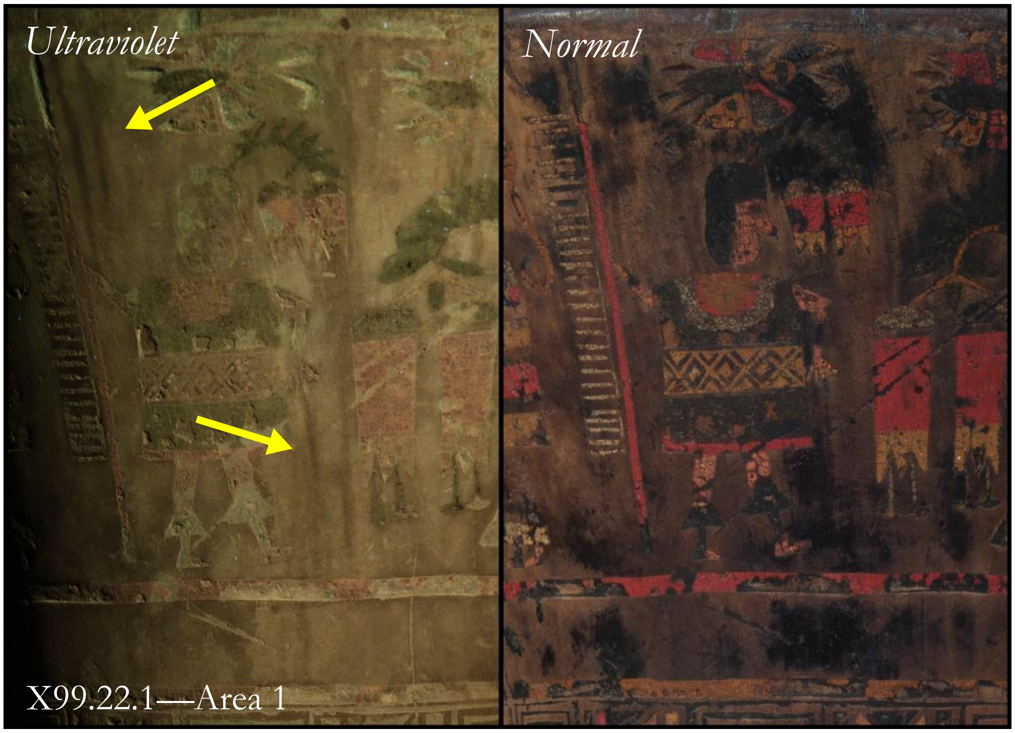


Fig. 28. UV examination showed vertical lines of absorption in background areas on *qero* X99.22.1, which did not match areas of bare wood or dark material observed under normal light.

Qero X99.22.10 showed traces of a very absorbing, practically black, material directly around inlay, which was not differentiated from other dark "background" material in normal light (fig. 29). Study under UV radiation also clearly showed a coating over the inlay on *qero* X99.22.10 that was not seen under normal light, which caused areas of *mopa mopa* to have the same hazy, yellowish-grey color as dark areas outside of inlay (fig. 29). Gloss and Type #2 dark material on *qeros* X99.22.3 and X99.22.5 fluoresced a very light, yellowish-grey color, both over and between inlay (fig. 30)—not unlike Type #1 dark material on the same cups—and examination under UV also showed where Gloss was likely present over inlay which was not visible during regular examination due to its colorless nature. For *qero* X99.22.11, annotated areas of Gloss showed no distinct UV-induced visible fluorescence (fig. 30, bottom).

Dark repair material, Type #3, was easily identified under UV on *qeros* X99.22.1 and X99.22.5, appearing an orange-brown or a bright, yellowish-orange color. Also, an area suspected to contain a repair to the decoration on *qero* X99.22.3 was confirmed as having dark material and inlay dissimilar to the surrounding surface materials (fig. 31).

Fig. 29. On *qero* X99.22.10, several areas of inlay appeared to be coated by a more reflective material under UV radiation, which was not apparent under normal light.

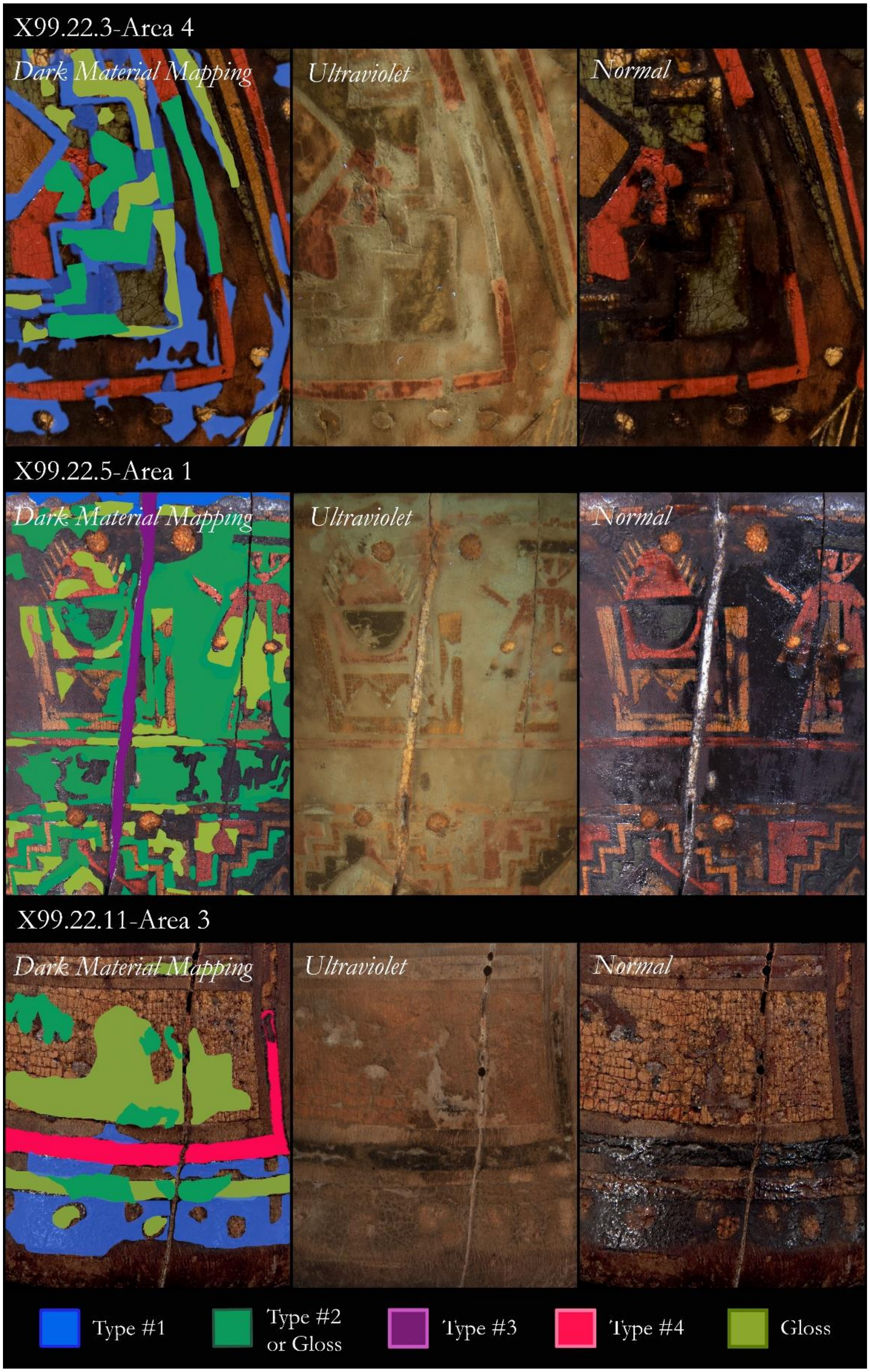


Fig. 30. On *qeros* X99.22.3 and X99.22.5, Gloss and Type #2 dark material fluoresced a very light, yellowish-grey color under UV radiation (top, middle), yet was not differentiated on *qero* X99.22.11 (bottom).

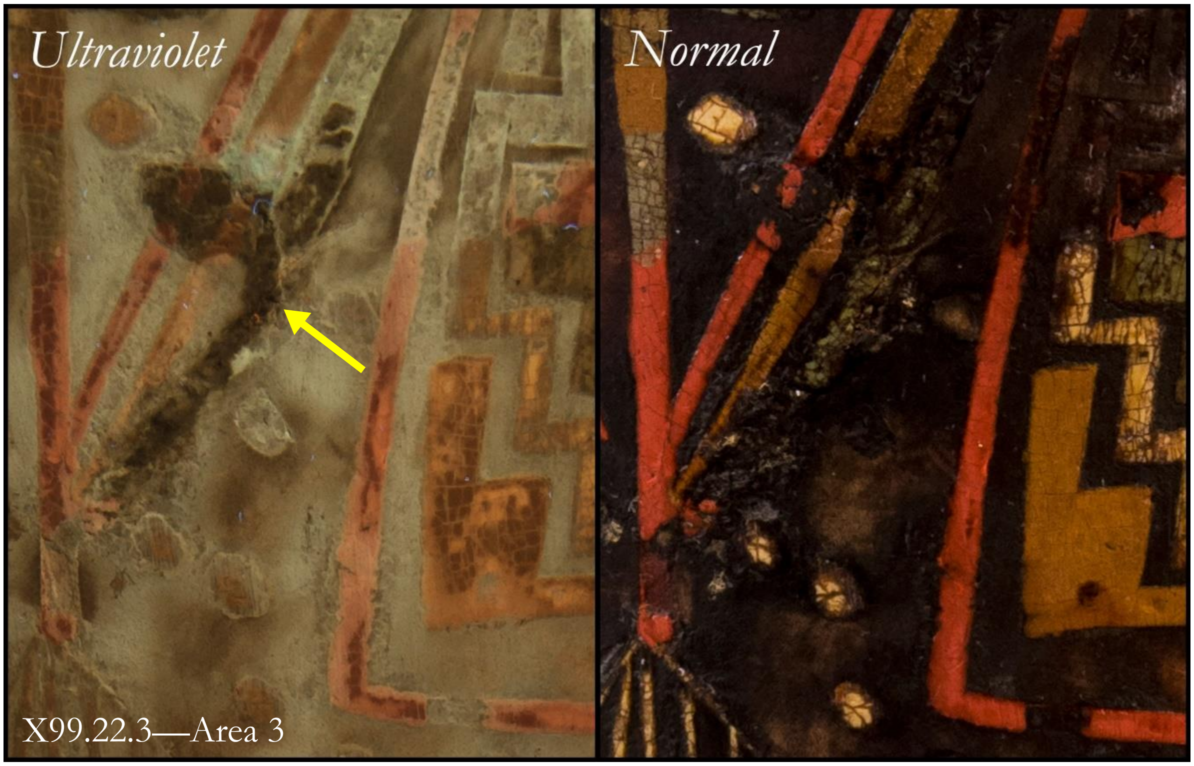


Fig. 31. Examination under UV confirmed the presence of a repair to decoration in an area on *qero* X99.22.3.

Fig. 32. On *qero* X99.22.3, dark inlay consistent with *mopa mopa* was very absorbing under UV radiation (Type #4), distinguishing itself from dark material on the surface outside of inlay (Type #1).

For Type #4 dark material, inlay with a craquelure like *mopa mopa* was dark and absorbing, contrasting with dark material outside of inlay areas (figs. 29, 32). This was also true for dark inlay on *qero* X99.22.11, even though it had appeared physically different from *mopa mopa* in normal light (figs. 30, 33). *Qero* X99.22.1 also contained dark inlay that looked dissimilar from *mopa mopa*; it was somewhat dark and absorbing under UV as well, however it appeared mottled as if parts were coated by another, more reflective, material (fig. 33).

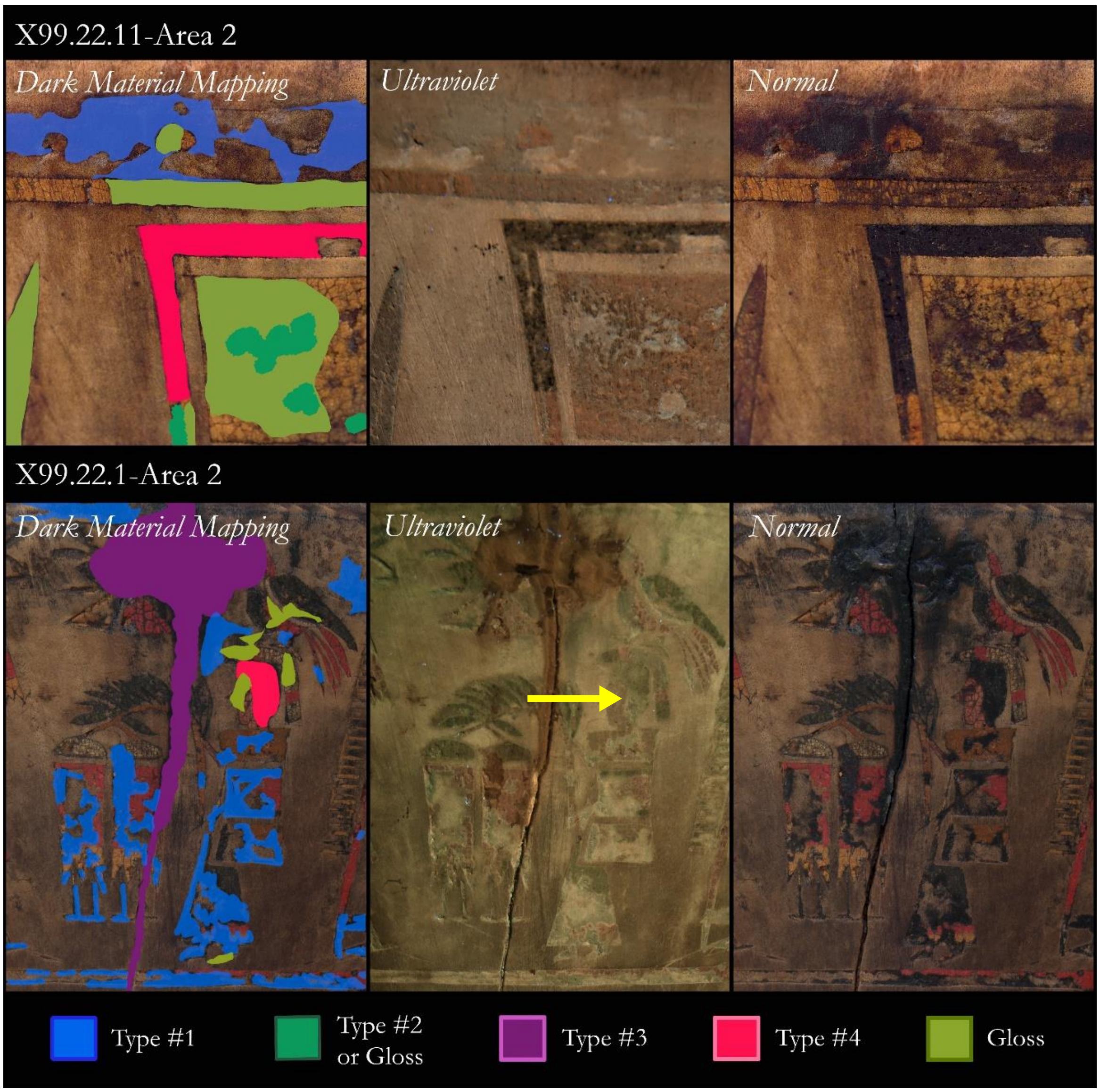


Fig. 33. Dark inlay (Type #4) on *qero* X99.22.11 was very absorbing under UV compared to dark material on the surface around inlay (Type #1), and dark inlay on *qero* X99.22.1 seemed to have a mottled fluorescence as though covered by a different material in areas.

5.2 Visual Analysis and Documentation: Condition Features

5.2.1 Categorization

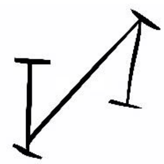
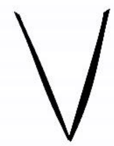
Notable condition features were divided into two groups: those that related to the characterization of surface materials, and those that related to the loss of dark material (Tables 3-4). Priority was placed on documenting and mapping those that potentially related to dark material loss, however examples of every condition feature were provided for each cup (when applicable) following survey forms in Appendix B, and all features were defined in a Condition Visual Glossary (Appendix D).

Table 3. Categorization of Condition Features

Related to Dark Material Loss	
Abrasion*	*Interventions or Modifications
Carved Marks*	
Pocking	
Scraping*	
Wear	
Related to Material Characterization	*Associated with*
Blistering	Dark Material
Block-shaped Losses	*Mopa Mopa*
Bubbling	Dark Material
Craquelure	Dark Material and *Mopa Mopa*
Efflorescence	Dark Material
Gouges	Wood and Dark Material
Pitting	*Mopa Mopa*
Pocking	Dark Material
Visually Altered Color	*Mopa Mopa*, but caused by dark or glossy materials

*"Interventions or Modifications" means these are condition phenomena that appear unrelated to the fabrication or typical use of the cups, and look to have occurred due to an individual mechanically intervening or modifying the surface. For "Carved Marks," this only refers to carvings on the exterior of the cups, and not marks on their undersides which may be maker's or owner's marks (see Table 4).

Table 4. Carved Marks on the *Qeros*

Qero	*X99.22.1*	*X99.22.3*	*X99.22.5*[3]	*X99.22.9*	*X99.22.10*	*X99.22.11*
Period	Colonial	Colonial	Colonial	Colonial	Late Colonial	Early Colonial
Carved Marks on Exterior[1]		-----		-----	-----	-----
Carved Marks on Underside[2]	-----	-----	-----			

[1] A repeating pattern

[2] Possible maker's or owner's marks

[3] A similar triangular pattern was carved onto another Fowler *qero* (X99.22.12), not chosen for this study.

5.2.2 Conditions Related to Material Characterization

A number of condition phenomena were noted for particular materials which may be relevant for their identification (Appendix C; figs. 34-40).

Type #1 dark material, when present more thickly on the surface, displayed an irregular cracking pattern, or craquelure, distinct from the rectangular craquelure typical of aged *mopa mopa*. This cracking resulted in dark material experiencing pockets of loss like "pockmarks," as opposed to *mopa mopa's* more rectilinear, block-shaped losses (fig. 34).

A white efflorescence, perhaps an organic bloom, was commonly seen with every type of dark material, save for dark inlay: it occurred with Type #1 material, particularly within recesses on *qero* exteriors; with Type #2 material on *qero* X99.22.3; with Type #3 material on *qero* X99.22.5; and with

Fig. 34. Dark material showed an irregular cracking pattern with pockmark losses, while *mopa mopa* had a rectangular craquelure and block-shaped losses.

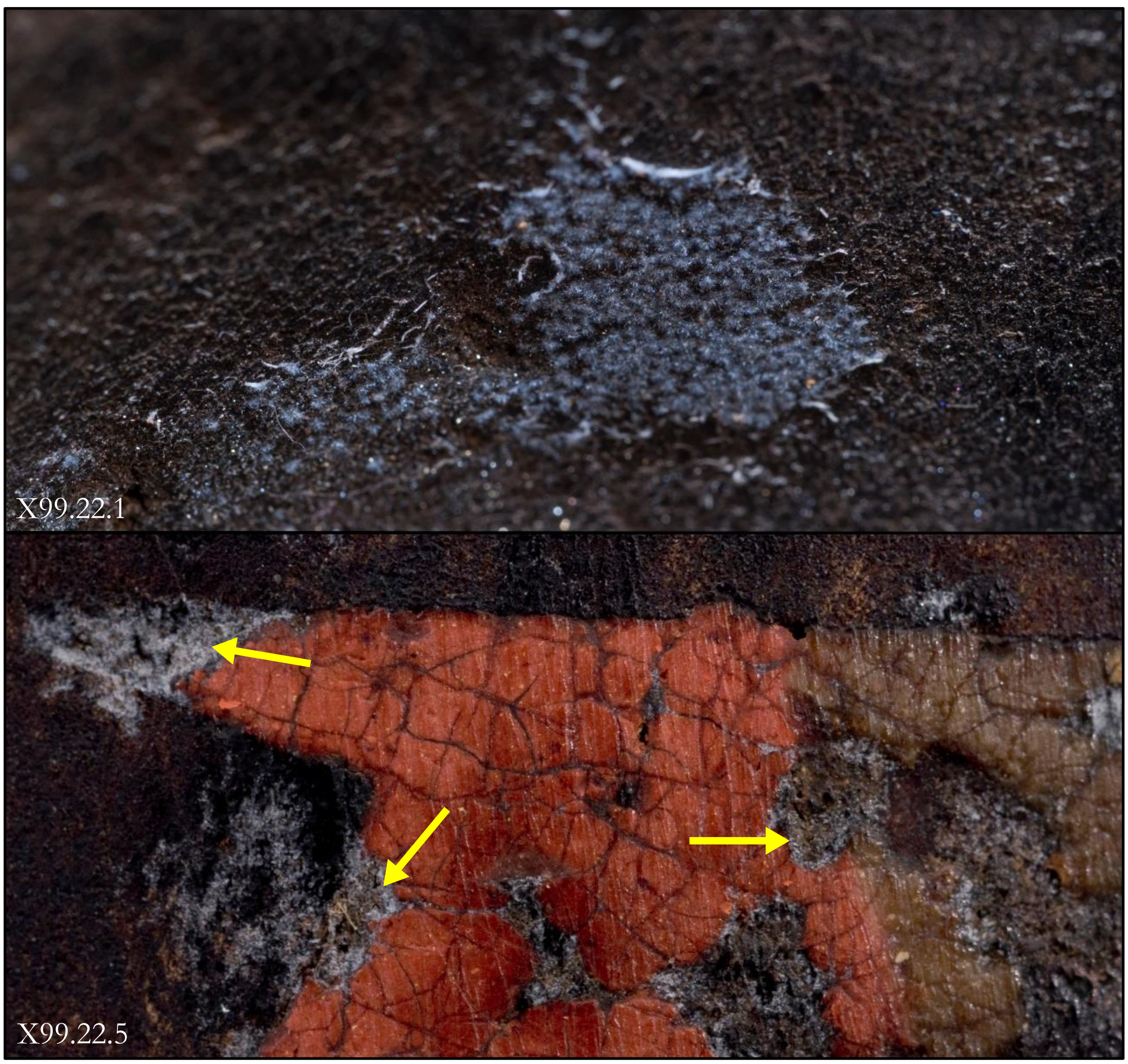


Fig. 35. A white efflorescence was on lower cup interiors (top) and sometimes within recessed areas on the exterior of cups (bottom).

Fig. 36. Dark material on upper *qero* interiors often displayed a "wrinkled" surface, called blistering, following a raised network of cracks. *Qero* X99.22.5 appeared coated by Gloss.

Type #5 dark material in lower *qero* interiors (fig. 35).[19] Interior dark material also often displayed "blistering"—a pattern of raised cracks creating a rough, wrinkled topography on upper *qero* interiors (fig. 36). Blistering on *qero* X99.22.3 was subtle, and *qero* X99.22.10 lacked it completely. The interior of *qero* X99.22.5 appeared to be coated by Gloss, like its exterior (fig. 36, middle).

Fig. 37. Type #2 dark material had a rough, bubbly nature. Rendering Mode: Specular Enhancement (Diffuse Color = 40; Specularity = 80; Highlight Size = 40).

On *qero* X99.22.5, Type #2 dark material sometimes had a bumpy, "bubbling" texture (fig. 37). The inverse was seen in certain areas of *mopa mopa* inlay, where an unusual pitting occurred, such as on *qero* X99.22.1 and within a vertical, columnar region down the side of *qero* X99.22.10 (fig. 38).

[19] In a paper submitted for the NYU Conservation Program by Patricia S. Griffin in 1991 (Griffin, unpublished), Griffin performed analysis on dark material on the interior of a *qero* from the NMAI (19/901) which contained this efflorescence, as well as analyzed the efflorescence itself, aiming to identify its source. Being a mixture of stearic and palmitic acids, she concluded that the efflorescence was caused by an aged, fatty organic material. She further indicates through GC/MS results that it is likely the corn beer *chicha* that is responsible for the organic bloom, or possibly a fatty deposit related to the wood or an application to the wood. She did not find a relationship between the dark material of the *qero*'s interior and the efflorescence.

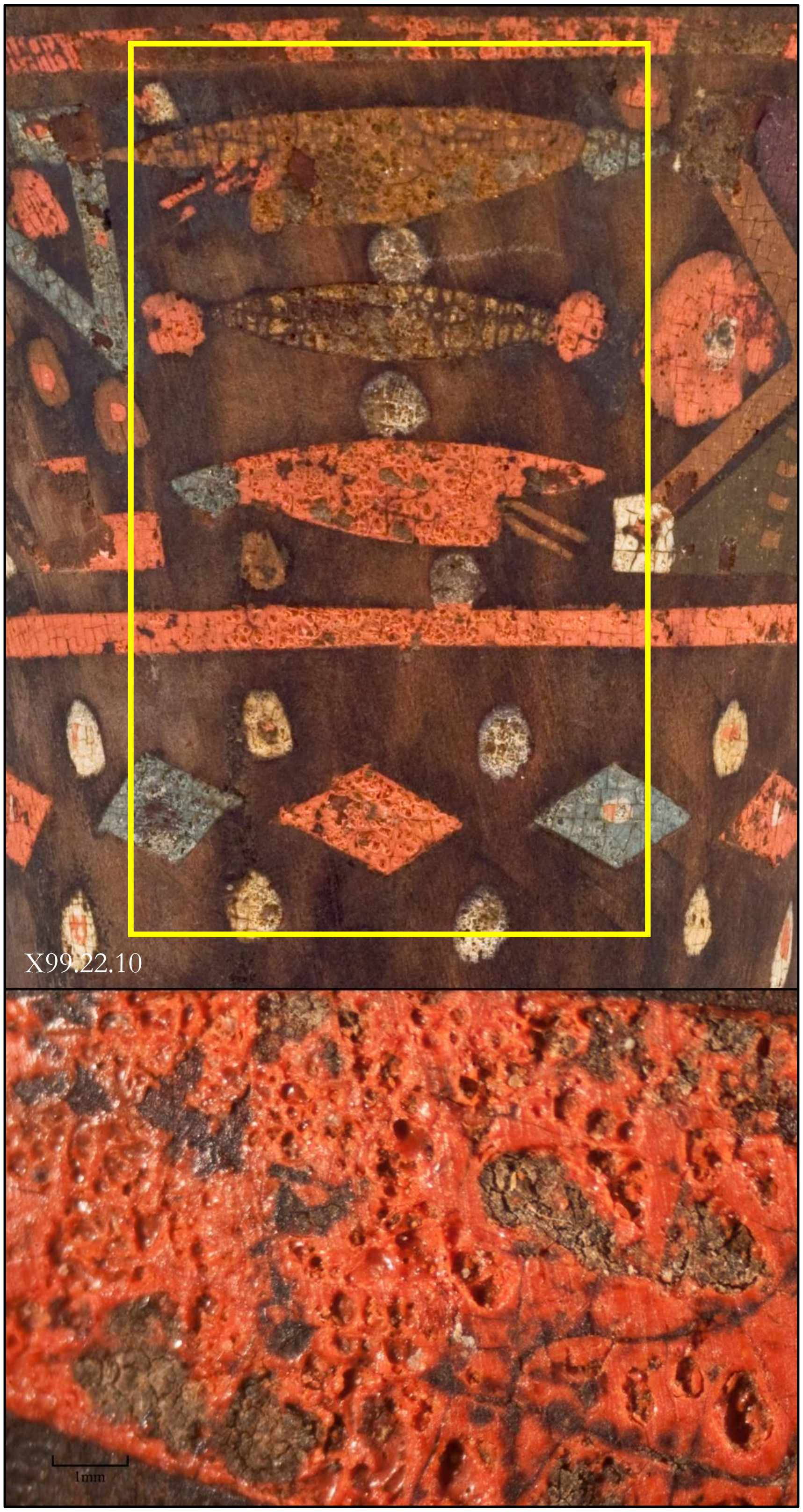


Fig. 38. Some *mopa mopa*, especially in an area on *qero* X99.22.10, showed pitting in its surface.

“Visually altered color” was used to describe areas of *mopa mopa* polychromy whose color clarity appeared affected by a coating of Gloss or dark material. Golds and pale yellows looked dirtied or stained, red colors intensified, and green inlay sometimes appeared nearly black on *qeros* X99.22.1, X99.22.3, and X99.22.5 (figs. 18, 39).

Large gouges from the cups’ rims were also common across the group, and dark material was often noted within these recesses, covered by a cracking, beige sediment (fig. 40).

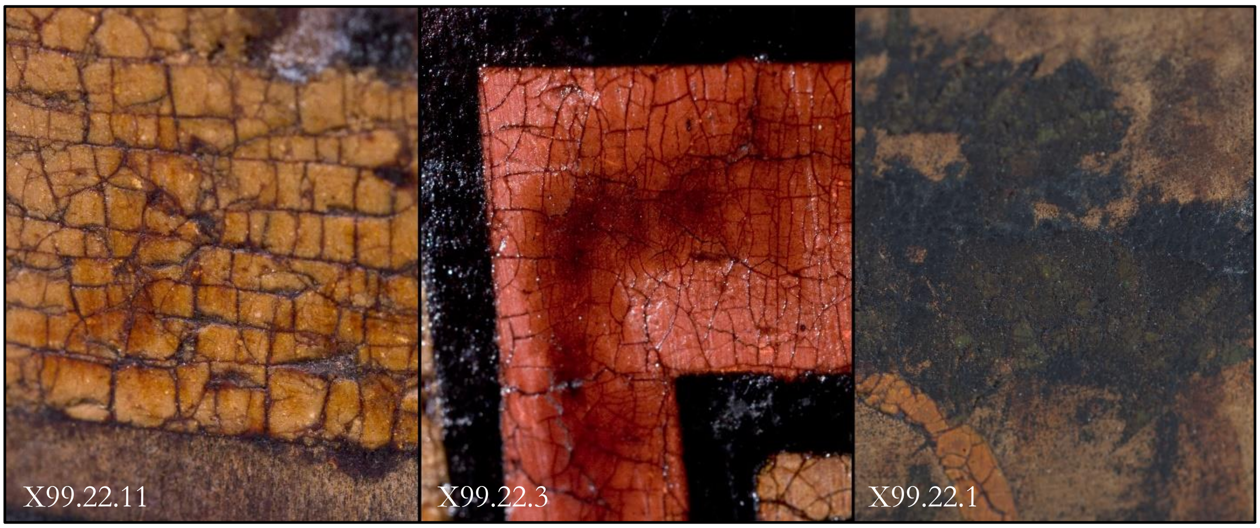


Fig. 39. “Visually altered color” included areas of gold or yellow inlay that looked stained (left), red inlay that had an intense color towards its center (middle) and green inlay that looked nearly black (right).

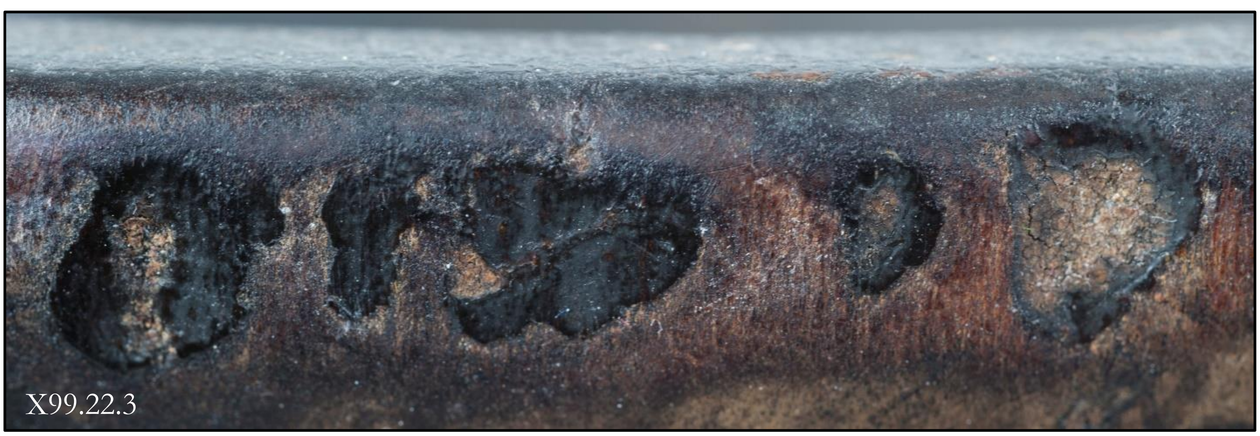


Fig. 40. Most *qeros* had a range of gouges out of their rims, which often contained dark material covered by a granular, beige sediment.

5.2.3 Condition Features and the Loss of Dark Material

Both abrasion and scraping, documented on every *qero* except for X99.22.9, were principally responsible for the loss of dark material. RTI proved a particularly useful technique in substantiating the presence of scraping marks and abrasion, elaborating on their depth, orientation, prevalence and effect in relation to surface materials.

Tool marks, interpreted as "scraping," were found in areas outside of inlay and appeared to specifically target the removal of dark material (figs. 41-48). Some of the most dramatic marks were on *qeros* X99.22.3 and X99.22.10 (figs. 43, 45-48). When studying the interactive RTI files, it was clear how the tool impacted the surface of the *qero*, shallowly shaving the wood or leaving hitched divots that punctuate the ends of repetitive scraping motions. Traces of dark material remained closely bordering *mopa mopa* inlay, demonstrating the careful avoidance of inlay during removal, though there was an isolated instance on the rim of *qero* X99.22.10 where *mopa mopa* inlay itself seemed to have been gouged out (fig. 48, middle). Also unlike the other *qeros*, X99.22.10 was scraped on its interior as well (fig. 48, bottom). From this angle, a ribboning of striations from the scraping tool were legible.

Fig. 41. Shallow divots on every *qero* (except X00.22.9) appeared to be evidence of tools being used to scrape dark material from the surface.

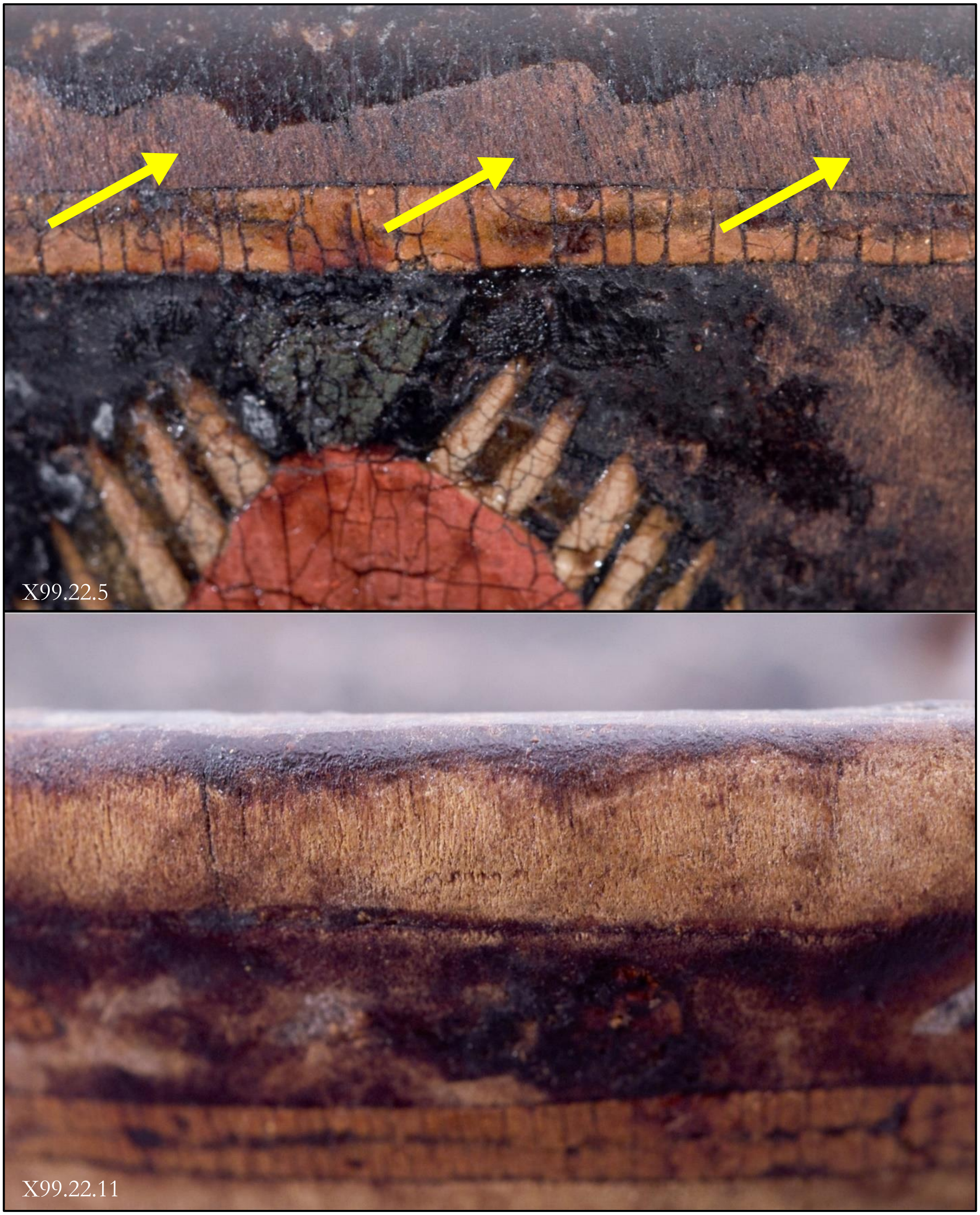


Fig. 42. Scraping was commonly seen near the rims of the cups, clearly showing a repetitive motion used to remove dark material (top), which sometimes shallowly shaved the wood (bottom).

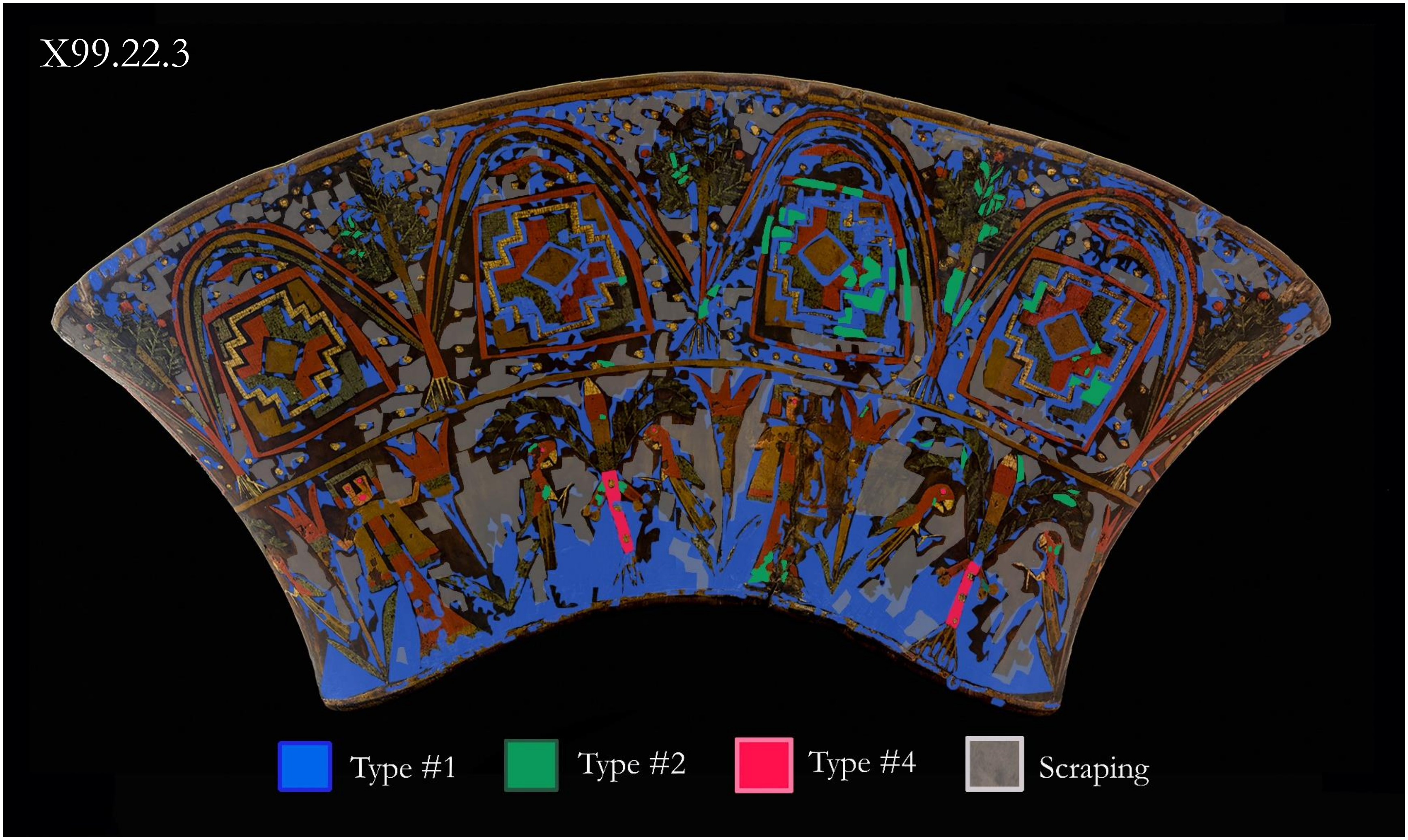


Fig. 43. Mapping scrape marks against the presence of dark material showed that scarping directly corresponded to the absence of dark material on the surface.

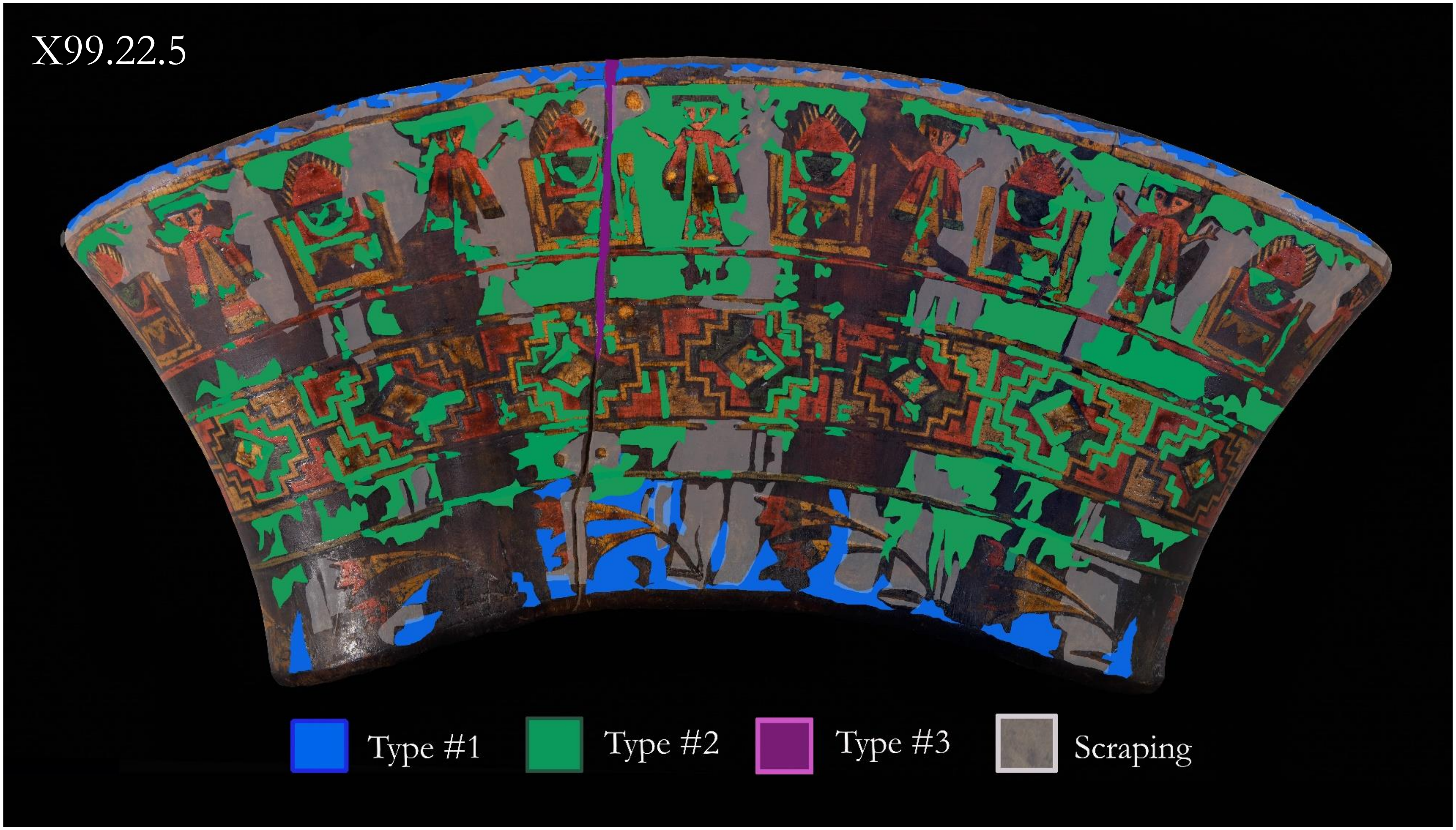


Fig. 44. *Qero* X99.22.5 mapping also clearly showed the relationship between scraping and the absence, or loss, of dark material.

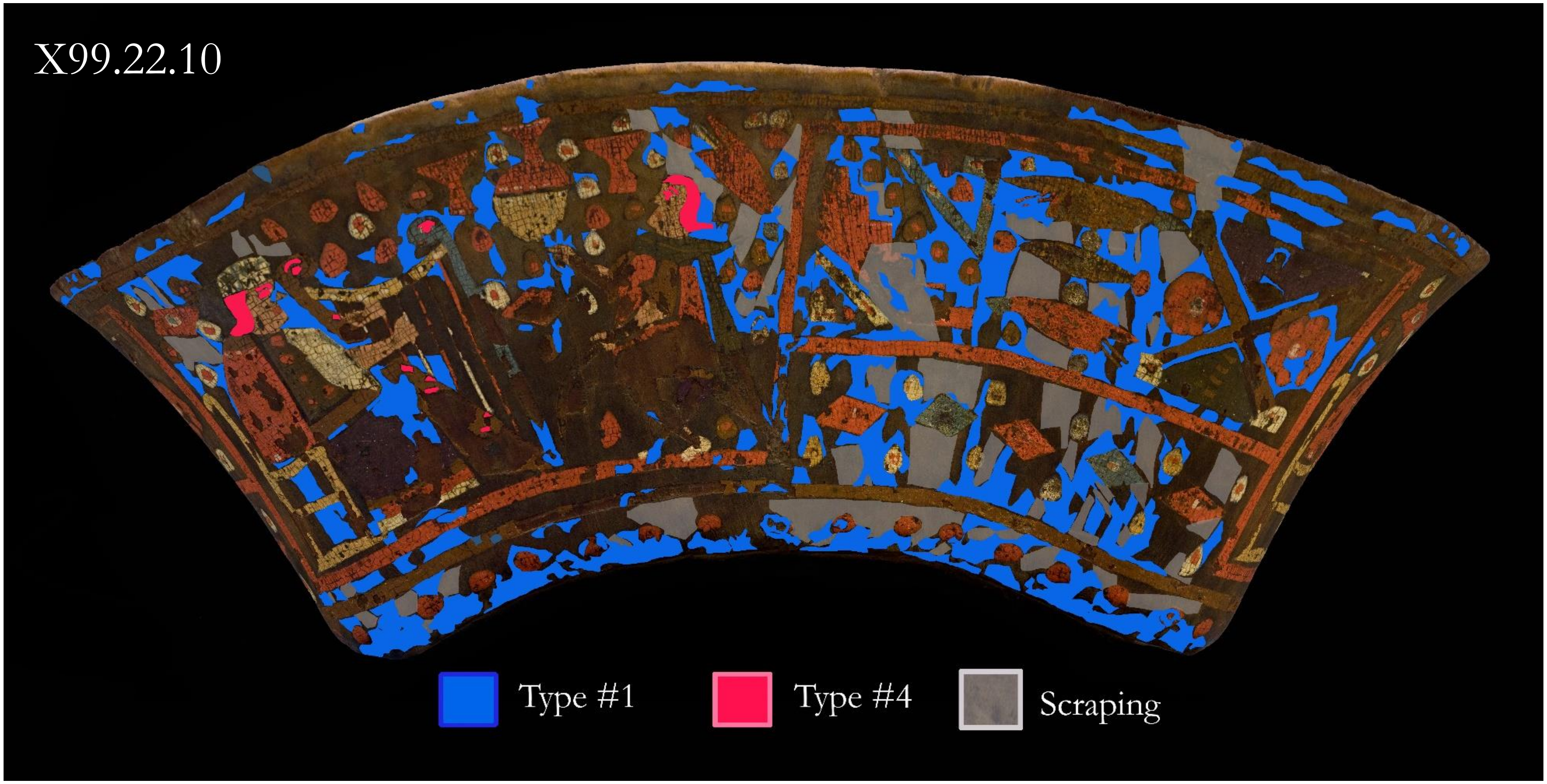


Fig. 45. Scrape marks on *qero* X99.22.10 is another example illustrating how scraping specifically targeted dark material and is responsible for its variable presence on the surface.

Fig. 46. *Qero* X99.22.3 showed how inlay was carefully avoided when dark material was scraped off around it.

Fig. 47. RTI captured the depth of scrapes on the surface, which abruptly stop near inlay. Rendering Mode: Specular Enhancement (Diffuse Color = 40, Specularity = 70, Highlight Size = 74).

Fig. 48. *Qero* X99.22.10 showed significant scraping marks, including notable vertical strokes down the cup's foot (top), deep gouges out the top of the rim that strangely look to target areas of red *mopa mopa* (middle), and scraping on the cup's interior (bottom).

Lines of abrasion, taken as evidence of sanding, ran in parallel or circular directions over the *qero* surfaces, travelling continuously through polychrome inlay, dark material between inlay, and bare wood where dark material was absent or scraped away (fig. 49-52). The depth and frequency of

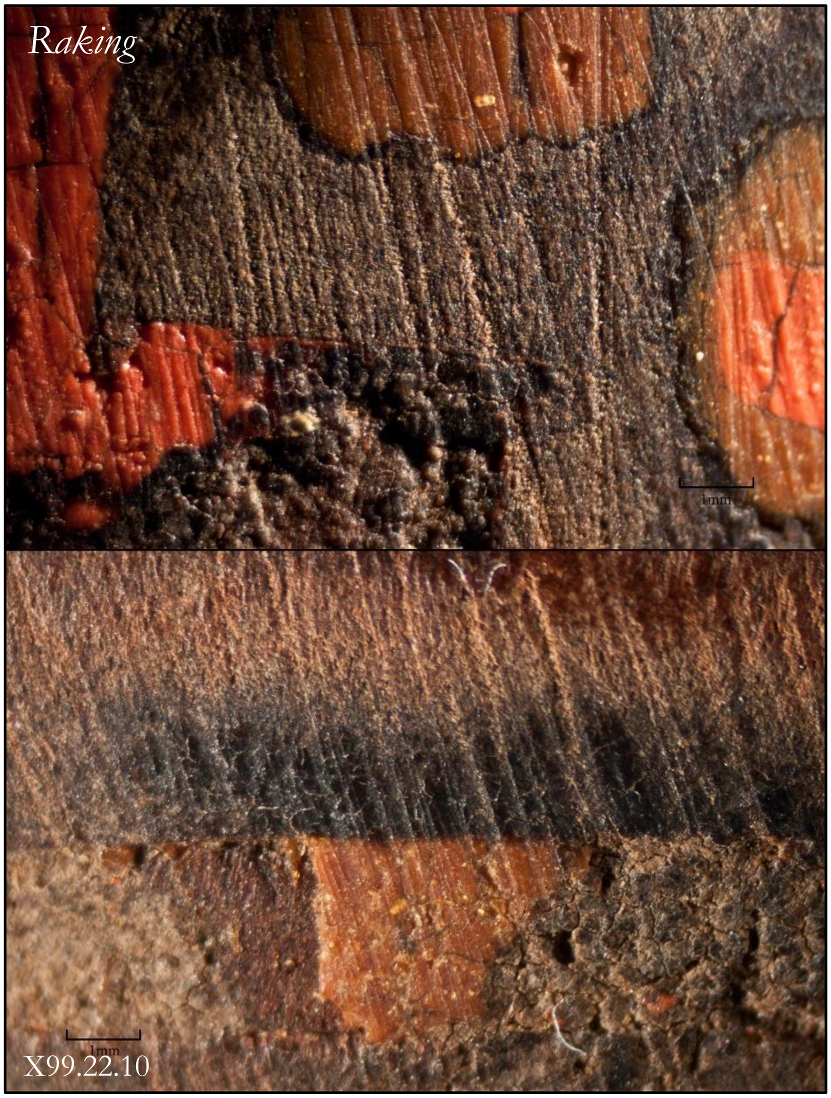


Fig. 49. Micrographs of *qero* X99.22.10 show deep abrasion that ran over the surface, through dark material, inlay, and bare wood.

abrasion was greatest over *qero* X99.22.10. Uninterrupted lines of abrasion through dark material and surfaces where dark material was scraped off, indicated that the *qeros* were sanded after their surfaces were scraped. It is significant to note that abrasion did not run through Gloss or Type #2 dark material on *qero* X99.22.5; rather these materials seemed to cover abrasion lines (fig. 53).

Fig. 50. Raking light was used to capture the occurrence of fine striations, or lines of abrasion, which ran over nearly every *qero* surface.

Fig. 51. RTI aided in capturing abrasion on the foot of *qero* X99.22.10, including lines that occurred in circular motions. Rendering Mode: Specular Enhancement (Diffuse Color = 40, Specularity = 70, Highlight Size = 75).

Fig. 52. Evidence suggested that the surfaces were sanded after dark material was scraped off. On *qeros* X99.22.11 and X99.22.10, there were faint tool-mark impressions beneath abrasion lines. Rendering Mode: Specular Enhancement (Diffuse Color = 40, Specularity = 70, Highlight Size = 75); Luminance Unsharp Masking (Gain = 60).

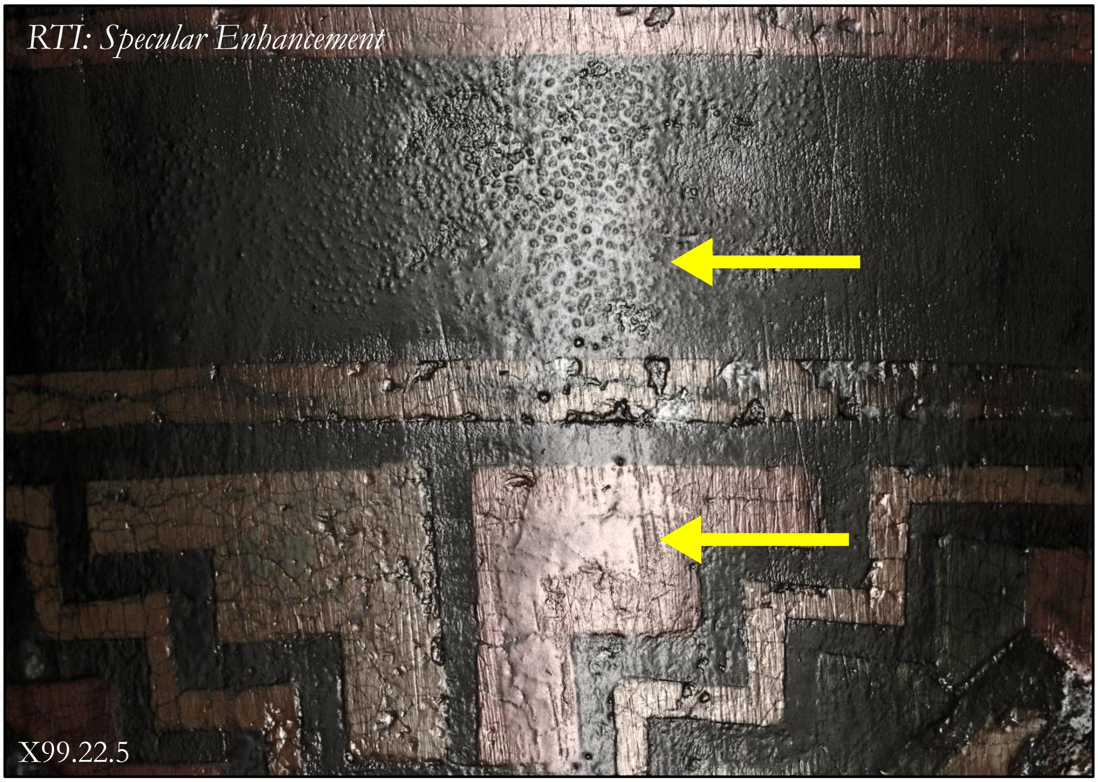


Fig. 53. On *qero* X99.22.5, bubbly Type # 2 or Gloss material occurred over abrasion lines. Rendering Mode: Specular Enhancement (Diffuse Color = 40, Specularity = 70, Highlight Size = 75).

Less consequential to the loss of dark material were wear and pocking. Wear was noted on areas of the surface that looked unusually smooth; this was often bare areas of wood where there was a partial or gradual loss of dark material and surface decoration. However, defining areas of smooth surface independently as "wear" was purely subjective, since a smoothed surface from handling could not be confidently discriminated from a surface that had been finely sanded to be smooth. *Qero* X99.22.1 showed a preferentially smooth surface around its center body, which was the most convincing example of possible use-wear from handling (fig. 54). Overall, wear was not an influential cause of dark material loss. Similarly, pocking—the pattern of loss related to the physical properties of the dark material and its thickness on the surface—accounted for very little loss across the group of *qeros*. At most, it was seen commonly over *qero* X99.22.9 due to the predominance of thick dark material over its surface (fig. 55).

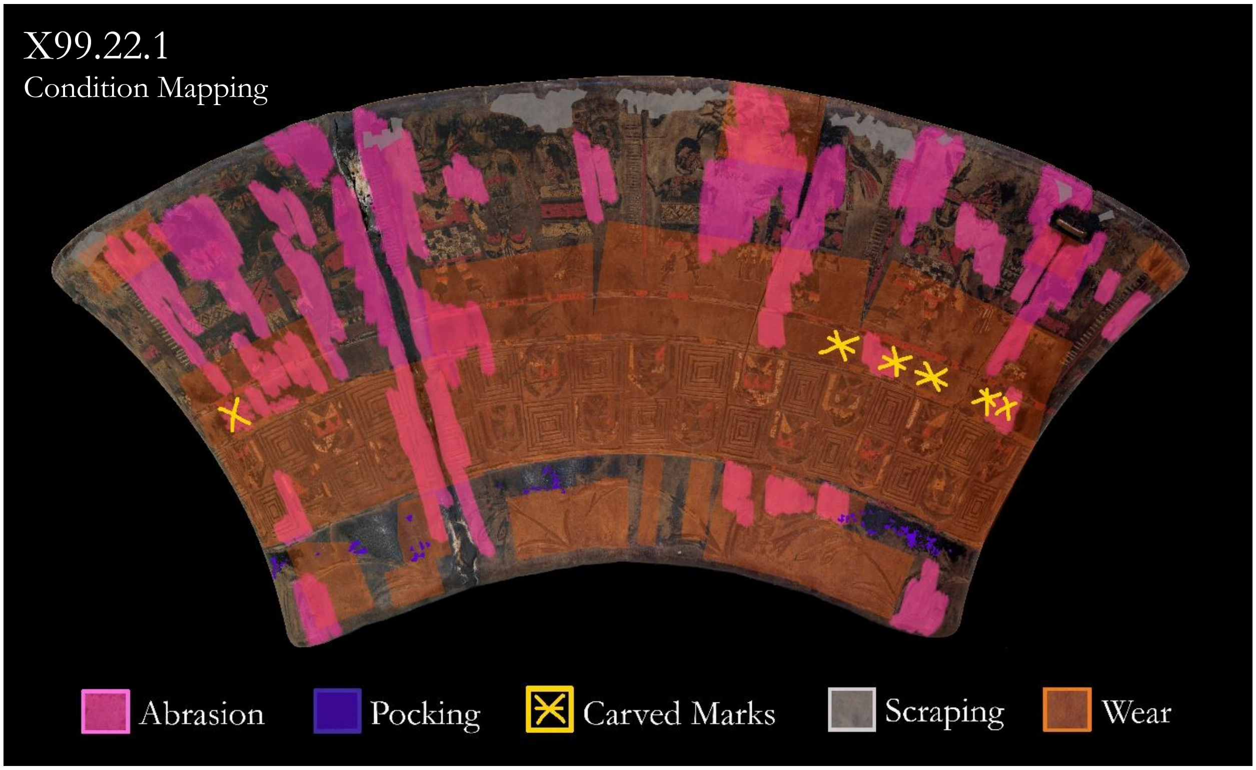


Fig. 54. *Qero* X99.22.1 seemed to have a worn surface around its center, as though due to handling.

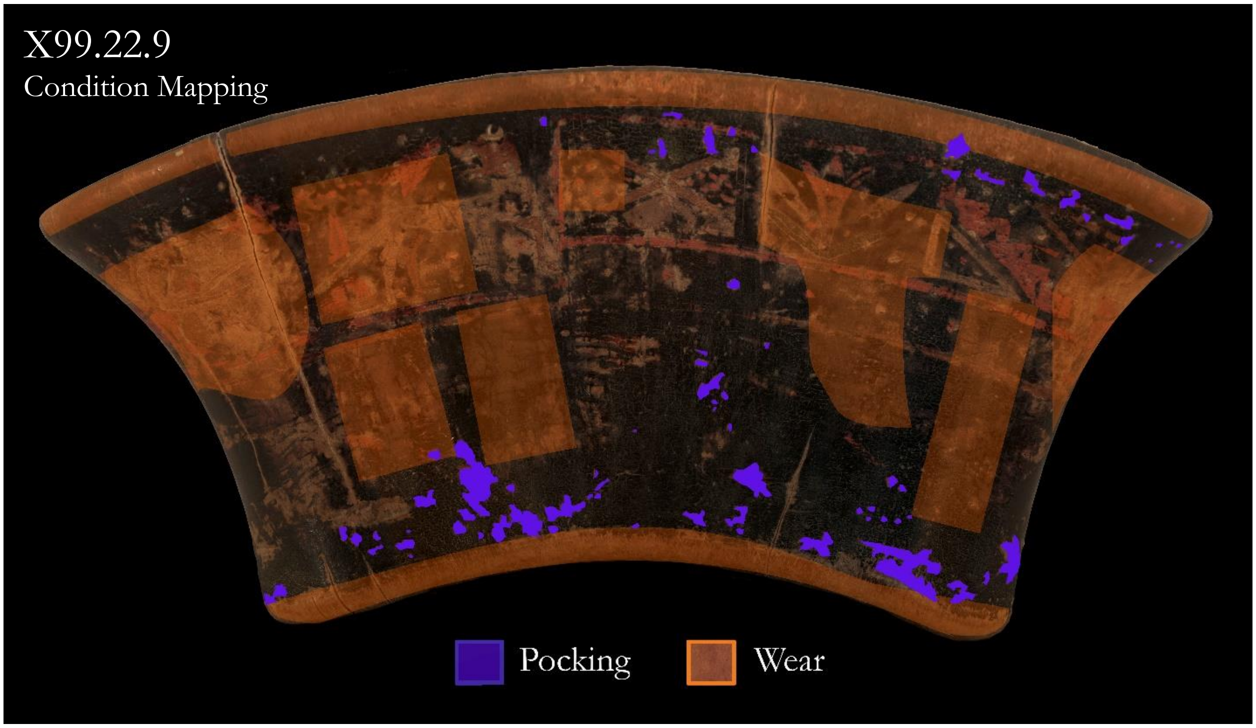


Fig. 55. Pocking was most common on *qero* X99.22.9, due to the extensive presence of thick dark material.

Lastly, there were examples of carved marks recorded on the *qeros* which were not related to incised lines cut into the wood for inlaying *mopa mopa* decoration (Table 4; fig. 56). *Qeros* X99.22.9, X99.22.10, and X99.22.11 had an isolated symbol or characters carved onto their undersides, which were likely maker's or owner's marks—not uncommon to find.[20] However, more significant, were two instances of a decorative pattern carved onto the exteriors of *qeros* X99.22.1 and X99.22.5 that were clearly added after their original decoration. A star pattern within a blank band on *qero* X99.22.1 repeated partially around the circumference of the *qero*, and a triangular pattern occurred around the lower register of *qero* X99.22.5, over and through its original inlay. Both patterns were crudely executed, inconsistent with inlay designs, and appeared to be unfinished or abandoned. While these carvings did not directly relate to the loss of dark material, their existence may be related to other signs of surface modification that do target dark material (i.e. scraping and abrasion).

Fig. 56. Carvings unrelated to original decoration were found on *qeros* X99.22.1 and X99.22.5.

[20] Cummins (1988, 384-85) discusses these marks and suggests their relationship to certain regions of production.

5.3 Analysis

5.3.1 Portable X-Ray Fluorescence Spectroscopy

Results from analysis with pXRF showed an overall homogeneity between the elemental compositions of the dark materials over an individual *qero* and between different *qeros* (Appendix G). The same was true in instances when spectra of the bare wood substrates were compared. The compositions contained aluminum (Al), silicon (Si), phosphorous (P), sulphur (S), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), and bromine (Br). A summary of pXRF trends in relation to areas of different dark materials is provided in Table 5.

Table 5. pXRF Trends vs. Types of Dark Material

Type of Material[1]	*Qero*[2]	Notable Peaks[3]
Type #1 Dark Material	X99.22.1; X99.22.3; X99.22.5; X99.22.9; X99.22.10; X99.22.11	Ca, Fe Pb (X99.22.11)
Type #2 Dark Material	X99.22.5	S, K
Type #3 Dark Material	X99.22.1	Fe
Type #4 Dark Material	X99.22.3	Pb
Type #5 Dark Material	X99.22.9; X99.22.11	Ca, Fe

[1] Gloss was not included in these analyses since it occurs over inlay, and all readings were aimed at locations that avoided the interference of inlay.

[2] In the interest of time, not every occurrence of each material type on each *qero* was analyzed. Rather, the most quintessential examples of each material type in a broad area were chosen, independent of which *qero* it occurred on.

[3] Given the overall homogeneity of the spectra, "notable peaks" refers to elements whose peak heights were notably greater when overlaid with other spectra, and not necessarily to elements unique to that type of material.

In general, there were notable peaks for calcium and iron found in Type #1 dark material between inlay and Type #5 dark material on interiors. Type #1 dark material also tended to have higher peaks for minor elements silicon, tin, and manganese when compared to the bare wood and other types of material. Reddish Type #2 material between inlay on *qero* X99.22.5 contained notable peaks for sulfur and potassium; when compared against another area of dark material described as "reddish" (Type #1 on *qero* X99.22.9), Type #1 stayed consistent in distinguishing itself with prominent calcium and iron peaks, and likewise Type #2 still had higher peaks for sulfur and potassium. In one instance of Type #1 dark material on *qero* X99.22.10—*not* described as reddish in nature—the spectrum showed a distinguishing mercury peak. This was undoubtedly due to its location between areas of red *mopa mopa* inlay colored by cinnabar, rather than the dark material itself containing a colorant.

An analyzed area of dark repair material, Type #3 on *qero* X99.22.1, contained a considerably higher peak for iron against Type #1 material on the same cup. Finally, the presence of lead was detected in two spectra, including in an area of Type #1 material between inlay (*qero* X99.22.11) and an area of Type #4 dark inlay on *qero* X99.22.3. This area of dark inlay was physically consistent with *mopa mopa*, and lead white is known to be used as part of many pigment mixtures with *mopa mopa* inlay on Colonial *qeros* (though typically for light colors) (Kaplan et al. 1999).

5.3.2 Fourier Transform Infrared Spectroscopy

While sampling the dark materials for FTIR analysis, further observations were made about their physical and optical properties (for sample locations and descriptions, see Appendix H). Unexpectedly, an overall consistent nature was noted as the materials were sampled; each becoming semi-translucent with a yellowish-brown or amber color. Many sample areas contained a whitish, waxy film over the surface of the dark material, which had made it appear matte and opaque—such as for Type #1 dark material—however this film easily pushed away to reveal the same darkly tinted, semi-translucent matrix with reddish and amber-colored areas (fig. 57). Also, nearly every sample was crumbly and/or brittle, with the exception for many samples taken from *qero* X99.22.5, which were especially soft, impressionable, and tacky.

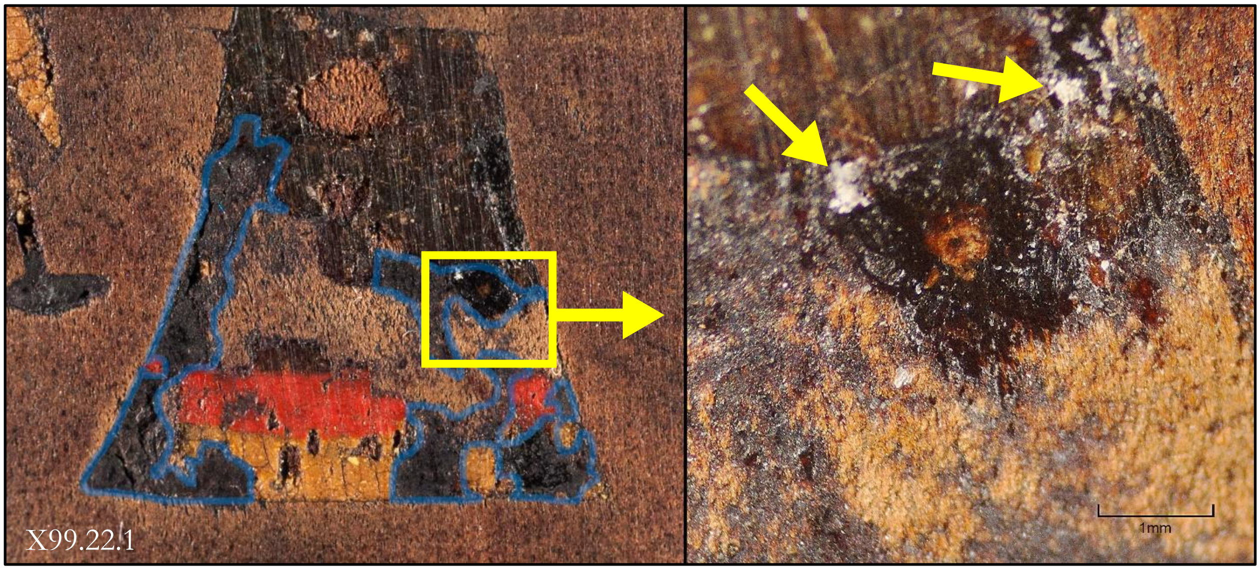


Fig. 57. During sampling, a hazy, waxy film was found over much of the dark material, like Type #1 (left, outlined in blue). This film could be pushed aside using a bamboo skewer (right, arrows), which revealed the dark material as semi-translucent and amber-colored.

Prior to analysis, samples were studied at the GCI and MFA via optical microscopy, and characterized in a similar manner: a more concentrated amber color was observed towards their centers and a gradual loss of color—seen as a whitening—occurred towards their edges where the material was thinner. At times this lead to multiple analyses performed on a single sample, in both the amber/reddish center and at the whitish edges. Analytical results are provided in Tables 6-7, according to each *qero* and each material type.

Table 6. Summary of Dark Material Analysis

■ = GCI analysis ■ = MFA analysis

Sample Location Reference #	*Type of Material*	*Location*		*FTIR Results*[1]	*GC/MS Results*
X99.22.1-1	Type #1	Between Inlay	MFA	Pattern C[2]	-----[3]
1-2	Type #4	Inlay	MFA	Pattern C	Fatty acids (oils: non-drying or semi-drying); no natural resins
1-3	Type #1	Between Inlay	MFA	Pattern C	
1-4	Type #3	Repair	MFA	Fatty acids	Fatty acids (oils: non-drying or semi-drying); no natural resins
1-5	Type #1	Inlay Loss	GCI	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
1-6	Type #1	Between Inlay	GCI	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
1-7	Type #5	Interior	MFA	Pattern C	Fatty acids (oils: non-drying or semi-drying); no natural resins
X99.22.3-1	Type #1	Inlay Loss	MFA	Pattern C	-----
3-2	Type #1	Between Inlay	MFA	Pattern C	-----
3-3	Type #2 or Gloss	Over Inlay	MFA	Pullulan (a derivative of starch)	-----
3-4	Gloss	Over Inlay	MFA	Pattern C	-----
3-5	Type #1	Between Inlay	GCI	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
3-6	Type #5	Rim/Interior	MFA	Pattern C	-----
X99.22.5-1	Type #2	Between Inlay	MFA	Pattern C with particles of hematite	-----
5-2	Type #1	Between Inlay	GCI	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----

5-3	Type #2	Between Inlay	■	Pattern C	-----
5-4	Gloss	Over Inlay	■	Oil with some particles of vermillion	-----
5-5	Type #1	Between Inlay	■	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
5-6	Type #3/5	Interior Repair	■	Oxalates + oil	-----
X99.22.9-1	Type #1	Between Inlay	■	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
9-2	Type #1	Over Inlay	■	Pattern C	-----
9-3	Type #5	Rim/Interior	■	Pattern C	-----
X99.22.10-1	Type #1	Between Inlay	■	Chitin or animal glue? Yellow portion of sample: oil + protein (similar to egg yolk)	-----
10-2	Type #1	Over Inlay	■	Oil + protein (similar to egg yolk)	-----
10-3	Type #1	Between Inlay	■	Oil + protein (similar to egg yolk)	-----
10-4	Type #1	Between Inlay	■	Animal glue, oils, fatty acids, natural resins, clay	-----
10-5	Type #5	Interior	■	Animal glue, oils, fatty acids, natural resins, clay	-----
X99.22.11-1	Type #1	Between Inlay	■	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----
11-2	Type #2 or Gloss	Over Inlay	■	Pattern C	-----
11-3	Type #4	Inlay	■	Pattern C	-----
11-4	Type #5	Interior	■	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	-----

[1] All FTIR results indicate "best matches" from available libraries, and should generally be considered tentative.

[2] "Pattern C" is an in-house profile at the MFA for materials sampled from *qeros* on previous projects, and represents an oil or oil + resin mixture.

[3] A blank field "-----" indicates GC-MS was not performed on the sample.

Table 7. FTIR Results Organized by Material Type

Sample #	FTIR Results[1]	■ = GCI analysis ■ = MFA analysis
Type #1		
1-1	Pattern C[2]	■ (MFA)
1-3	Pattern C	■ (MFA)
1-5	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
1-6	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
3-1	Pattern C	■ (MFA)
3-2	Pattern C	■ (MFA)
3-5	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
5-2	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
5-5	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
9-1	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
9-2	Pattern C	■ (MFA)
10-1	Chitin or animal glue? Yellow portion of sample: oil + protein (similar to egg yolk)	■ (MFA)
10-2	Oil + protein (similar to egg yolk)	■ (MFA)
10-3	Oil + protein (similar to egg yolk)	■ (MFA)
10-4	Animal glue, oils, fatty acids, natural resins, clay	■ (GCI)
11-1	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■ (GCI)
Type #2		
5-1	Pattern C with particles of hematite	■ (MFA)
5-3	Pattern C	■ (MFA)
Type #2 or Gloss		
3-3	Pullulan (a derivative of starch)	■ (MFA)
11-2	Pattern C	■ (MFA)
Gloss		
3-4	Pattern C	■ (MFA)
5-4	Oil with some particles of vermillion	■ (MFA)
Type #3 (Repairs)		
1-4	Fatty acids	■ (MFA)

5-6	Oxalates + oil	■
Type #4 (Inlay)		
1-2	Pattern C	■
11-3	Pattern C	■
Type #5 (Interior)		
1-7	Pattern C	■
3-6	Pattern C	■
5-6	Oxalates + oil	■
9-3	Pattern C	■
10-5	Animal glue, oils, fatty acids, natural resins, clay	■
11-4	Oils, fatty acids, natural resins, metal soap (calcium oxalate?), proteins, silica material	■

[1] All FTIR results indicate "best matches" from available libraries, and should generally be considered tentative.

[2] "Pattern C" is an in-house profile at the MFA for materials sampled from *qeros* on previous projects, and represents an oil or oil + resin mixture.

The GCI reported on ten samples from throughout the group of six *qeros*, which included eight samples of Type #1 and two samples of Type #5 dark material (Appendix I). All samples poorly matched against a reference sample of *mopa mopa* (*E. pastoensis*); instead, they all represented a similar, complex mixture of materials that included oils, fatty acids, natural resins, metal soaps, proteins, and silica-containing components. Samples from *qero* X99.22.10 best matched with a mixture of spectra for animal glue, oil, natural resin, and clay (fig. 58).

The MFA also found overall consistent results for the remaining twenty-one samples (Appendix J). These results were able to be placed within a larger body of FTIR data at the MFA, collected from hundreds of samples from other *qeros* in past projects. Most were found to match a spectrum called "Pattern C" –an in-house profile that related to miscellaneous coatings or residues on *qeros*, which had not been considered associated with original decoration (fig. 59). Pattern C is characterized

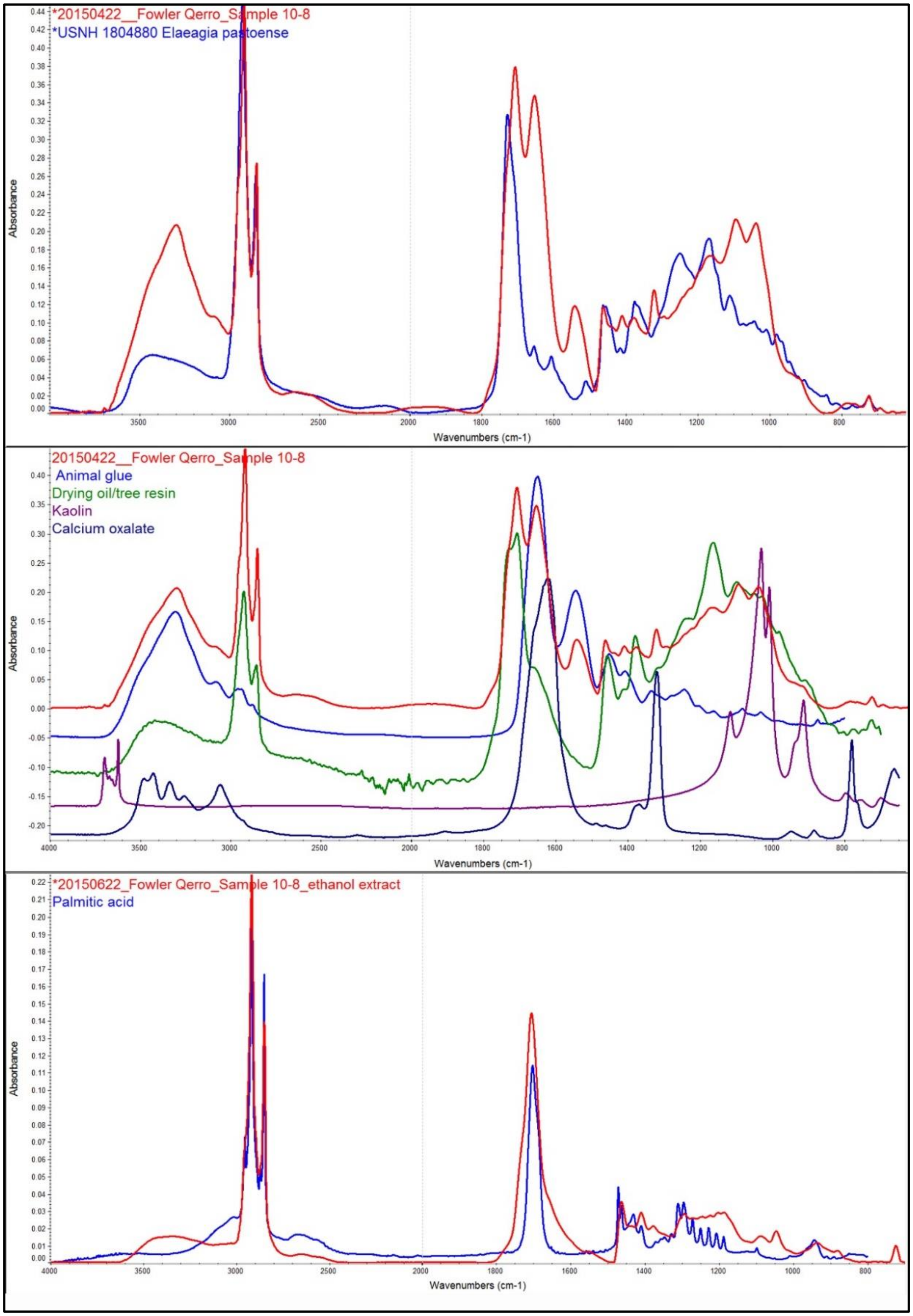


Fig. 58. As an example, sample # 10-4 (formerly 10-8) of Type #1 material taken from between inlay showed a poor match for *mopa mopa* (*E. Pastoensis*) (top). Instead, it matched with animal glue, drying oil/natural resin, clay, and oxalate (middle). Extraction with ethanol showed a close match with palmitic acid (bottom). *Analysis provided by Herant Khanjian (GCI) (Appendix I).*

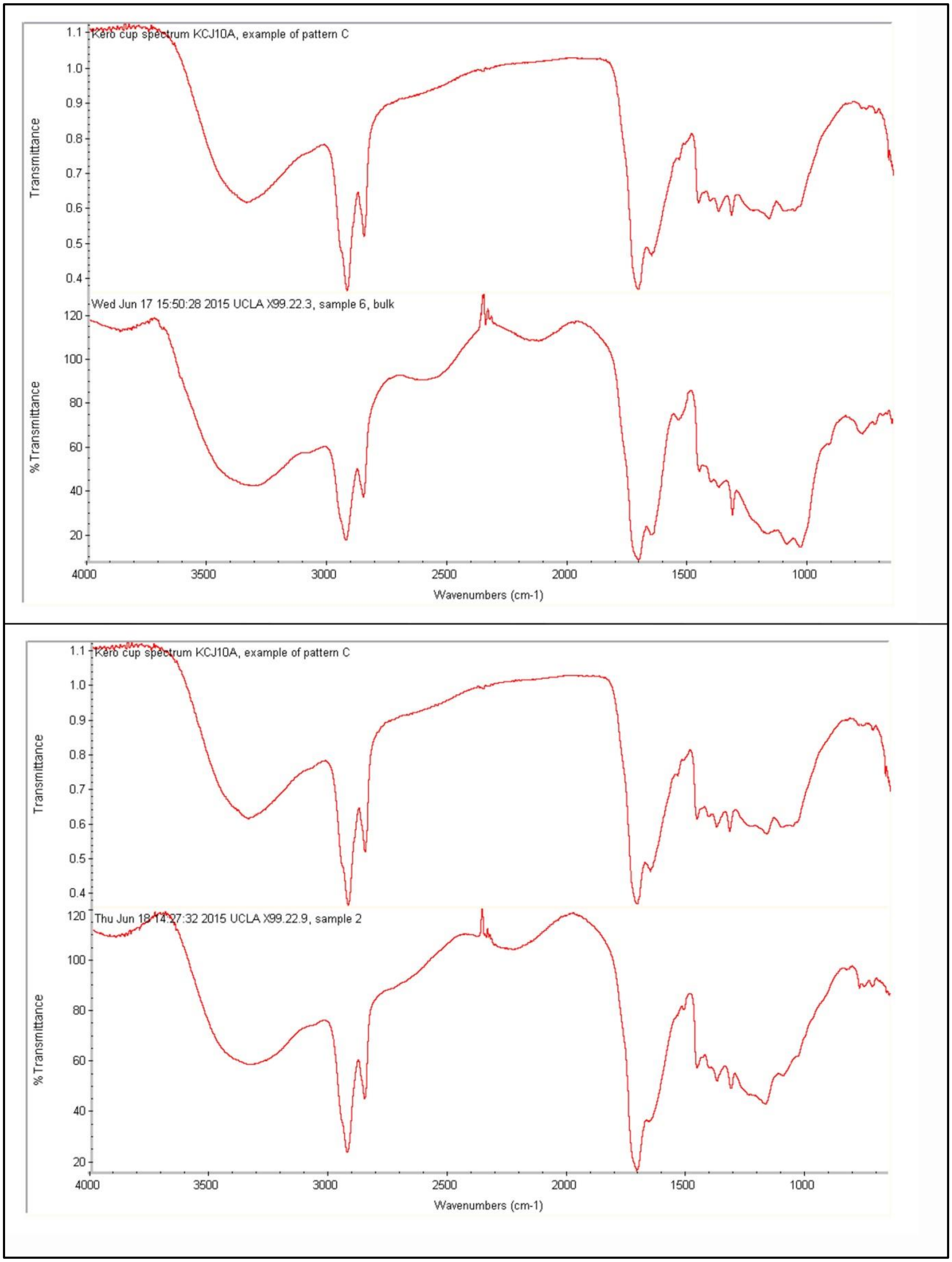


Fig. 59. Samples 3-6 (top) and 9-2 (bottom) illustrate the similarity of dark material from the Fowler *qeros* with the in-house MFA spectrum called "Pattern C"—an oil or oil +resin mixture. *Analysis provided by Richard Newman (MFA-Boston) (Appendix J).*

broadly as an oil or oil + resin mixture,[21] and it was the best match for most samples across all categories of dark material, save for Type #3, dark repair material, which was more specifically identified. The repair within a radial crack on *qero* X99.22.1 (1-4) was a close match for fatty acids, and further analysis (see 5.3.3 Gas Chromatography-Mass Spectrometry) found that it was a non- or semi-drying oil with no presence of natural resins. Repair material sampled on the interior of *qero* X99.22.5 (5-6, classified as both or either "repair" material and "interior" dark material) was also an oil but showed the presence of oxalates as well.

Dark inlay that looked physically different from *mopa mopa* on *qero* X99.22.1 (1-2) and *qero* X99.22.11 (11-3) was confirmed by FTIR to be chemically different from the plant exudate, yet interestingly proved in keeping with Pattern C, despite occurring in the context of intentional and/or original inlay decoration and appearing distinct from surrounding dark material under UV examination. Like the repair material on *qero* X99.22.1, sample 1-2 was further analyzed (see 5.3.3 Gas Chromatography-Mass Spectrometry) and found to contain fatty acids associated with non- or semi-drying oils, and no natural resins.

Materials described as Type #2 and/or Gloss closely matched Pattern C, with a few exceptions. Particles of color were found in two samples, both on *qero* X99.22.5. Hematite was detected in sample 5-1, which was an area of Type #2 glossy dark material described as having an orange-red colorant visible along internal cracks. Also, vermillion was detected within a sample of Gloss (5-4), which closely matched the profile of an oil. The Gloss was sampled from over an area of red inlay, which would account for the particles of vermillion, and the hematite found in the area of Type #2

[21] The MFA reported that the closest matches to "Pattern C" in available databases were: aged tung oil coating (IRUG 2007); mummy pigment from the Forbes Collection (Straus Conservation Center, Harvard University; sample contains oil and resin); China wood oil from the Forbes Collection; amber varnish (IRUG 2007); and hiawa gum from America (IRUG 2007; precise composition uncertain, but not a true gum) (Appendix J).

dark material were likely displaced particles from nearby *mopa mopa* inlay. In one instance, a sample of reddish-tinted glossy material on *qero* X99.22.3 (3-3) matched against a spectrum for pullulan—a polysaccharide produced by the fermentation of corn starch (Dixon et al., n.d.).

Qero X99.22.10 produced a unique group of FTIR results from the rest of the *qeros*. A mixture of oil and a protein similar to egg yolk matched Type #1 dark material present both over (10-2) and between (10-3) inlay. Also, an area of dark material directly bordering inlay (10-1) produced a spectrum similar to chitin or animal glue. This material was classified as Type #1 dark material, however its absorption under UV radiation distinguished it from other dark materials on the surface (see 5.1.2 UV-induced Visible Fluorescence for examples of this darkly absorbing material bordering inlay decoration on *qero* X99.22.10).

5.3.3 Gas Chromatography-Mass Spectrometry (GC/MS)

Further analysis was performed at the MFA using GC/MS on three samples from *qero* X99.22.1 to better characterize the materials, since FTIR can only indicate the presence of oils and resins and cannot distinguish between specific types (Appendix J; Table 6; fig. 60). These samples included dark inlay material uncharacteristic of *mopa mopa* (1-2); dark repair material within a radial crack (1-4); and dark material from the interior of the *qero* (1-7). All three samples were found to contain fatty acids with low amounts of azelaic acid associated with non-drying, or possibly semi-drying, oils; natural resins were not detected. The different P/S ratio (palmitic/stearic acid) of the interior dark material suggested the oil is different from the other two samples, however this ratio could be affected by multiple sources of oil.

diC8 = suberic acid (dimethyl ester); A = azelaic acid (dimethyl ester); M = myristic acid (methyl ester); P = palmitic acid (methyl ester); S = stearic acid (methyl ester)

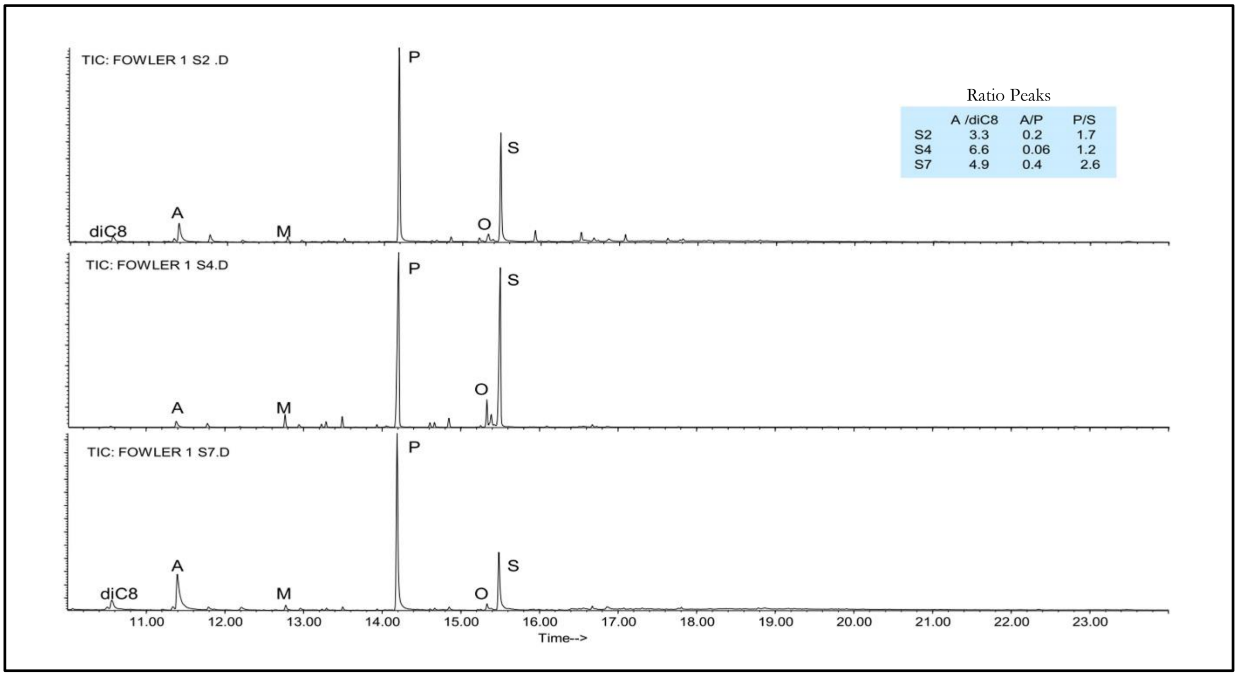


Fig. 60. Chromatograms from GC/MS performed on samples 1-2 (dark inlay), 1-4 (dark repair), and 1-7 (dark material from interior) showed the presence of fatty acids associated with non- or semi-drying oils, and showed no presence for natural resins. *Analysis provided by Richard Newman (MFA-Boston) (Appendix J).*

6. Discussion

This technical study considers the identity, origins and purpose of dark material that is often observed between inlay decoration on Andean drinking vessels called *qeros*, and further aims to explain why the presence of this dark material varies between *qeros* and appears by conservators to have been scraped off.

6.1 The Identity and Purpose of Dark Surface Materials

To begin, we know that many *qeros* were elaborately decorated with colored *mopa mopa* inlay (from *E. pastoensis and E. utilis*), and that there appears to be dark material that intentionally borders inlay decoration. Though Rowe (1961) and others have visually described this as a dark lacquer (i.e. *mopa*

mopa) background, these analyses have established that dark material between inlay is not pigmented *mopa mopa*; in fact, none of the dark surface materials taken from the Fowler *qeros* match the plant resin. Further, although mapping shows that dark material preferentially exists in background areas, it is also recorded over polychrome inlay and within recesses of inlay loss, which does not suggest its use as a background decoration.

The position of dark materials and their varying thickness over *qero* surfaces, as well as the presence of a white, waxy film at times, causes discrepancies in their color, opacity, sheen, and physical nature. Aside from dark repair material (Type #3), dark inlay (Type #4) and interior dark material (Type #5), three materials were initially classified on *qero* exteriors: Type #1, Type #2 and Gloss. Physically, Type #1 is brittle and crumbly, while Type #2 and Gloss are soft and tacky. The distribution and UV-induced visible fluorescence of Type #2 and Gloss suggest that they are the same material, yet analysis actually found all materials to be generally homogenous on a chemical level. FTIR and GC/MS results indicate that most of the dark material is a similar, complex mixture of organic components—fatty acids, oils, and perhaps natural resins—that best match against an FTIR profile called Pattern C at the MFA; Pattern C represents an oil or oil + resin mixture found on *qeros* in previous studies. It is believed that the majority of samples analyzed at the GCI—interpreted as combinations of oils, fatty acids, and resins, among other things—would also match closely with Pattern C, had they access to this in-house profile. Uniquely, for *qero* X99.22.10, both institutions suggest that animal glue and/or other proteins similar to egg yolk are present in addition to an oil or oil + resin mixture; these results are consistent for dark material sampled from over and between inlay, as well as from within the cup.

Though it is unlikely this organic mixture was intentionally applied as a background decoration during the *qeros*' lifecycle, the idea is not unfounded. A recent publication briefly mentions *qeros* with "broad transparent purple backgrounds" that contain the carmine lake colorant, cochineal (Pearlstein et al. 2015, 49), bound in an oil mixture (R. Newman, unpublished data).[22] *Mopa mopa* is known to be tinted and used as a transparent glaze, however the addition of a colorant in these non-*mopa mopa* backgrounds would seem to point towards an intentional material prepared and applied as background decoration, whose binder differs from the rest of the cups' decoration. In this study, colorants were detected in only two samples: particles of vermillion in an oil sampled over red inlay (5-4) (which can be explained by the sample location), and particles of hematite in a soft, translucent, dark reddish-purple background material (5-1). Similar to what is noted in Pearlstein et al. (2015), this red colorant is bound in an oil/oil + resin mixture (Pattern C), with no detection of *mopa mopa*.

Perhaps more evocative for the support of this organic mixture being used as intentional decoration, are the results of dark inlay studied on the Fowler *qeros*. Two examples of dark inlay—used for the hair of figures on *qero* X99.22.1 (1-2) and geometric elements on *qero* X99.22.11 (11-3)—are also a close match for an oil or oil + resin mixture, and not the plant exudate *mopa mopa*, known for *qero* inlay. However, despite their physical and chemical similarities, both instances of the oil-bound inlay absorb UV radiation differently from adjacent dark materials outside the inlay; this is especially true for inlay on *qero* X99.22.11, and indicates that the inlays are a different organic mixture than what occurs elsewhere on the surfaces.

It makes more sense for these dark, organic materials to be inadvertent deposits on the surface from the cups' use. We know that *qeros* were (and are currently) used regularly in various toasting

[22] Richard Newman, email message to Ellen Pearlstein, October 6, 2014.

ceremonies that leave heavy residues and accumulations of various kinds, as photographs from the field attest. Therefore, it is reasonable to suppose that this dark material is the result of years of handling and use, especially since anthropologists have witnessed little to no cleaning of *qeros* in the field. This is supported by the material's presence indiscriminately over the surface, and it also explains why the dark material that coats *qero* interiors chemically matches what is found on their exteriors. Additionally, the prevalence of iron found through pXRF analysis likely accounts for dirt impurities trapped within the material, and the match for pullulan in one case could be evidence of *chicha*—the fermented corn beverage frequently drunk from *qeros*. Use-deposits of various kinds are not only possible, but in all likelihood common.

An intentional surface application for maintenance or other treatment is also worth considering, especially given the coating-like appearance of some of the oil-based mixtures. The unique distribution of Type #2 dark glossy material over *qero* X99.22.5 makes it appear related to radial crack repairs, however it actually seems to have been applied more broadly on the surface and then selectively wiped off, especially from inlay; it follows, that some parts of the inlay were likely missed in this process, explaining why the glossy material occurs over inlay at times. An oil application that has collected dirt and darkened to varying degrees would account for many of the dark materials observed over the *qeros*, as well as for the visual alterations to *mopa mopa* inlay. In could be true that for *qero* X99.22.9, an oil or oil-based mixture was applied broadly over the surface and then aged and dirtied enough to become dark and obscuring. Surface treatments may have been possible while the cups were still in use by their source communities, however correspondence with anthropologists suggests that there are no such practices of applying oils or fats to *qero* surfaces intentionally. In this study, dark ethnographic repairs were generally similar to other dark surface materials on a chemical level, but their UV-induced visible fluorescence set them apart. If not treated in the communities, *qeros* may have undergone a variety of treatment practices once they entered collections; unfortunately, early treatment records are too scarce to confirm this.

6.2 Surface Modification and Intervention

Whether the surfaces of *qeros* were altered in their source communities for upkeep or aesthetics, is an intriguing question. In this group of *qeros*, there are instances of unrefined decorative carvings that were clearly added after original inlay and may indicate a desire to redecorate the *qeros*; however, it is unknown whether this is (or was) culturally acceptable or practiced. Redecoration over the generations, and the application of different, subsequent materials on the surface certainly seems possible. In fact, recent radiocarbon dating of a *qero* archaeologically recovered from the site of Moqi in Peru contained inlaid *mopa mopa* motifs consistent with the Early Colonial Period (1600-1650 C.E.), yet was found to have wood dating much earlier to 1416-1448 C.E. (Zori, forthcoming). Surface intervention, if not modification, is well established in this study, and the existence of carvings on *qeros* X99.22.1 and X99.22.5 is at least additional evidence of an individual intervening on the surface and changing it post-manufacture.

The most significant sign of surface intervention is evidence of tools being used in scraping motions to aggressively remove dark material from the *qeros*. These scrapes stop short of inlay areas and sometimes miss dark material that borders it, which expresses a clear intent to avoid hitting inlay decoration. *Qeros* were used on a regular basis throughout several generations with minimal cleaning, so it stands to reason that they left their communities with a fair amount of use-life accretions obscuring their surface decoration. Yet, *qeros* in European and American collections often appear very "clean" with visible and vibrant imagery. Since the art market likely demanded the cups' aesthetic clarity over their obscuring use-patina, it follows that many *qeros* underwent a mechanical "scraping" treatment to remove these dark accretions. As scraping has been noted on *qeros* from at least 2 other collections besides the Fowler Museum,[23] it is likely that this removal was common practice for cups entering the art market; it is also possible that this was a technique used within private collections and public institutions to make cups more presentable. *Qero* X99.22.9—the only *qero* in the group without scrape marks—may well represent an example that did not undergo this process and has retained its dark use-accretions. This theory lends considerable support for the dark material's identity and origins as unintentional ethnographic deposits—especially for material physically matching Type #1, which predominantly remains at the top and bottom edges of the cups. If true, it explains why dark material is found quite thickly on *qero* interiors, while only existing as thin remnants outside of inlay on their exteriors.

In addition to scraping, every cup (with the exception of *qero* X99.22.9) has fine lines of abrasion covering their surface; this could be striations left from the scraping tool or evidence of surface finishing, such as by sanding. In some areas, scraping activities left an uneven surface with divots or shallow gouges, yet the *qero* surfaces are overall generally even and smooth, especially *qero* X99.22.11. Given this, and given that striations run continuously through inlay, scraped areas of bare wood, and remaining dark material, it seems clear that the *qeros* were sanded to finish the surface after scraping. *Qero* X99.22.5 falls outside this trend, having dark, glossy material that looks to cover lines of abrasion; in this case, it could be that the cup received an oil-based surface application after its ethnographic accretions were removed and the surface sanded. It is worth noting that Dr. Bolin has heard that modern *qeros* made for tourists are given distressed surfaces and are rubbed with oil to

[23] Besides the Fowler Museum at UCLA, this study is aware of *qeros* looking "scraped" at the American Museum of Natural History and the Metropolitan Museum of Art.

create the appearance of age;[24] it may be that after scraping, a cup looks too raw and clean and is then given an oil-based coating to restore an "ethnographic" patina. An applied coating like this on *qero* X99.22.5 would explain why the cup's interior dark material seems to have a glossy appearance when compared to other cups in the group.

Abrasion may also be from the *qeros*' use-life. At least some abrasion, such as on *qero* X99.22.1, seems directly related to ethnographic repairs at radial cracks, and has Dr. Bolin described the harsh scrubbing of *qero* surfaces with sandy sediment as a method of cleaning in the Peruvian highlands. While this type of cleaning is not likely true of every community, it can be influential when interpreting surface abrasion on the *qeros*. This study noted that the *qeros* commonly have gouges on their rims, and that dark material is within these recesses covered by a cracking, beige sediment. It is possible that this granular sediment is left from a cleaning action such as that done in the highlands, and that the granules are responsible for leaving fine striations over the *qero* surfaces. Further, it makes sense for these gouges to have a notable concentration of dark material if that material was scraped and sanded away from the level surfaces around it, again lending support for the identity of dark material as ethnographic deposits.

7. Conclusion

The nature of Andean wooden *qero* technology has been the subject of several technical studies in the last two decades, each advancing our understanding of their material technology and prompting additional questions about their decoration, use and lifecycles. In this study I investigated dark materials variably present on *qero* surfaces in an effort to identify them and understand their origins and purpose. Additionally, I characterized peculiar condition features and aimed to explain marks

[24] Dr. Inge Bolin, email message to author, July 13, 2015.

that have been described by conservators as "scraping." For this, a group of Colonial period *qeros* belonging to the Fowler Museum at the University of California-Los Angeles were selected based on a preliminary evaluation of their dark materials and surface conditions. Each possessed a unique distribution and quantity of dark material with varying physical characteristics.

Through visual analysis and different imaging techniques, several types of dark material were categorized and their distributions mapped against notable features of condition on each *qero* surface. Examinations suggested potentially six different dark materials, including material found broadly on *qero* exteriors (Types #1-2 and Gloss), material used for repairs at radial cracks (Type #3), material used as inlay (Type #4) and material coating the cups' interiors (Type #5). Interestingly, analysis using FTIR spectroscopy and GC/MS found all material types to be largely similar on a chemical level. Most samples matched an in-house FTIR profile called "Pattern C" at the MFA, which represents an oil or oil + resin mixture, and additional analysis on a few samples using GC/MS further deconstructed the material as fatty acids associated with non- or semi-drying oils, with no presence of natural resins. None of the dark materials matched with the plant exudate, *mopa mopa*, which is known for *qero* decoration, and there was little evidence to support this material's use as a decorative background surrounding polychromy, as interpreted by early researchers such as Rowe. Extensive scraping was also confirmed on five of the six *qeros* studied, as well as lines of abrasion that suggest surfaces were sanded after being scraped. These features appear to be interventions aimed at removing dark surface materials.

Several theories may explain the origins and purpose of these dark, oil-based mixtures, including their possible application as a maintenance or surface treatment. However, given various physical evidence, it is this author's opinion that the majority of dark material designated as Type #1 on the exterior (and also Type #5 on the interior) are ethnographic accretions from the *qeros*' many years of use, which remain after attempts were made to scrape the material off before entering the art market so that their polychrome imagery showed unobscured. Also, at least one case shows evidence to support this activity was followed by the intentional application of a glossy, translucent, oily medium on the surface—Type #2 and Gloss—perhaps to bring back an aged or "ethnographic" quality to the cup.

Despite overall trends, it is clear that each *qero* experienced a complicated history influenced by their unique passage through their source communities and into private and public collections. This study showed that Reflectance Transformation Imaging is a remarkably useful tool in revealing features that help understand these lifecycles. Undoubtedly, this subject would benefit from further analysis of dark materials and *qero* surface stratigraphy on a larger corpus of *qeros*, as well as study and analysis of the fermented beverage, *chicha*, which could aid in understanding some of the dark deposits. Even more crucial, will be fieldwork in the Andean region to observe and create a dialogue with the communities who produce, use and maintain *qeros* for centuries prior to their transfer into art collections.

References

Allen, Catherine J. 2002. "The Incas Have Gone Inside: Pattern and Persistence in Andean Iconography." *RES: Anthropology and Aesthetics* 42 (Autumn): 180-203.

Bolin, Inge. 1998. *Rituals of Respect: The Secret of Survival in the High Peruvian Andes*. Austin, TX: University of Texas Press.

Brundage, Burr. 1967. *Lords of Cuzco: The History and Description of the Inca People in their Final Days*. Oklahoma: University of Oklahoma Press.

Bushell, G. H. S. 1956. *Peru*. London, UK: Thames & Hudson.

Cummins, T. B. F. 2002. *Toasts with the Inca: Andean Abstraction and Colonial Images on Quero V essels*. Ann Arbor, MI: University of Michigan Press.

Cummins, T. B. F. "Abstraction to narration: Kero imagery of Peru and the colonial alteration of native identity." MA thesis, University of California-Los Angeles, 1988.

Cutler, Hugh C., and Martin Cardenas. 1947. "Chicha, A Native South American Beer." *Botanical Museum Leaflets, Harvard University* 13 (3): 33-60.

Dixon, B., P.J. Abbott, P. Verger, G. Pascal, and M. DiNovi. n.d. "Pullulan." IPCS INCHEM, the International Programme on Chemical Safety. Accessed August 6, 2016, www.inchem.org/documents/jecfa/jecmono/v56je05.pdf.

Griffin, Patricia S. "An Investigation of Fatty Bloom on Incan Beer Drinking Vessels." Unpublished manuscript, submitted May 1991 to Practical Problems in Preservation: Organic Archaeological and Ethnographic Material. Photocopy.

Howe, Ellen. 2001. "Color and Resin on Andean Qeros." *Met Objectives* 3: 4-6.

Jennings, Justin, and Brenda J. Bowser. 2008. "Drink, Power, and Society in the Andes." Florida: University Press of Florida.

Kaplan, Emily, Ellen Howe, Ellen Pearlstein, and Judith Levinson. 2012. "The Qero Project: Conservation and Science Collaboration over Time." *RATS, Research and Technical Studies, Specialty Group Postprints from the 40th Annual Meeting of the American Institute for Conservation of Historic and Artistic Works, Albuquerque, May 8—12, 2012*. Vol. 3: 1-24.

Kaplan, Emily, Ellen Pearlstein, Ellen Howe, and Judith Levinson. 1999. "Análisis técnico de qeros pintados de los períodos Inka y colonial." *Iconos: revista peruana de conservación, arte, y arqueología* 2: 30–38.

Kirsop, Megan. "Vessel of Life: A Case Study of a Colonial Andean *Kero*." MA thesis, University of Florida, 2013. University of Florida Digital Collections (IR00003848).

Lafleur, Yvan, Regis Miller, Alex Wiedenhoeft, and Marie-Jose Ribeyron. 2002. *CITES Identification Guide-Tropical Woods: Guide to the Identification of Tropical Woods Controlled under the Convention on International Trade in Endangered Species of Wild Fauna and Flora*. Published with the collaboration of CITES Secretariat and the United States Department of Agriculture (USDA) Forest Service and Animal and Plant Health Inspection Service. Canada: Authority of the Minister of Environment, Minister of Supply and Services Canada. Accessed August 6, 2016, https://cites.unia.es/file.php/1/files/CAN-CITES_Wood_Guide.pdf.

Mason, Alden. 1957. *The Ancient Civilizations of Peru*. Middlesex, England: Penguin Books Ltd.

Menzel, Dorothy. 1977. *The Archaeology of Ancient Peru and the Work of Max Uhle*. California: The Reagents of The University of California.

Metraux, Alfred. 1965. *The Incas*. Great Britain: Studio Vista Limited.

Moseley, Michael, N. Nash, P. R. Williams, S. D. deFrance, A. Miranda, and M. Ruales. 2005. "Burning down the brewery: Establishing and evacuating an ancient imperial colony at Cerro Baul, Peru." *PNAS, The National Academy of Sciences of the USA* 102 (48): 17264-17271. doi: 10.1073/pnas.0508673102.

Newman, Richard, Emily Kaplan, and Michelle Derrick. 2015. "Mopa Mopa: Scientific Analysis and History of an Unusual South American Resin Used by the Inka and Artisans in Pasto, Columbia." *Journal of the American Institute for Conservation* 54 (3): 123-148.

Newman, Richard, and Michelle Derrick. 2002. "Painted Qero Cups from the Inka and Colonial Periods in Peru: An Analytical Study of Pigments and Media." *MRS Proceedings* 712, II9.8. doi: 10.1557/PROC-712-II9.8.

Ochoa, Jorge A. Flores, Elizabeth Kuon Arce, and Roberto Samanez Argumendo. 1998. *Qeros: Arte Inka En Vasos Ceremoniales.* Peru: Banco De Credito Del Peru.

Owens, R. J. 1963. *Peru*. Oxford, UK: Oxford University Press.

Pearlstein, E., Emily Kaplan, Ellen Howe, and Judith Levinson. 1999. "Technical analyses of Inca and colonial painted wooden keros." *Proceedings of the Objects Specialty Group Session at the 27th Annual Meeting of the American Institute for Conservation of Historic and Artistic Works, Saint Louis, Missouri, June 11, 1999*. Vol. 6: 94-111.

Pearlstein, E., Mark Mackenzie, Emily Kaplan, Ellen Howe, and Judith Levinson. 2015. "Tradition and Innovation, Cochineal and Andean Keros." In *A Red Like No Other: How Cochineal Colored the World*, edited by Carmella Padilla and Barbara Anderson, 44-51. Rizzoli, NY and Museum of International Folk Art, Santa Fe, New Mexico.

Rivery, Raquel Capreras and Andres Escalera. 1998. "Identificación de la madera de las vasijas de libación inca (keros) pertenecientes a la colección del Museo de America," *Anales / Museo de América* 6: 217–222.

Rowe, John. 1961. "The Chronology of Inca Wooden Cups." In *Essays in Pre-Columbian Art and Archaeology*, edited by Samuel K. Lothrop, 317-341. Boston: Harvard University Press.

Stone-Miller, Rebecca. 2002. *Art of the Andes, from Chavin to Inca*. Second print, London, UK: Thames & Hudson Ltd. First published in 1995.

Zori, C. Forthcoming. "Archaeological Recovery of a Resin-Inlaid *Quero* from the Site of Moqi, Locumba Valley, Peru." In *Inka and Colonial Wooden* Keros*: Recent Advances in Multi-Disciplinary Studies*, edited by E. Kaplan and M. Sepúlveda. Washington D.C.: Smithsonian Institute Scholarly Press.