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Technical examination of a bone ornament ensemble from the Himalayan region with comments on handling, treatment, storage, and display

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A thesis submitted in partial satisfaction

of the requirements for the degree of Master of Arts

in Conservation of Archaeological and Ethnographic Materials

by

Ayesha Carol Victoria Fuentes

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ABSTRACT OF THE THESIS

Technical examination of a bone ornament ensemble from the Himalayan region with comments on handling, treatment, storage, and display

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Ayesha Carol Victoria Fuentes

Master of Arts in Conservation of Archaeological and Ethnographic Materials

University of California, Los Angeles, 2014

Professor Ioanna Kakoulli, Chair

This thesis is a technical examination of a bone ornament ensemble from the Himalayan region, currently in the collection of the Fowler Museum at UCLA. This ensemble is used in various practices and performances associated with Vajrayana (Tibetan) Buddhism. The materials used in the construction of this object are examined through both noninvasive and minimally-invasive methods of scientific analysis. A comparative survey on the treatment, handling, storage, and display of similar bone ornaments at museum collections is presented. This study finds that this ritual object is a composite of human bone, bast fiber yarns, pigments, and deterioration products. The thesis includes treatment of the object through minimum intervention, mechanical stabilization, and the development of guidelines for storage, handling, and display.

The thesis of Ayesha Carol Victoria Fuentes is approved.

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Figure 1.1: Bone ornament assemblage, Fowler # X69.300 A-J, Fowler Museum at UCLA (objects are not pictured at true relative scale).

1. Introduction

This project examines an assemblage of bone ornaments from the Himalayan region, originally used for ritual and performative purposes, now in the collection of the Fowler Museum at the University of California, Los Angeles (Fowler # X69.300 A-J) (Figure 1.1). Collection and registration information reports that the object was purchased from a Tibetan vendor in Kathmandu though its origins may be Newari; it was collected by the museum in 1969. The assemblage or ensemble includes an apron, crown, arm band, and other assorted similarly constructed ornaments with unidentified function meant to be worn during public performances and private devotional exercises. This type of regalia is traditionally made from human bone, carved into beads and decorative plaques and joined with cordage (strong, multi-ply yarns). Other materials present here include metal bangles and numerous colored deposits or residues on the surface of the object substrate.

This research paper (submitted in partial fulfillment of the requirements for the degree of Master of Arts at the UCLA/Getty MA Program in the Conservation of Archaeological and Ethnographic Materials) investigates the bone ornament ensemble through noninvasive and minimally-invasive methods of analysis for the characterization of materials used in its construction. The following sections also discuss how materials have been applied in the production of the object: Section 2 reviews literature that informs the objects' original purpose and function; Section 3 reviews the methodology and findings of the analysis; Section 4 articulates how these results relate to recorded information on material cultural traditions and how the current condition of the object might be related to its historic use; Section 5 presents the results of a survey on handling and treatment of similar objects in museum collections; Section 6 presents the treatment of this object with an emphasis on minimizing handling and physical stabilization.

2. Literature review

'Bone ornaments' are a type of regalia consisting of bone girdle or apron, crown, necklace, arm bands, and ear ornaments, not all of which are represented by this assemblage.[1] This regalia, in addition to the thigh-bone trumpet, skull cup, and *damaru* (two-headed drum), is part of a specific class of ritual objects made from human bone and associated with esoteric practices of Vajrayana or Tibetan Buddhism, as well as public performances of healing or divination in the Himalayan region (Figure 2.1). Scholarship on ritual objects and ornaments made from human bone can be divided broadly into three categories: art historical, ethno-historical, and the religious texts of esoteric Buddhism that address

Figure 2.1: Performer wearing a bone apron and ornaments (Image: Loseries-Leick 2008).

[1] 'Bone ornament' regalia may also include a string of corpse hair, though this is typically reserved for male deities and/or ascetic practitioners.

their use and ritual significance.

Bone ornaments are most often used in the context of worship and practices dedicated to wrathful forms of deities. Texts like the *Cakrasamvara Tantra*, for example, relate detailed information about the liturgical use of these objects during devotional practices. However, the great number of variations for these activities make it difficult to relate the textual precedent to practical use or its effect on the objects themselves.[2] Art historical and ethno-historical sources, however, provide some insight into the material concerns of conservation and collections stewardship.

North American and European art historical scholarship on the material culture of Tibetan Buddhism tends to focus on forms most familiar to fine arts audiences: *thangka* (paintings) and sculpture in metal or stone. Tucci (1967) writes extensively of aspects of daily and religious life in Tibet but isolates his discussion of artistic practice to *thangka,* wall paintings, sculpture, and architecture. More recent scholars like Huntington have addressed bone ornaments insofar as they relate to painted or cast images of deities and a 2004 publication (with Bangdel) discusses the arts and material culture of esoteric Buddhism in terms of its endemic practice, religious significance, and categories of use. He connects a bone girdle — or apron, as it will be referred to in this paper — to practices associated with Cakrasamvara and his female consort, Vajravarahi, two deities with wrathful forms that incorporate bone ornaments. Beer (1999) describes bone ornaments based on their iconographic significance in Tibetan arts, where they are often rendered in depictions of certain deities (Figure 2.2). Beer's exceptionally informative work describes specific iconographic features (long-established based on archaeometric principles) but also relates aspects of the religious history behind the incorporation of these motifs. However, the representation of

[2] See Gray's annotated translation of the *Cakrasamvara Tantra* (2007) or Edou's *Machig Labron and the foundations of Chöd* (1996) for details of practical, liturgical, or historic religious use during specific rites or teachings of esoteric Buddhism in the Himalayan region.

bone ornaments in paintings and sculpture is distinct from their existence as regalia.[3] The author's own unpublished master's thesis attempts to relate the intangible representation in both art and religious history to the material object through the example of the skull cup, a related topic (Fuentes [2011]).

Figure 2.2: *Kurukulla,* Tibet, 13th c., Virginia Museum of Fine Arts; Image from Bangdel and Huntington (2004): The figure is rendered wearing a bone apron, crown, arm and wrist bands, and necklace.

Ethno-historical literature has been somewhat more informative about aspects of material culture, though much of what was written in the early to mid twentieth century by scholars — who were commendable field researchers — is misleading. Scholars like Rock (1959) and Nebesky-Wojkowitz (1957) wrote of the association of bone ornaments with 'demons' and 'exorcism' which misrepresents their ritual function in practices associated with wrathful deities and public performances of healing rites. Laufer (1923) overemphasizes the use of human bones in Tibet as a type of magic and simplifies the many and variable religious teachings in which these objects are applied. Many scholars in ethnography and anthropology have presented what Boivin (2009) identifies as a preference to interpret material culture as a 'system of symbols' meant to reinforce an intangible reality, without understanding the technology and construction of objects as informational resources for that culture. From a conservation

[3] Interestingly, there is fairly little research on bone ornaments as part of costume and textile traditions in the region. Handa (1998), for example, presents the costume tradition in the Western Himalayas without mentioning bone ornaments, though other types of accessories are discussed. It may be suggested that their religious connotations have exempted them from such studies.

perspective, this is manifest in comparatively little field-based scholarship on the technology of these objects or circumstances of their use.

More recently, however, Loseries-Leick (2008) has produced a comprehensive resource on the use of human bone in the material culture of esoteric Buddhism as it is practiced in Tibet and Tibetan exile. Her work describes the contemporary and historical use, production, and religious context of bone ornaments as both scholar and practitioner, without relating information on specific ritual functions or significances, which might violate her role as a student of these esoteric practices. She also describes details of the objects' constructions; for example, the application of motifs and arrangement of designs is often the prerogative of craftsman commissioned to create the object. Traditional craftsmen specialize in carving bone ornaments, developing and maintaining techniques that are passed to apprentices. Loseries-Leick also presents the technology used to create bone ornaments, including both traditional hand tools and power drills. Designs may or may not be drawn onto the surface before carving, depending on the specific craftsman. The preparation and procurement of raw materials are also discussed where, historically, bones were gathered from human bodies deposed at sky-burial grounds.[4] Historically, these materials have been accessible in Tibet, where sky-burial was widely practiced, partially because of hard, frozen ground and lack of firewood for cremation. However, Losieries-Leick writes, as many Tibetans are now living in exile in India and other areas, there is a relative scarcity. Common substitutions include yak and water buffalo bone; ivory and tortoise shell are also known to have been used. Loseries-Leick presents a broad view of ornaments and ritual objects made from human bone including spiritual, cultural, and technical concerns.

However, the type of early ethno-historical scholarship discussed here is more often incorporated into the collection information for these types of objects, which is likely related to the historical period in which many bone ornaments were collected. Historical museum publications that present bone objects as

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[4] Sky-burial is a practice historically used in Tibet to dispose of dead bodies by having them cut into pieces and fed to birds and other wild animals by specially trained laity and religious representatives.

part of North American or European collections are generally from the early to mid twentieth century and often fail to adequately interpret the multivalent character of Himalayan ritual objects. Braunholtz (1930), for example, writes for the British Museum of a "necromancer's" bone apron. An anonymously written selection for the American Museum of Natural History from 1936 refers to 'sorcerers' and the use of bones from criminals as raw material. Unfortunately it seems that many of these historical publications still hold sway in the curation of bone ornaments, most often found in natural history collections where they are interpreted as ethnographic objects with fixed cultural significance. Harris (2012) has recently called for a museological investigation, presenting Tibet and the material culture of esoteric Buddhism in the Himalayan region as contemporary and dynamic.

Finally, there is a dearth of conservation literature on ritual objects from the Himalayan region, though there is a significant amount of scholarship on the materials, techniques, and treatment of *thangka* (Huntington 1970; Jackson and Jackson 1984; Cotte 2011). Scholars like Hatt (1980) have presented excellent technical information about metal sculpture. Studies of other types of painted surfaces (such as shrines and furniture) have also been conducted (Chao [2011]). Shaftel (2013) writes about the special preventive needs that ritual objects may need in their cultural settings as well as the need for sensitivity when treating works associated with esoteric traditions (Shaftel 1986). The handling of human remains has also been a topic of concern for conservators (McGowan and Roche 1996; *Human remains and museum practice,* eds. K. Goodnow and J. Lohman 2006), though this is often in the context of archaeological or anthropological specimens where the concerns of ancestors or Native American sovereignty are a priority. Literature addressing the treatment of human bone is generally concerned with adhesives or consolidants for bone in archaeological contexts (Johnson 1994; Storch 2003). It can be said that there is a need for published examples of conservators working with ritual objects from esoteric Buddhist traditions as well as human remains, where the function of the bone is as raw material for cultural properties and not a mortuary object or specimen. At the same time, Loseries-Leick (2008) writes that human remains, in the tradition of esoteric Buddhism, are inherently powerful; this is the reason for their utilization in ritual objects and should be remembered by those who come in contact with them, whatever the context.

3. Analytical methodology and results

3.1 Description

A variety of noninvasive and minimally-invasive methods were used to document and characterize the materials of this assemblage and its construction. Forensic and analytical digital photography were used to record the condition as well as macro- and microscopic features of the object's surface including morphology, construction, technique, and deterioration phenomena. The elemental composition of the surface (and subsurface) was characterized using x-ray fluorescence (XRF) spectroscopy. In addition to generating valuable data, noninvasive methods were used to guide decision-making about the use of minimally invasive methods and to devise a sampling strategy. A more precise chemical and physical characterization of the materials and surface features of this object was undertaken through micro-sampling and analysis, using polarized light microscopy (PLM), x-ray diffraction (XRD), micro-chemical tests (MCT), and Fourier-transform infrared spectroscopy (FTIR).

3.2 Noninvasive methods of analysis

3.2.1 Forensic and analytical digital photography

Forensic or analytical photography was used to document and examine the surface characteristics of the object. All digital images were captured with a Nikon D70 Digital SLR camera and Camera Control Pro 2 software, processed with Adobe Bridge CS5.1 software. The following three configurations were used in combination with this camera and software, except where otherwise noted:

Photomicrography: Digital photomicrographs were taken with a Meiji Techno adapter on a Meiji EMZ-TK binocular microscope.

Forensic photography: A SPEX Forensics Mini-Crimescope 400 was used as an excitation source. The Mini-Crimescope is equipped with a 400W metal halide lamp and filter wheels enabling selection of specific broadband excitation wavelengths, given below in Table 3.1. Image capture for this technique used a series of filters on the camera lens to capture reflectance and fluorescence from the object. These filters are given below in Table 3.2 with their relevant information, including transmission range (in nm). As an experiment to record a range of reflectance (capture range: UV-NIR) and fluorescence (capture range: visible-NIR) scenarios at various wavelength bands of both excitation and emission, each broadband excitation wavelength was used in combination with each type of filter for image capture (Table 3.2); only the most informative images from this process will be evaluated.

Center wavelength (±8nm)	Bandwidth (nm)
350 (ultraviolet)	80 (310-390)
415	45
445	40
455	70
475	45
495	45
515	45
535	45
555	30
575 (short pass)	175 (400-575 nm)
600	50

Table 3.1 Excitation bandwidth ranges used for both reflectance and fluorescence-type forensic imaging

Analytical photography: Photographs were taken using directed white light, provided by the Mini-Crimescope or a tungsten Interfit Halogen 100 lamp.

Filter set-up	Filter range (in nm)
Peca #916	400-725 (visible range)
XNite330 XNiteBP1 Used with modified Nikon D90 digital SLR with IR/UV filters removed	330: 330 (peak) BP1: 330-630, 930-1400
Peca #912 Used with modified Nikon D90 digital SLR with IR/UV filters removed	700-1100
50094VS Yellow viewing shield (Spex Forensics)	500+
50091VS Orange viewing shield (Spex Forensics)	550+
50089VS Red viewing shield (Spex Forensics)	600+

Table 3.2 Emission capture filters with their transmission ranges

While the entire object was examined at different wavelength bandwidths for both excitation and capture, only the crown (Fowler # X69.300 B) was photographed with each excitation source and capture/ filter set-up. This was due to considerations for the overall safety of the object, based on its fragile nature, and the crown's complex and intriguing obverse surface. Ultraviolet (UV) reflectance, UV-induced visible fluorescence, and visible-induced infrared (IR) luminescence imaging were all conducted as part of this examination using the settings described above.

3.2.2 3-D reconstructed digital micrography

Additional photomicrography of the physical character and morphological features on the surfaces of a few sections of the object were taken on a Keyence VHX-1000 series digital microscope at the UCLA Department of Materials Science and Engineering.

3.2.3 X-ray fluorescence spectroscopy (XRF)

Elemental composition spectra were taken with a Bruker Tracer III-IV+ hand-held X-ray fluorescence (XRF) system to characterize surface and bulk materials. Spectra were processed using S1PXRF software. Spots were all run at one or both of two settings, seen below in Table 3.3.

Setting 1: general	No filter, vacuum, 40 kV, 1.9 μA, 180 sec
Setting 2: heavy metal sensitive	Cu/Ti/Al Filter, no vacuum, 40 kV, 20 μA, 180 sec

Table 3.3 Settings for spectra taken with Bruker Tracer III-IV+ portable XRF

3.3 Minimally-invasive methods of analysis

Micro-samples (< 5 mg) of original material were collected from the object and its surface deposits and analyzed (see Appendix H). Fiber samples were taken with steel hand tools and mounted in deionized water on a glass slide with a cover. Dispersion samples were mounted on a glass slide in Cargille Meltmount (refractive index = 1.662) and then covered with a glass cover slip. Samples were otherwise taken with steel hand tools and a synthetic bristle brush and sealed in aluminum foil in a polyethylene sample vial.

3.3.1 Polarized light microscopy (PLM)

An Olympus BX51 polarized light microscope was used for the examination of organic and inorganic materials. Images were captured using a Martin Microscope Company adapter, the Nikon D90 camera and same software as above. Fiber samples were examined for diagnostic morphological and optical features in transmitted plane and crossed polarized light. These were compared to samples from a reference set by Cargille, Set. No. CF-7, Commercial Fibers. Dispersion samples were used to similarly investigate the inorganic phases of pigments and surface materials.

3.3.2 Micro-chemical testing (MCT) and micro-solubility testing

Micro-chemical tests were performed to characterize surface deposits and deterioration products. These were performed on a glass slide under magnification with the exception of the amine test for proteins, which was carried out in a glass test tube. A glass alcohol lamp was used for heat. The reagents for individual tests are given in Table 3.4. Micro-solubility testing was conducted with small, dry samples of material on glass slides to which drops of deionized water, ethanol, acetone, and/or mineral spirits were introduced. The solvent was evaporated under a heat lamp and then the slide was examined for residues.

All test results were evaluated against reference materials of known chemical composition.

Objective	Reagents	Source
Protein Biuret test	2% (w/v) (aq) $CuSO_4$, 1.2 M NaOH (aq)	(Odegaard, Carroll, and Zimmt [2000] 2005)
Protein Amino groups	CaO (s), heat, ColorpHast pH-indicator strip	(Odegaard, Carroll, and Zimmt [2000] 2005)
Mg	NH_4Cl, citric acid, Na_2HPO_4, heat, NH_4OH (aq)	(Crawford 2009)

Table 3.4 Reagents for micro-chemical spot tests

3.3.3 Flame test

Flame tests were performed by isolating the sample on aluminum foil over a glass alcohol lamp, under a fume extraction trunk. This technique was used to determine whether a material was organic, inorganic, or a combination thereof.

3.3.4 X-ray diffraction spectroscopy (XRD)

XRD was used to analyze and identify the crystalline inorganic and mineral content of surface deposits. Sample material was mounted on a glass spindle and analyzed using a Rigaku Spider R-Axis X-ray diffractometer. XRD spectra were recorded at 50 kV and 40 mA using a Cu-Kα target. XRD data was processed and matched against reference spectra from the International Center for Diffraction Data (ICDD) using Jade software v. 8.2.

3.3.5 Fourier-transform infrared spectroscopy (FTIR)

FTIR was used primarily to investigate organic materials or residues on the surface of the object. FTIR was performed at the UCLA Department of Chemistry on a Jasco FT/IR-420 Spectrometer. Approximately 2 mg of well-ground sample material was mixed with 180 mg of potassium bromide (KBr) and compressed into a pellet. Spectra were recorded in % absorbance over a range of 4000 to 400 cm^{-1} (wavenumbers) and processed using Jasco Spectrum Manager and PerkinElmer Spotlight (v.4.3.3) software.

3.4 Results

Results of the analyses conducted are summarized below; further discussion and conclusions are described in Section 4.

3.4.1 Substrate identification and preparation

Macroscopic attributes of the bulk material or substrate include porous surfaces identical to cancellous bone formations in combination with areas of dense cortical layers displaying Haversian canals suggested the presence of bone (Espinoza and Mann 1999). The identification of the bone as human, and not animal, was achieved in consultation with zooarchaeologist Dr. Thomas Wake and physical anthropologist Dr. Wendy Teeter, both members of the Cotsen Institute for Archaeology at UCLA.[5] The

[5] Dr. Wake, especially, has been helpful in the articulation and interpretation of the microscopically-observed morphological features presented here.

criteria and unique features of the substrate discussed during this consultation are presented in Appendix F, with a suggested protocol for identifying human bone in cultural objects.

Forensic imaging showed a UV-induced visible florescence not inconsistent with the appearance of the primary mineral component of bone, hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$] (Figure 3.1).[6] This was observed in all sections of the object, in alternation with occasional areas where the surface was obscured by superficial layers of material. Examination of the surface using high resolution digital microscopy revealed the vascular morphology of capillary beds within the substrate surface (Figure 3.2) as well as grain — the delineation of axial morphology corresponding to the growth of bone — (Figure 3.3) and mineral formation within the bone (Figure 3.4).

XRF spectroscopy of multiple spots on the substrate surface (Figure 3.5) consistently registered the presence of Ca and P as major elements. Other minor and trace elements were also recorded, varying

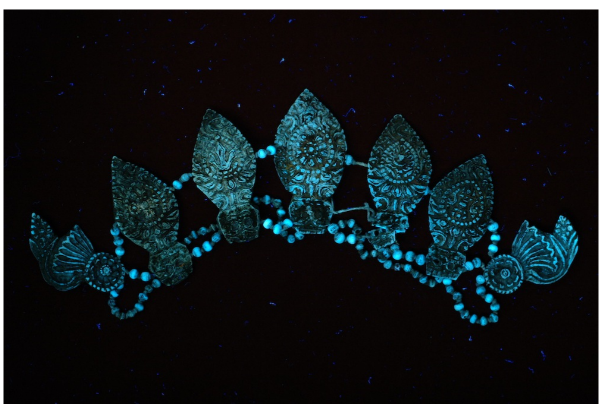


Figure 3.1: UV-induced visible fluorescence digital image (λex=300-400nm, 400-700nm capture) of crown (Fowler # X69.300B) showing blue-white fluorescence of bone mineral; dark areas are due to thicker layers of surface residue.

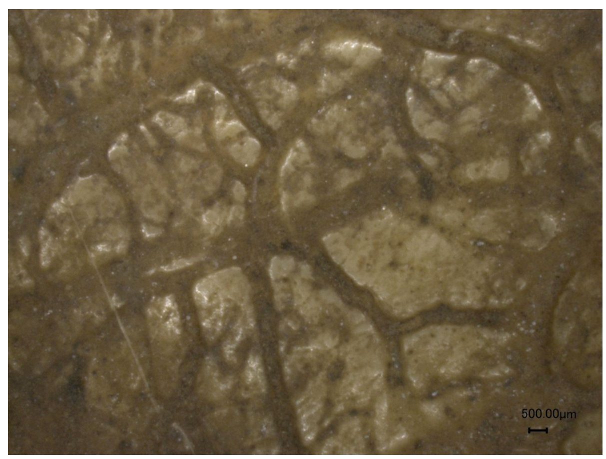


Figure 3.2: Capillary beds on reverse of central component of arm band (Fowler # X69.300 C); the piece is identified as human cranium.

[6] NB: The blue-white appearance under UV-induced visible light cannot be used to diagnose the presence of bone minerals specifically as other types of inorganic and organic material exhibit similar behavior. This method can be used as an initial investigation but the identification of bone, specifically, should be supported by more in-depth analysis of morphology and features (see Appendix F).

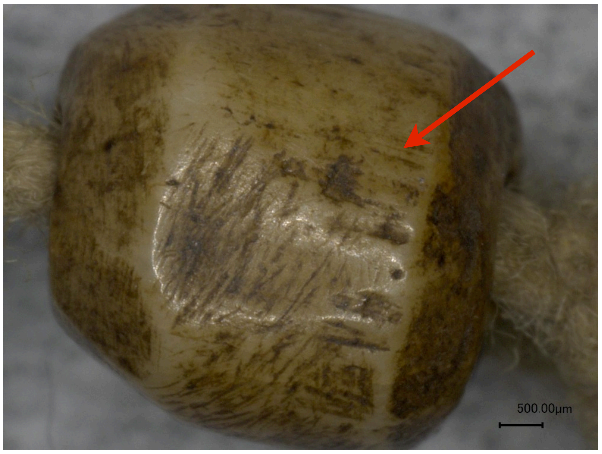


Figure 3.3: Delineations parallel to the longitudinal axis of the bead (red arrow) are grain; other marks are from shaping and tools uses during construction.

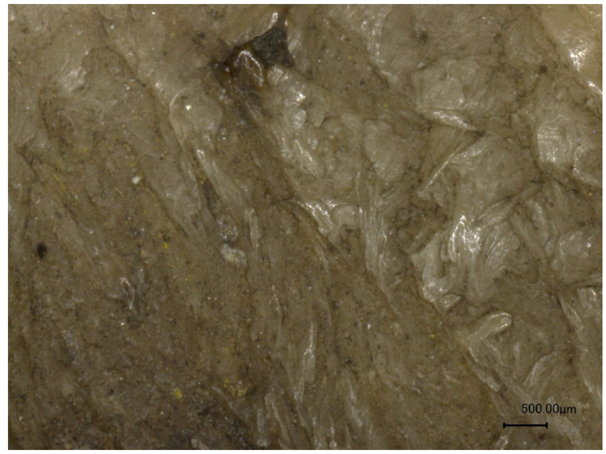


Figure 3.4: A broken section of cortical bone reveals the patterns of mineral deposition during bone formation.

Figure 3.5: Areas of spot analysis using XRF spectroscopy: The numbers correspond to specific samples discussed and their proformas (Appendix H).

according to the area being measured. The intensity of peaks for Ca and P were relative to the presence of other materials on the surface such as heavy metals, colored deposits or surface layers (Appendix C).

The preparation of the bone substrate for use in the construction of this object is indicated by features observed through raking light (oblique illumination) and microscopy. Raking light on sections of the arm band (Fowler # X69.300 C) reveal the depth of relief in the carving and the finesse of its execution (Figure 3.6). Raking light on the reverse of a constructed aperture in another element of on the arm band, illustrates — by its smoothed ridges of displaced material — the plasticity of the bone during its manipulation in the production of the object (Figure 3.7). In microscopic examination, it was found that tool

Figure 3.6: Raking visible light reveals the depth and finesse of the carving on the object.

Figure 3.7: Raking light photograph of the reverse of the central plaque of the arm band (Fowler # X69.300 C); red arrow indicates smooth ridges of displaced material from manufacture.

Figure 3.8: Photomicrograph showing concentric type tool marks on bead surface.

Figure 3.9: Digital micrograph showing short, irregular linear marks (red arrow) which are diagonal to grain and likely created by sanding during shaping.

marks on the beads alternate between turning type marks which are concentric and perpendicular to the bone grain (Figure 3.8) and short, parallel strokes distributed across the surface, inconsistent with the bone grain, which indicate sanding or other shaping methods (Figure 3.9).

The substrate of the central component of an ornament with unidentified function (Fowler # X69.300G) was markedly different in character from other areas in the object (Figure 3.10). When measured with XRF, it was seen to contain Ca and P, as in other sections identified as bone (Appendix C). Its appearance under UV-induced visible fluorescence is similar to other areas, though in visible light it was seen to be orange-brown in color with a smooth, luster finish. With microscopic examination, the

Figure 3.10: The round, dark orange-brown central component of this section is markedly different in appearance than other parts of the object substrate (Fowler # X69.300 G).

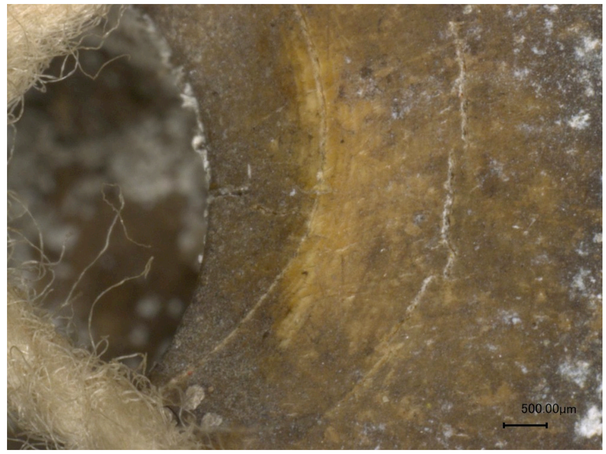


Figure 3.11: Digital micrograph showing concentric grain differs from other areas of the substrate that displays linear grain.

Figure 3.12: Digital micrograph showing mottling in color along polished edge (red arrow) is indication of characteristic patterning of ivories.

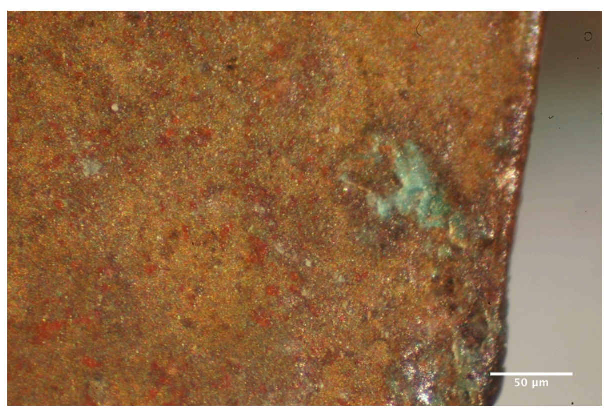


Figure 3.13: Compact area of light green corrosion consistent with deterioration of cuprous alloys.

morphology of this component was documented as uniquely concentric, rather than granular and axial as in other sections of the substrate (Figure 3.11). Variations in coloration, or mottling, that likely correspond to the characteristic formation within ivory known as Schreger lines (Espinoza and Mann 1999) were also recorded (Figure 3.12). There was no indication of how this piece was carved from its surface condition.

Finally, the type of alloy used for the metal bangles on the object was identified through XRF, which registered the characteristic x-rays of Cu, Zn, and traces of Fe (Appendix C). This suggests the bangles are made from brass. Microscopic examination of the surface of the bangles revealed areas with bright green corrosion (Figure 3.13), characteristic of Cu-containing alloys (Scott 2000).

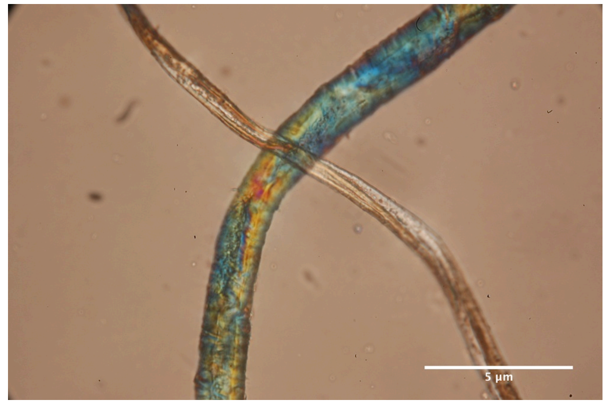
3.4.2 Fiber analysis

Fiber micro-samples were taken from various locations and applications within the object (Figure 3.14) and examined under PLM. The results for this analysis are summarized in Table 3.5. Fibers were found to be cotton, bast, or a mixture of the two. Cotton was identified by its characteristic shape (flattened tube, lack of central element, twist) and strong birefringence (Figures 3.15 and 3.16). Two types of bast fiber were found, with slight variations in morphology, size, and behavior under cross-polarized light. Both types of bast fibers were observed to have regular markings perpendicular to the axis of growth; these markings were generally smooth and simple in shape, in contrast to scales on animal fibers (Goodway 1987; Leene 1972). Bast fiber type A was larger, with widely spaced and smooth perpendicular bands, an irregular central component, a bright, primarily blue birefringence towards the fiber's outer surface every 90 degrees, and did not display complete extinction (Figures 3.17 and 3.18). Bast fiber type B has more closely-spaced and irregularly-shaped cross-hatchings, bright pink and yellow birefringence colors, a

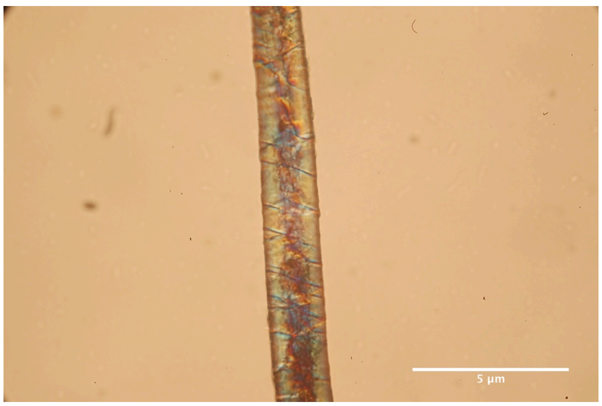
Figure 3.14: Locations for micro-sampling to identify fibers used in cordage, tassels, and woven textiles on object.

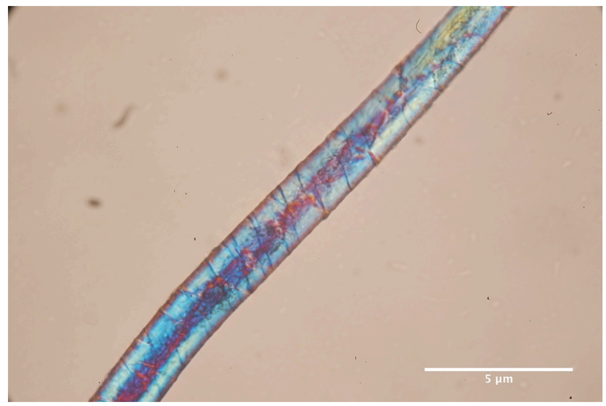
Sample location/ Proforma #	Function	Description	Observations	Results
35	Tassel	Brownish-grey; Z-twist, single ply	Smooth, slightly curved cross-hatchings perpendicular to axis of growth, evenly spaced; bright blue birefringence colors, no central element	Unidentified bast fiber (type A)
	Cordage on tassel	White-grey, Z-twist, 2-S ply	Two fiber types present; one is flattened tube with twist, no surface markings; second has indistinct surface markings, central component with mainly blue also yellow, red birefringence colors	Mixture of cotton and unidentified bast fiber
36	Cordage	Grey, Z-twist, 6-S-ply	Two fiber types; one is flattened tube with dark central component and orange, yellow, blue birefringence, straight, no surface markings; second is larger with regularly spaced, smooth cross hatching, primarily bright blue birefringence, indistinct central, interior element	Mixture of cotton with unidentified bast fiber (type A)
37	Cordage	Z-twist, 6-S-ply	Angular cross hatchings with linear central component, primarily bright pink/blue and yellow birefringence; fiber is very straight	Hemp (bast fiber type B)
38	Tassel?	Black, Z-twist, single ply	smooth, slightly curved perpendicular markings (deteriorated, difficult to see), no extinction, white with blue, red, purple birefringence colors, poorly defined central component; appears dark blue in plane polarized light (dye)	Likely unidentified bast fiber (type A)
		Brown, Z-twist, single ply	Angular, closely-spaced cross hatchings with linear central component, primarily bright pink and yellow birefringence, no extinction; transparent in plane polarized light	Unidentified bast fiber
		Red, Z-twist, single ply	Two fiber types: first is mostly white in crossed polars with some blue, purple, pink birefringence colors; shape is flattened tube with central component, some twisting, no discernible surface markings/cross-hatchings; second has regular, smooth, curved cross-hatchings with no extinction, blue and yellow birefringence, transparent in plane polarized light	Mixture of cotton with unidentified bast fiber (type A)
39	Cordage	Blue-ish, loose S-twist, single ply	Closely spaced, angular cross-hatching; cross polars has complete extinction every 90 degrees, straight with linear central component; bright yellow, pink, and blue birefringence	Hemp (bast fiber type B)
40	Detached textile fragment	Grey-brown, plain-woven; yarn is Z-twist, single ply	Under crossed polars exhibits bright pink and yellow birefringence colors, angular, closely spaced cross-hatchings, no extinction, linear central element	Unidentified bast fiber

Table 3.5: Fiber analysis by PLM with observed behavior and summarized results; *n.b.* 'Cordage' refers to a yarn with the primary function of fastening or connecting carved bone elements.

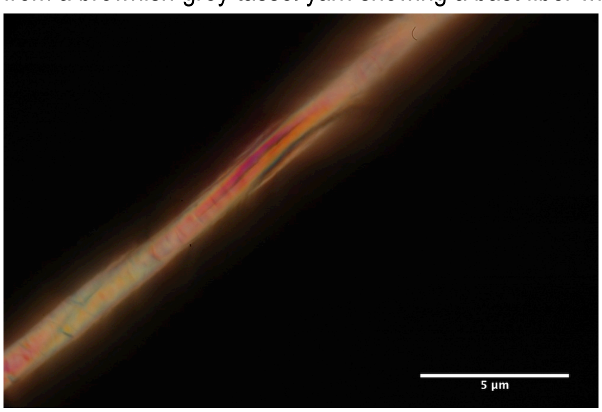


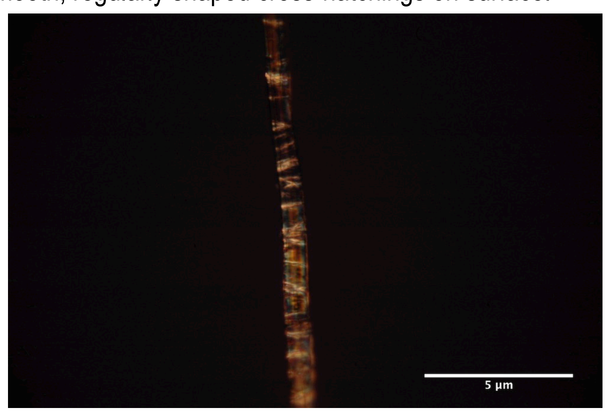
Figures 3.15 and 3.16: Photomicrographs of a sample in plane (3.15, left) and semi-cross polarized light (3.16, right) from a white-grey cordage with a mixture of cotton and unidentified bast fiber.





Figures 3.17 and 3.18: Photomicrographs of a sample in plane (3.17, left) and semi-cross polarized light (3.18, right) from a brownish-grey tassel yarn showing a bast fiber with smooth, regularly shaped cross-hatchings on surface.





Figures 3.19 and 3.20: Fiber sample from blue-dyed cordage in cross polarized light showing pink birefringence colors and linear central component (3.19, left) and rotated 90 degrees to show cross-hatchings (3.20, right).

distinctly linear central component, and extinction of birefringence colors with illumination of cross-hatchings every 90 degrees (Figures 3.19 and 3.20).

Recorded observations of fiber behavior under PLM were compared to a reference set of fibers which included hemp, jute, nettle, and ramie. Considering the morphological and optical characteristics of the fibers, bast type B is likely hemp (*Cannabis* spp.) but the specific identification of type A and other bast fiber species remains inconclusive. Some unidentified fibers share features with bast fiber type A and may represent different raw materials of the same species.

3.4.3 Surface materials

3.4.3.1 Pesticide residues

XRF measurements of the surface of the object consistently registered Pb. Though Pb-based pigments were also found on the surface of the object (see Section 3.4.3.2, below), there was a persistent presence of signals for Pb on other sections, including measurements taken on a yarn tassel with no evident pigment or residue (Appendix C). The ubiquity of signals for Pb and the object's collection history strongly indicate an application of Pb-containing pesticide. This was most likely applied as part of an early-mid 20th century collections care regime (Goldberg 1996), though the specific circumstances are unknown.

3.4.3.2 Colored deposits

Observation in visible light as well as forensic imaging revealed an irregular deposition of residue layers on the object surface (Figures 3.21 - 3.24). With the exception of red color inside the eyes of the round, skull-shaped plaques in the apron (Fowler # X69.300 A), the application of colorants to the object surface is seemingly random and do not correspond to carved motifs or shapes.

The materials examined here are discussed as deposits, rather than paints; there was no attempt to distinguish binding media in colored materials or to discern the stratigraphy of successive layers of application. Material types are presented here in terms of their appearance and/or relationship to the object surface. Due to a lack of standard reference material on the luminescence of substances using forensic imaging, this technique could otherwise not yield much diagnostic information about the types of materials

Figure 3.21: Reflected visible/white light image (λex=400-700nm, 400-700nm capture) of crown (Fowler # X69.300B)

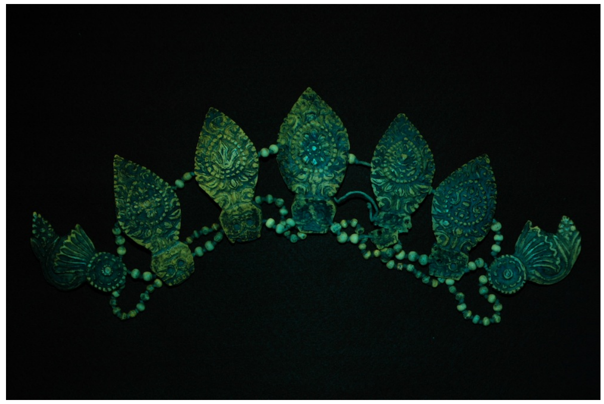


Figure 3.22: λex=475nm, 500+nm capture

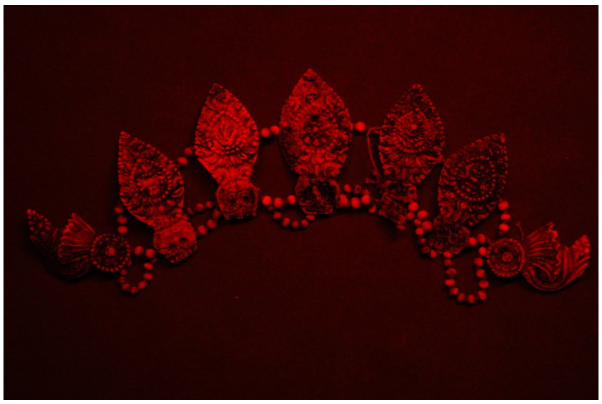


Figure 3.23: λex=495nm, 600+nm capture

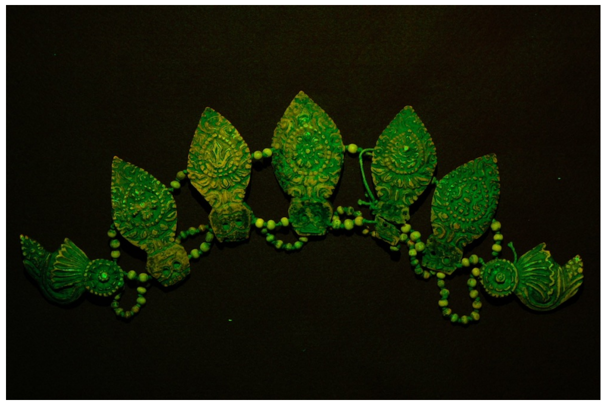


Figure 3.24: λex=575nm, 550+nm capture

present on the surface of the substrate. Resources on the diagnostic application of forensic imaging is currently being developed and may later provide more information for the interpretation of data presented here.[7]

Red stain

Areas of red staining were found primarily on beads, in all sections of the bone ornament ensemble (Figure 3.25). Red stains were also found on the side and reverse surface of plaques and carved decorative elements (Figure 3.26). This red stain is a generally a thin layer, at times transparent, and well-

[7] See Kakoulli, I. and A. North, "Beyond the visible: Macro and micro-analytic forensic imaging for the documentation and investigatin of archaeological objects," Paper presented at the American Institute for Conservation's 41st Annual Meeting, Indianapolis, IN, May 2013.

adhered to the object surface. UV-induced visible fluorescence on areas with red staining showed dull to bright orange, characteristic of shellac, a varnish derived from the exudate of the lac insect (Koob 1998) (Figures 3.27 and 3.28).

XRF spectra of the areas with the red stain was intermittently present on the object surface showed no significant compositional difference from those areas without it; areas with the stain had slightly stronger signals for Fe, Cu, and Sr but no elements were observed unique to areas with color (Appendix C). Because it is consistent with other areas of the substrate where no colorant is present, XRF data supports

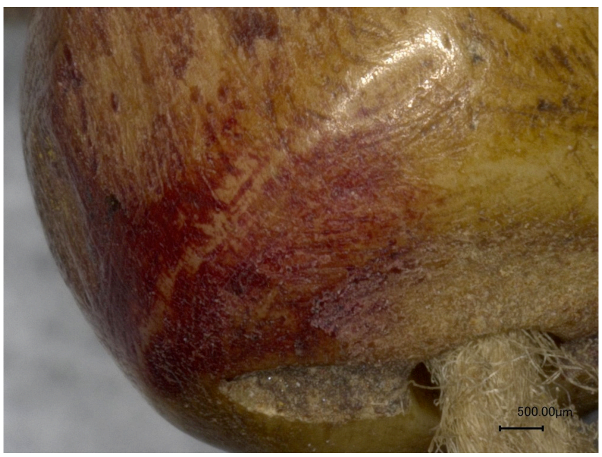


Figure 3.25: Red stain on the surface of a bead; red arrow indicates area where red stain covers unpolished surface.

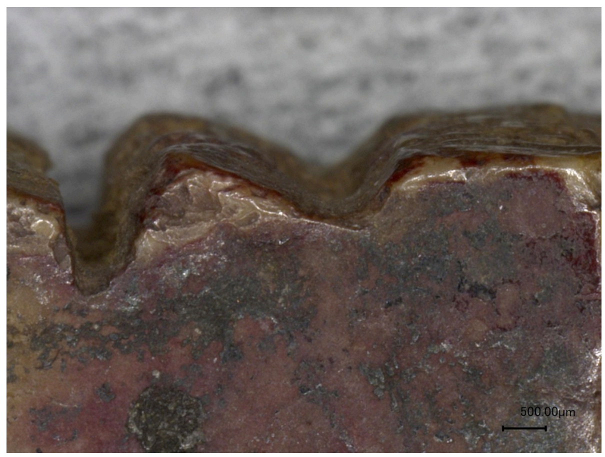
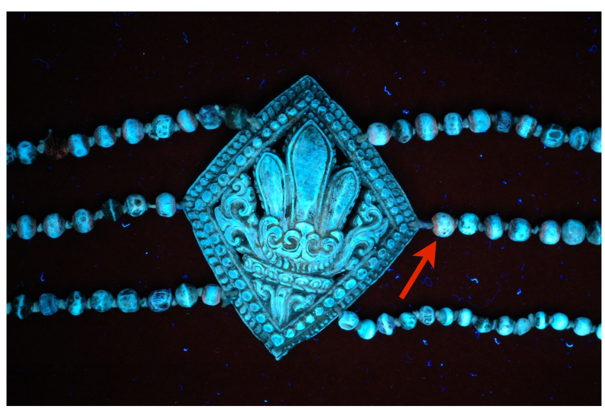


Figure 3.26: Red stain on the surface of the reverse of a plaque in unidentified ornament (Fowler #x69.300 D).



Figures 3.27 and 3.28: Beads with red stain are spaced irregularly in object and here on the arm band (Fowler # X69.300 C); red arrow indicates same position in each image where reflected visible light shows red and UV-induced visible fluorescence ex=300-400nm, 400-700nm capture) shows bright orange; other areas show orange that varies from dull and/or pale to bright.

the assumption that the red stain may be organic in nature and lac dye (a component of shellac, often red) is the assumed material used to create this type of staining (see also Appendix G).

Red

There are a number of red-type material deposits on this object ranging in color from light pink to bright orange to crimson. Table 3.6 summarizes results and classifies each type of red or chromatically related material analyzed through noninvasive methods and micro-sampling (Figure 3.29). Eight of these colors were selected for analysis with XRF and micro-analytical techniques. It was found they are generally Pb-based (minium [Pb_2PbO_4]) or Hg-based (cinnabar [HgS]), with impurities or other, unidentified substances creating variations in hue and value.

FTIR analysis on two samples of red material with organic content — as suggested by a flame test — illustrates the complexity of some of the deposits on the object surface (Appendix E).[8] It should be noted that FTIR spectroscopy was interpreted here in terms of results from other methods of analysis. In

Figure 3.29: Locations for analysis of red materials, locations are indicated by sample/proforma # (Appendix H).

the first sample of red material (50), three absorption peaks between 1050 and 1200 cm^{-1} likely correspond

[8] Invaluable assistance was provided in the interpretation of these FTIR spectra by Herant Khanjian, Assistant Scientist at the Getty Conservation Institute; other resources consulted were Coates (1999) and Derrick, Stulik, and Landry (1999).

Color	Sample position/ Proforma #	Method of analysis	Results	Interpretation
Red	17	XRF	Hg, Pb,	
	33	XRF	Hg, Pb	
	53A	XRD	Cinnabar, calcite	
	53A	XRD	Cinnabar, calcite	Cinnabar
Peach	18	XRF	Pb, Hg, Ca, P, Fe, Ba (L lines)	
	50	Flame test	Some organic content	
	50	FTIR	Barite, protein	
	50	XRD	Barite, minium	Minium, barite with organic content and possibly cinnabar
Dark pink	51	XRD	Minium	Minium with unidentified colorant
Dark pink	48	Flame test	Some organic content	
	48	FTIR	Calcite, clay, gum?	Organic with possible inorganic colorant
Peach	21	XRF	Pb	
	49	XRD	Minium, goethite?	Minium
Orange	26	XRF	Pb, Ca, P, Fe	
	46A	XRD	Minium	
Pink	46B	XRD	Minium	Both orange and pink in this area are minium, mixed with unidentified colorant
Red	30	XRF	Hg, Pb, Ca	Cinnabar
Pink	42	XRD	Minium, hydoxylapatite	Minium with unidentified colorant

Table 3.6 Red deposits, examined and presented here with analytical methods, results, and interpretation.

to sulfate (SO_4^{-2}) in barite ($BaSO_4$). Proteins are indicated by the broad absorption at 3397 cm^{-1} (N-H stretching) and amide I and II absorptions at 1638 and 1516 cm^{-1}, respectively.[9] In the second sample (48), an absorption at 1414 cm^{-1} may be related to carbonates (CO_3^{-2}) in calcite; signals at 534 and 468 can be from Si-O in quartz; and the peak at 3435 cm^{-1} with that at 1035 cm^{-1} may come from a gum or other polysaccharide material, which is suggested by the overall spectrum shape as well as similar materials being found in other samples (see below).

Yellow

Yellow-colored deposits are composed primarily of barite with other trace components; identification is complicated by limited material for sampling. Table 3.7 presents the methods of analysis attempted with the available samples and results thereof. The material is generally finely powdered and homogeneous.

Sample position/ Proforma #	Method of analysis	Results	Interpretation
24	XRF	Al, Si, K, Sr, Ca, P, Ba (L lines), Pb	
29	XRF	Al, Si, Ca, P, Ba (L lines), Pb	
43	PLM	White crystalline material with smaller, yellow phase associated	
	XRD	Barite, calcite	
	FTIR	Barite, possible clay	Barite with second unidentified yellow component, possibly organic and some clay

Table 3.7 Yellow deposits, examined and presented here with analytical methods, results, and interpretation.

[9] Derrick, Stulik and Landry (1999) relate that function groups for proteins are generally recognized by a combination of an absorption at 3350 cm^{-1} in combination with absorptions for amide I near 1650 cm^{-1}, amide II near 1550 cm^{-1}, and amide III near 1450 cm^{-1}.

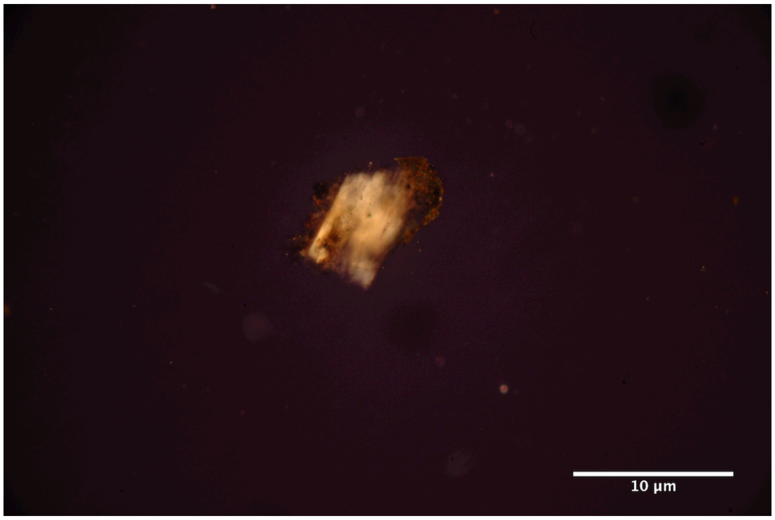


Figure 3.30: Photomicrograph of a dispersion of a sample of yellow pigment in cross polarized light showing two phases, or an alteration of a primary phase, in close association, one white and the other an opaque yellow-brown.

Analysis by FTIR was inconclusive due to a lack of sufficient sample size (Appendix E). Absorptions at 2363 and 2334 cm^{-1} likely correspond to atmospheric CO_2 and signals above 3300 cm^{-1} which might aid in the identification of clays are complicated by possible absorbed water in the sample. As above, absorptions between 1050 and 1200 cm^{-1} can be attributed to the sulfate in barite. PLM shows barite crystals (tabular plate-like rhombic prism) in close association with a yellow material, or alteration phase, with a comparatively smaller particle size (Figure 3.30).[10]

Black/dark brown

Two types of black or dark brown surface materials are analyzed here: the first is a stain, a coloration of the substrate surface. It was examined by XRF and has a small peak for Cu and a stronger signal for Fe in comparison to the area with no staining (Appendix C) (Figure 3.31). A similar comparison from the reverse of another plaque (Fowler # X69.300 B) shows that areas without the black stain have stronger signals for the substrate (Appendix C).

The other type of dark brown/black deposit examined here shows a more complex composition and relationship with the substrate. Microscopy shows an irregular distribution of the material, which is

[10] Resources for the interpretation of materials by PLM included Nesse (2004) and Eastaugh *et al.* (2008).

Figure 3.31: Black stain on surface of plaque on apron (Fowler # X69.300 A).

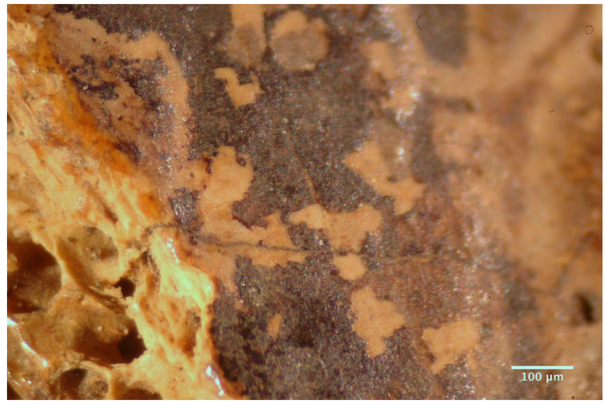


Figure 3.32: Photomicrograph of dark brown/black material on surface of crown plaque (Fowler # X69.300 B).

generally well-adhered to the surface in a thin layer (Figure 3.32). A flame test for this material confirms that it is organic and an acrid scent produced suggests the presence of proteins. FTIR spectroscopy shows peaks between 460 and 610 cm^{-1} and above 3500 cm^{-1} which may suggest the presence of clays in the sample (Appendix E). The broad peak at 3350 cm^{-1} in conjunction with peaks at 1646 and 1419 cm^{-1} support an identification of proteins, as suggested by flame test.

Figure 3.33: Position of light brown material on crown obverse face (Fowler # X69.300 B).

Light brown

A light brown material was found in the obverse surface of the crown plaque (Fowler # X69.300 B) (Figure 3.33). A flame test suggests that the material is primarily organic in nature. Micro-solubility tests demonstrated that a portion of the material is soluble in warm water, with a trace amount responding to acetone. In FTIR analysis, the potential functional groups found in polysaccharides — a gum, for example, which is soluble in warm water — is supported by absorptions at 1054 cm^{-1} in combination with the broad absorption at 3346 cm^{-1}. The samples were observed to be well-adhered to the surface and homogeneous.

Off-white

An off-white colored material was found on a carved plaque at the top of the apron (Fowler # X69.300 A) (Figure 3.34). A flame test was inconclusive with charring but no combustion of material. XRD analysis revealed the presence of quartz, hypercinnabar (HgS, a high temperature phase of cinnabar), and possible clay-like components (alumino-silcates) (Appendix D). The material is a coarsely ground-powder with phases of pink/red particles intermixed.

Figure 3.34: Position of off-white material on apron (Fowler # X69.300 A).

Figure 3.35: Position of green material on unidentified ornament (Fowler # X69.300 E).

Green

Green was found on an ornament of undetermined function (Figure 3.35). The green layer was thinly applied, opaque, and well-adhered to the surface. XRF analysis taken of this area and immediately adjacent recorded the characteristic x-rays for Cu where the green material was present and Hg where it was not (there is some red material in this area of the object surface as well) (Appendix C). The two areas consistently showed characteristic x-ray emissions for Ca, P, Fe, and Pb, though signals for Ca and P were stronger where no green was present. XRD analysis of the green material revealed the presence of atacamite [$Cu_2Cl(OH)_3$] and calcite ($CaCO_3$) (Appendix D).

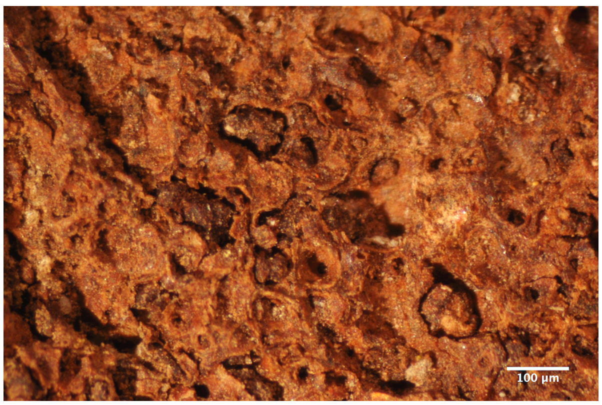


Figure 3.36: Photomicrograph of soft red-brown material in pores of exposed cancellous bone.

3.4.3.3 Deterioration products

A dry, brown, granular substance was noticed separating from pores in the exposed cancellous bone on the reverse of the skull crown (Fowler # X69.300 B). Under the stereomicroscope, it was observed that this material was pliable and came from within the porous structure of this area of the bone (Figure 3.36). The material is a combination of larger dark-brown masses and light red-brown, translucent phases. The results of micro-chemical testing are inconclusive; some phases were soluble in deionized water and proteins were detected with the Biuret ($CuSO_4$/NaOH) test.

White spots were observed on the reverse of an ornament with undetermined function (Fowler # X69.300 D). These spots were seen on top of an area with red stain (likely lac dye) and blackish material (Figures 3.37). Examination under PLM revealed that the material is amorphous (Figure 3.38), appearing waxy, softly-contoured, and glossy. XRF analysis of the area recorded an elemental composition similar to areas of exposed bone substrate, suggesting the black and red layers are likely organic. Further analysis of these white spots was complicated by the limited amount of material. A flame test revealed that it may

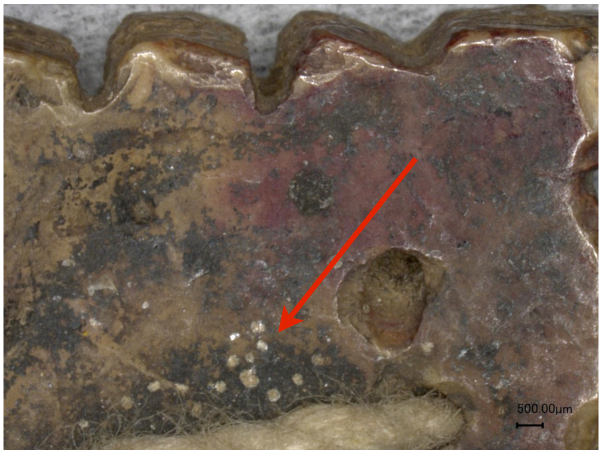


Figure 3.37: Red arrow indicates spots of a white waxy material on the reverse of Fowler # X69.300 D in area with black material and lac dye.

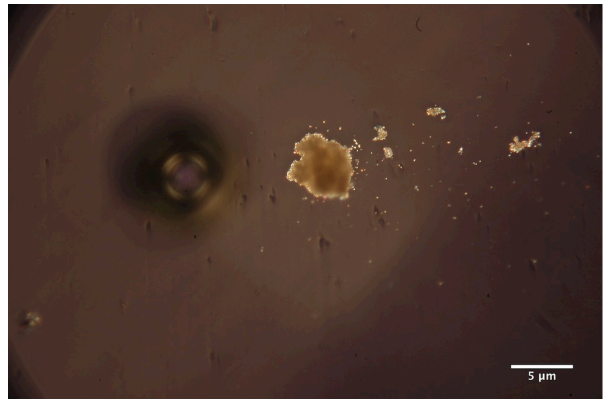
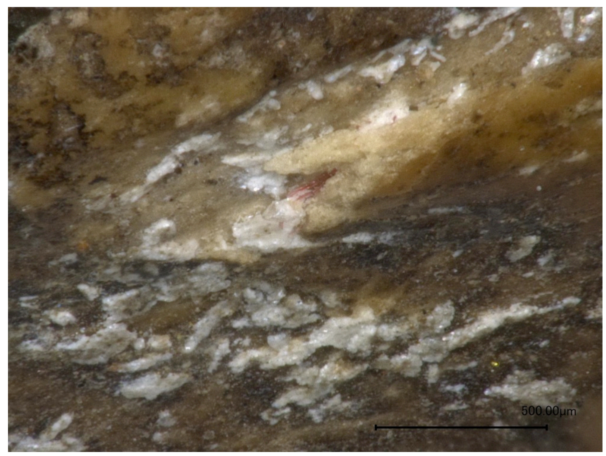


Figure 3.38: Photomicrograph of a white, waxy-looking deposit with opaque, granular appearance.



Figures 3.39 and 3.40: Crystalline material forming between grain boundaries in substrate at 50x (left) and 200x (right).

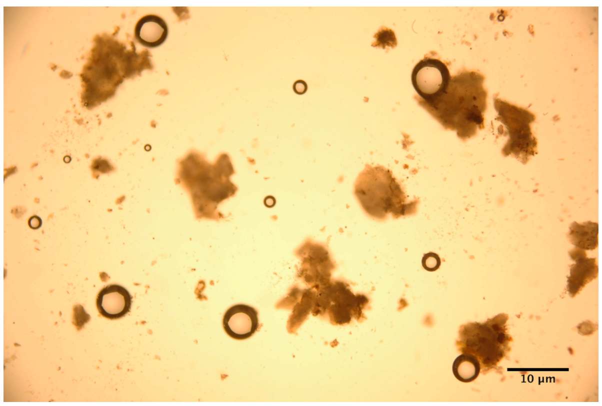
be responsive to heat by partially melting and leaving a waxy residue on the surface of a glass slide. Micro-solubility tests with deionized water, acetone, ethanol, and mineral spirits gave inconclusive results.

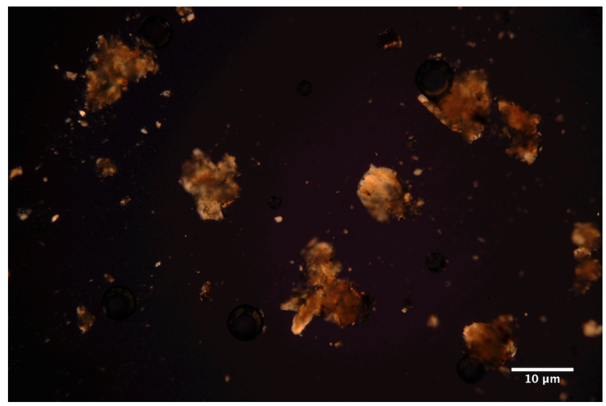
Crystalline substances were found on certain beads, corresponding to boundaries in the natural grain or axial growth layers of the bone (Figures 3.39 and 3.40). This material is closely associated with the substrate; no sampling or further analysis was attempted.

Finally, a large amount of powdery, white material on the reverse and, in trace amounts, on the sides and obverse, of the central component of an ornament with undetermined function (Fowler # X69.300 G) was examined to determine its composition (Figure 3.41). XRF spectra were recorded from the front

Figure 3.41: Reverse of ivory element in Fowler # X69.300 G with white deposit.

Figure 3.42: Red arrow indicates one of the many globular, egg-like formations found in this area.





Figures 3.43 and 3.44: Dispersion mounted sample of white deposit on reverse of ivory element in Fowler # X69.300 G) in plane (3.43, left) and cross (3.44, right) polarized light.

and reverse of this component where those from the front had stronger signals for Ca, P, Fe and other trace elements (K, Mn, Ni, Cu) (Appendix C: XRF spectra, *28_X69-300_ivory*, etc.). These variations in peak signal strength, however, may be related to the thickness of the deposit on the reverse surface or to the challenge of getting accurate XRF readings from complex shapes. Under BM and 3-D digital microscope, this substance was granular with small, globular formations similar in shape and size to insect egg casings, sometimes closely associated with organic material (Figure 3.42). A flame test demonstrated that this substance is largely inorganic, including the globular, egg-like formations. Under PLM, the material is a number of closely related and difficult to distinguish phases with poor morphology (Figures 3.43 and 3.44). The most prevalent phase is transparent in plane polarized light, white to yellow in crossed polars with poorly formed crystals and undular extinction every 90 degrees. A second phase of opaque, dark brown material which appeared to be amorphous. Micro-chemical testing revealed the presence of Mg and using XRD, it was confirmed that this white material is a combination of calcite, newberyite [$Mg(HPO_4) \cdot 3H_20$], and hydroxyapatite (Appendix D).

4. Discussion

Specific materials found in this investigation are generally consistent with available published information about the construction of bone ornaments. Table 4.1 summarizes the results of the analytical examination. The following discussion is intended to contextualize these findings and make estimations about how the object's condition and constitution reflect its construction and material history. Section 5 will reflect specifically on how the findings of this investigation compare to other, similar bone ornament assemblages.

The finding that the substrate for this object is human bone, with an ivory component, is consistent with long-standing traditions about materials used for this type of ritual object. Loseries-Leick (2008) comments that though some substitutions — camel, buffalo, or mule bones — have no significance, the

Substrate	Human bone, ivory
Fibers	Hemp, unidentified bast fiber, cotton
Surface materials	Minium (red lead), cinnabar, barite, atacamite Clay (alumino-silicate), quartz, calcite Lac dye
Surface materials presumably related to substrate deterioration or reactivity	Proteins, newberyite (magnesium phosphate), hydroxyapatite

Table 4.1 Summarized results of analytical investigation of materials used in object construction or found on the surface.

use of ivory may be a deliberate attempt to enhance the value of the object. She also reports that different kinds of wood are traditionally recommended as substitutions. It should be noted that ivory is not native to all regions of the Himalayas (*e.g.* Tibet) and may have been imported from India. It is not known from which species this ivory comes though its concentric morphology and region of provenance suggest elephant. The types of tool marks on the bone elements provide inconclusive information about how the object was shaped though it can be said that a variety of techniques were used. In her study of contemporary Tibetan bone carvers in exile, Loseries-Leick (2008) notes the used of metal hand tools and the absence of text-based references for traditional or pre-modern carving techniques. Microscopic examination revealed areas where bone material was displaced in smooth ridges during working and this can be interpreted to illustrate plasticity in the bone during its manipulation. By extension, this indicates that the bone was somewhat freshly harvested during manipulation and had not yet become embrittled due to loss of collagen during biological decay (Teeter, personal communication; Wake, personal communication). It has been observed here that different types of bone have been utilized differently in the object: the crown (Fowler # X69.300 B) and arm band (Fowler # X69.300 C) plaques are both carved from cranial pieces while all other sections seem to have been made from lower limbs, primarily femur (Teeter, personal communication; Wake, personal communication). These bones, specifically, are thick and dense enough to support the intricate carvings of medium to high relief found on bone ornaments. It can be assumed that the beads, which are generally dense and highly polished, have been created from assorted bones and that these also are human, though no comprehensive review of micro-morphological features in the beads has been undertaken.

In terms of fiber identification, results are consistent with available reference resources. The use of cotton in woven fabrics, especially as plain-woven support for *thangka*, is well-documented (Huntington 1970; Jackson and Jackson 1984; Cotte 2011). Many types of bast fibers — including hemp, nettle, and mulberry — are also commonly used for textiles and cordage in the Himalayan region (Brennan, personal communication). Furthermore, there are also native species used as sources for bast fiber for which there is little published information: *Girardinia diversifolia* — Himalayan giant nettle or *allo,* as it is known in Nepali — is one such resource (Singh and Shrestha 1988). Fiber identification was undertaken in comparison to available resources including reference sets and the *Fiber Reference Image Library* (fril.osu.edu) though the lack of conclusive identification for this object may be a symptom of limitations in commonly available resources. In a study of textile traditions of the Western Himalayan region, Handa (1998) focuses exclusively on the use of wool and cotton. Further work with a botanical specialist may provide more conclusive results that those offered here. In this object, both cordage and yarns used for weaving are primarily bast fiber (either hemp or an unidentified species), with some cotton being used in both cordage and decorative yarns (tassels). Yarns and cords are consistently Z-twisted with S-twist ply; some samples initially recorded as S-twist were found to be the unwound ply of larger yarns or cords. Some yarns were colored blue and pink, and though dyes were not analyzed as part of this project, indigo and madder have well-recorded use in the region (Jackson and Jackson 1976).

The variety of materials found on the surface of the object indicates the complexity of this bone ornament assemblage's material history. Minium (red lead), cinnabar, atacamite, and red lac dye have been used as pigments or colorants in *thangka* (Jackson and Jackson 1976; Jackson and Jackson 1986; Mass *et al.* 2009). Red lac dye is also seen on other bone ornaments, similarly applied to the beads at irregular intervals (Figure 4.1). Calcite and quartz have been documented as part of ground layers or

Figure 4.1: Yellow arrow indicates area where red lac dye has been applied to the surface of beads on a bone ornament (Image: Courtesy of Dr. Jinah Kim).

white pigments in wall paintings and *thangka* (Mazzeo *et al.* 2004; Huntington 1970). Atacamite and other basic copper chlorides have been used as pigments in this region but it is not certain if these represents true pigments or are the result of chemical transformations from other cuprous materials (Scott 2000). Yellows from this region are typically found to be arsenical (*e.g.* orpiment and realgar) or iron-based (*e.g.* yellow ochre) and the findings here of a yellow compound that is primarily barite (a white mineral) are provocative. For example, Chao (unpublished, 2011) records barite used as a white pigment in a Bhutanese shrine. PLM analysis shows barite as white crystals with a closely associated and finely particulate yellow phase but it is yet unclear what this colored material might be. Scholars have remarked on the variability of the palette in the region due to intra-regional trade and, in recent centuries, industrialization and the availability of commercially produced paints and pigments (Jackson and Jackson 1984; Mass *et al.* 2009). Whether the barite is being used as an extender for a modern paint or as the substrate for a lake with an organic yellow colorant is uncertain.

Clay minerals may be related to the object's production. Loseries-Leick (2008) describes a method for transferring designs onto raw bone material that involves covering the substrate in thin layers of watery clay, into which the image is traced by removing material. The bone is then lightly fired, charring the bone where the surface is unprotected by clay, fixing the image onto the substrate surface. After this, the clay is removed. This technique is not used by all traditional craftsmen and, in general, it seems that the contemporary practice of bone carving is highly idiosyncratic (Loseries-Leick 2008). Archaeometric texts and their commentaries may offer more technical information about historical practices but these sources have yet to be investigated thoroughly. Nonetheless, findings of alumino-silicate materials and quartz in some samples might be related to this or other techniques used during production.

What is especially curious about the materials found here, however, is the pattern of their deposition on the surface. It is highly irregular, almost entirely with no correspondence to the carved decorations. At the same time, colored deposits are ubiquitous and random on the object: small dots of yellow material will be found in areas of red; smudges of bright orange are found on the reverse of some plaques; red lac dye is applied to beads as well as plaque sides and backs, etc. (Figures 4.2 and 4.3). Many of these materials are used in the production of other forms of material culture while bone ornament ensembles are always depicted as white in historical and contemporary images of use. This author knows of no instance in which they are decorated with color applied directly to the surface.[11] Three possible explanations are suggested: the first is that the origin of these colors and materials on the object surface is in some way related to a previous owner/user's private ritual practice. The second is that the materials were deposited on the surface by practitioners honoring the object through the common practice of *puja*, wherein a devotee places his/her fingers first in a pigment, fragrant powder, or other precious material and

Figure 4.2: Skull-shaped plaques on the bone apron or girdle (Fowler # X60.300 A) are the only elements to which color has been applied in a manner that corresponds to the carved decoration. Here the recesses of the carved area are covered in cinnabar; the yellow arrow indicates a small dot of yellow material on top of the red layer.

Figure 4.3: A red arrow shows the position of an area of orange, minium-based pigment on the side of a plaque on the crown (Fowler # X69.300 B).

[11] See Section 5, following, for a comparison of this object to bone ornaments found in other collections.

then touches the object, leaving some of that material on the object surface. Dr. Jinah Kim (personal communication) has suggested this origin, noting similar practices in Nepal towards manuscripts and other sacred objects. A third solution to the mysterious origins of the materials found on the object surface might be suggested by their variety, which includes clays and pigments as well as possible binding media like proteinaceous glues and/or gums.[12] Potentially the object, before its purchase in Nepal, was housed in a workshop that produced other types of decorative or artistic works and its complex surface character is the result of its interaction with this space and its inhabitants. This object also has layers of accumulated and unidentified surface grime that complicate analysis and testify to this ensemble's heavy use, in whichever setting, before its collection. At any rate, it can be said that the materials found on the surface of the object represent a complex mixture of uncertain origins.

Finally, there are a few materials that qualify as deterioration products or are uniquely tied to the object substrate. Proteins found on the reverse of the crown (Fowler # X69.300 B) are being shed by the porous, exposed cancellous bone and are certainly related to the material's biological nature and the preparation (or lack thereof) of raw material during production. Hydroxyapatite — and possibly calcite — found on the surface is likely related to the mineral components of bone being mixed into the sample, either through their chemical reactivity or sampling technique. Newberyite, a magnesium phosphate, was useful in determining that the ivory component (Fowler # X69.300 G) was in fact ivory and not bone, though this determination was made primarily through the observation of morphological features. Magnesium phosphates have been found on elephant and mammoth ivory as the result of diagenetic processes during burial and on cultural objects in collections previously treated with peroxides (Freund *et al.* 2002). Newberyite is a hydrated magnesium phosphate and needs high relative humidity in order to form. Possibly this mineral formed in greater abundance on the reverse of the ivory component because its

[12] See Birstein (1975) as well as any of the above-mentioned sources that present the techniques of *thangka* painting for discussion of binding media used in this region.

hollow shape harbored water vapor which then condensed on the substrate surface. The curious egg-like form of this deterioration product is a mystery, however, and may have formed through minerals precipitating out of solution at the surfaces of droplets or be the result of some insect activity that utilized or activated the surface minerals. Further analysis is needed to give a conclusive explanation for this.

5. Survey of bone ornaments in other collections

As part of this thesis, a comparative survey of bone ornaments in North American and UK-based collections was undertaken. Seven museums, in addition to the Fowler Museum at UCLA, participated by allowing the author access to bone ornaments in storage or on display in their collections with the purpose of recording key features and condition. Representatives of these institutions generously shared information on conservation issues and the objects' histories.[13] This section presents observations on the iconography, handling and display strategies, as well as material histories of these objects in order to provide insight on the ways in which these ritual objects have been interpreted and treated in museum collections. The summarized results of this comparative study can be found in Table 5.1. It should be noted that only objects for which there was sufficient information available on condition, handling, and collections history are included in this table. Many other bone ornaments were examined virtually through images, correspondence, and online collections databases.

Loseries-Leick (2008) remarks that the decorative iconography of bone ornaments is largely the invention of the craftsman who executes the design. It is likely, however, that it was also subject to the approval of the person or institution commissioning the object and therefore somewhat predetermined.

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[13] Special thanks to Chris de Brer at the Fowler Museum at UCLA; Joan Cummins at the Brooklyn Museum, Brooklyn, NY; Michelle Bennett at the Rubin Museum of Art, New York, NY; Karl Knauer at the American Museum of Natural History, New York, NY; John Clarke at the Victoria and Albert Museum, London, UK; JP Brown and Ruth Norton at the Field Museum, Chicago; Annie Kuang at the Pacific Asia Museum, Pasadena, CA; and Sydney Hengst, Susan Tai, and Nancy Rodgers at the Santa Barbara Museum of Art, Santa Barbara, CA for their knowledge, time, and encouragement.

Ornament type(s)	Estimated period of creation	Year of acquisition	Type of collection	Documented place of origin	Integrated support (pre-acquisition)	Display strategy	Storage strategy	Residues on surface
Apron, crown, arm band, etc. (Fowler # X69.300 A-J)	N/A	1969	Ethnographic	Nepal/Tibet(?)	None	N/A	Polypropylene bags (Before treatment)	Red lac dye, various pigments, miscellaneous
Crown	N/A	1974	Ethnographic	Nepal	Affixed to fabric cap	N/A	Open cell, polyethylene foam support	N/A
Apron	N/A	Early 20th century (pre-1966)	Natural history/ ethnographic	Tibet	Textile belt along top of apron	Reinforced textile belt used to mount apron on mannequin	N/A	Red pigments on large decorative plaques
Apron	16th c.	1924	Fine art (originally ethnographic)	Tibet	None	N/A	Velcro: Hook is attached to reverse of plaques with adhesive; loop is attached to fabric-covered board	Minimal
Apron	18/19th c.	2006	Fine art	Tibet/Nepal	None	Suspended vertically on clear plexiglass (acrylic) mount, anchored with clear monofilament (nylon)	Tissue-covered polyethylene support in opaque archival flat box with lid	None

Table 5.1: Summarized results from a comparative survey of eight North American and UK collections

Ornament type(s)	Estimated period of creation	Year of acquisition	Type of collection	Documented place of origin	Integrated support (pre-acquisition)	Display strategy	Storage strategy	Residues on surface
Apron	17_{th} c.	1984	Fine art	Tibet	Textile belt along top of apron	N/A	Attached to fabric- wrapped board with monofilament; board is wrapped in translucent plastic (unknown type) sheeting	Red, orange, yellow, peach
Apron	$17/18^{th}$ c.	2001	Fine art	Tibet	Painted backing cloth	Cloth is fastened to clear plexiglass with monofilament, displayed vertically	Display set-up is housed in archival box with tissue	None
Necklace	19_{th} c.	2002	Fine art	Tibet	Under individual plaques only	Anchored to fabric-wrapped board with steel pins, displayed vertically	N/A	None
Apron	Mid-19^{th} c.	N/A	Natural history/ ethnographi c	Tibet	None	Fabric-wrapped board, displayed horizontal/flat	N/A	Red, pink
Apron	18/19th c.	1954	Fine art	Tibet	Leather belt at top of apron	N/A	Anchored to fabric- wrapped board with steel pins	Red lac dye

Table 5.1: Summarized results from a comparative survey of eight North American and UK collections

Common elements are acanthus leaves, skulls, sun and moon motifs, deities associated with esoteric practices, starbursts, flowers, and conch shells. Gega Lama, in his study of Tibetan archaeometry (1983), notes that iconography should be appropriate for the types of ritual practices for which the object is intended: Wrathful deities are therefore likely figures in bone ornaments. Gega Lama also notes that an apron should consist of 64 plaques with bells and strings of beads. This specificity, however, seems more directed toward conventions of rendering bone ornaments in paintings of deities.

There are some consistencies in the shape and composition of bone ornaments discussed here. Bone aprons, or girdles, are generally square or rectangular and are by far the most common type of bone ornament to be found in museum collection. Some aprons are triangular, tapering from the top to bottom and Loseries-Leick (2008) remarks that this is likely a regional variation. Triangular-shaped aprons are likely to be from Nepal, she writes, though this claim needs deeper investigation to be proven. Aprons can have between five and thirteen main decorative plaques. These are generally two by five to six inches in dimension, often made from femurs (which have a characteristic curve and density), ornately carved with figures, and are oriented along the top of the apron (Figure 5.1). In the object examined as part of this research, these large, ornate plaques are missing or have been substituted by flat bone plaques with no carved designs (Figure 5.2). Often there are also large, apotropaic figures along the bottom and at the top corners as well (Figures 5.3 and 5.4). Bronze bells and bangles are also common elements for bone aprons. In some illustrations and examples from museum collections, the apron is attached to a painted backing cloth or belt (Figure 5.5). Many apron plaques in museum collections have several empty holes drilled through the substrate, seemingly original to the object suggesting that these were once used to secure the object to a backing cloth. Less often found than aprons, crowns also popular in museum collections. These usually have five large plaques, shaped as skulls with flaming crowns (Loseries-Leick 2008); this is true of the objects examined here, including Fowler # X69.300 B. The carved elements are

Figure 5.1: Top, proper left corner of a bone apron showing three of eight large decorative plaques; these plaques typically have the more ornate design with carving in high relief (Brooklyn Museum).

Figure 5.2: Top section of Fowler # X69.300A; more commonly seen ornate plaques have been removed or replaced by plain rectangular bone plaques.

Figure 5.3 (Rubin Museum) and Figure 5.4 (Fowler # X69.300 A): Apotropaic figures at the bottom and top proper left corner of bone aprons.

often sewn to a fabric cap or band (Figure 5.6). Other types of bone ornaments are less well collected and documented, and therefore harder to formulate generalizations on.

The reuse and substitution of components also complicates the articulation of standard forms and compositions in bone ornament ensembles and the issue of pastiche is unavoidable in a discussion of

Figure 5.5: Performer wearing a bone apron and ornaments; (Image: Loseries-Leick 2008).

Figure 5.6: Crown with five plaques and skull shapes is attached to a fabric backing (Image: American Museum of Natural History).

these objects in museum collections. Evidence for pastiche includes condition records that mention consultations on composition for restringing, inconsistent rendering styles and wear patterns on the edges of plaques, and the fragmentary or incomplete condition of many examples of bone ornament, including the object examined as part of this thesis.[14] It can be hypothesized that as international trade, especially with North America and Europe, increased after the late nineteenth century, competition drove decision-making about commercially viable forms of artistic practice. There is certainly evidence that techniques and materials have changed and adapted in the twentieth century (Loseries-Leick 2008; Mass *et al.* 2009) and economical considerations must be taken into account when evaluating the "integrity" of these objects. Considering this investigation, it can also be said that the re-configuration of bone ornament ensembles may be at the hands of anyone in the object's journey: from the original user/practitioner, vendor, private collector, curator, to the conservator.

[14] Condition reports and collections records for several objects have been reviewed by the author and paraphrased here to anonymize those institutions that generously gave access to their resources for a critical review.

Finally, from a conservation perspective, the objects studied during this evaluation present an intriguing range of conditions and handling strategies. As Table 5.1 shows, there is a variety of storage and display systems and the surface condition of each object differs greatly. Some examples were highly polished and bright white, some were — like Fowler # X69.300 A-J — covered in layers of surface grime and discolorations of the substrate surface. A few also had red lac dye on the beads (but not the plaques) and colored deposits on plaques in the bone apron. It has been observed by the author that the majority of bone ornament ensembles in North American collections are in natural history museums as ethnographic or anthropological materials. It was also found that very few (if any) fine art museums include a bone ornament as part of their permanent collection on display. Further study on this subject could include a survey of materials used in bone ornaments or the expansion of a discussion of material and collections history to include other types of Himalayan ritual objects made from human bone.

6. Treatment and recommendations for handling, storage, and display of the Fowler Museum object # X69.300 A-J

Though the focus of this thesis was technical examination and research on handling, some minor conservation treatment was also completed. After an initial examination of the object's condition (see Appendix A), it was determined that the bone ornament ensemble's greatest vulnerability is structural compromise through unsafe handing. Other condition issues that were determined to require conservation intervention included the white material (determined through analysis to be hydrated magnesium phosphates) on the reverse of the central component of Fowler # X69.300 G; a broken plaque in the crown, Fowler # X69.300 B; and adhesive residues on a section of the apron, Fowler # X69.300 A. This section describes how these issues were addressed, based on a principle of minimum intervention.

Figures 6.1 and 6.2: Before (left) and after (right) cleaning through mechanical action and swabbing with cotton and deionized water.

6.1 Removal of white material from the reverse of Fowler #X69.300 G

White deposits on the reverse of the ivory component of Fowler # X69.300 G were identified through XRD as newberyite, a hydrated magnesium phosphate (see Section 3.4; Figure 6.1). Due to the potential hygroscopicity of these deposits, they were removed mechanically through light cleaning with cotton swabs and deionized water (pH 6.5). (It is suggested by Freund *et al.* (2002) that these minerals will not form on ivory objects stored below 55% relative humidity). In order to minimize the amount of moisture introduced to the ivory substrate, cleaning was restricted to the reduction of white deposit and not on its complete removal (Figure 6.2).

6.2 Repair of broken plaque on Fowler # X69.300 B

A broken plaque on the skull crown (Fowler # X69.300 B) was repaired with PVA-AYAF in acetone, 40% (w/v) (Figures 6.3 and 6.4). PVA, or polyvinyl acetate, is generally recommended for use on bone as an adhesive or consolidant (Storch 2003, Johnson 1994).


Figures 6.3 and 6.4: Before (left) and after (right) treatment photos of break in plaque repairs with PVA; there was some loss of surface material along the break edge.

6.3 Removal of adhesive residue from plaque in Fowler # X69.300 A

During the initial condition reporting, adhesive residue was noted on a carved plaque on the apron, at top (Figure 6.5). Treatment records provide no information on the origin of this residue and the unknown adhesive was found to be flexible, slightly yellow, and translucent. The residue swells in acetone and was removed mechanically with steel hand tools. After removal, the break edges on the plaque were observed to be smooth and it is believed that these breaks originated sometime during the object's use before its collection. Because this can be considered evidence of original use, it was decided that no new

Figure 6.5: Position of plaque with adhesive residue, during treatment on apron, Fowler # X69.300A.

adhesive would be introduced and the broken element was to be stabilized mechanically as described below.

6.4 Stabilization of bone ornament ensemble through mechanical methods and construction of mount for handling, storage, and display

Figure 6.6: Bone apron with original backing cloth, very similar to apron in Figure 5.5 (Pacific Asia Museum).

Taking into consideration the strategies for display and storage of similar bone ornament ensembles in other museums, as well as the literature review completed as part of this research, the object has been mechanically and physically stabilized with a fabric backing cloth, mimicking a possible original appearance of some bone ornaments (Figures 6.6-6.8). There is evidence that the Fowler bone ornament ensemble was once similarly attached to a woven fabric, fragments of which are preserved on the object (Figure 6.9).

A 100% acrylic, solution-dyed fabric — engineered for outdoor use to be microbiologically and UV resistant — was selected as a support cloth for the construction of a mount that would facilitate handling, storage, and display. This cloth — trade-name Sunbrella® — is known to be used as a lining material for canvases in paintings conservation (CAMEO). A 100% polyester, solution-dyed, heavy weight sewing thread was selected for construction of the fabric mount and to secure the object to the support with hand-stitching. Tissue paper was used to make templates for the support, based on the size and shape of


Figures 6.7 and 6.8: Front (left) and reverse (right) of arm bands and bracelets from bone ornament ensemble (Images: Dr. Jinah Kim).

Figure 6.9: Plain-woven textile fragment attached to beaded section of bone apron (Fowler # X69.300 A).


Figures 6.10 and 6.11: Tracing a template of the object onto tissue paper (above) and using it to cut fabric to fit the object (below).

the original object (Figures 6.10 and 6.11). Two layers of fabric were used for strength and durability. Accession numbers were embroidered in white, 100% polyester thread on the reverse of the fabric supports (Figure 6.12).

The ornaments were joined to their fabric mounts using robust existing holes in the substrate or by loosely anchoring cords in beaded sections (Figures 6.13 and 6.14). Sections with broken cords were secured to the support cloth in configuration that was determined to best represent the original position of the individual elements (Figures 6.15 and 6.16).

Figure 6.12: Accession number embroidered in white on reverse of Fowler # X69.300 C.

Finally, because of the organic materials used in the object's construction as well the use of cinnabar, it is recommended that this object be stored and displayed under a minimum amount of direct visible and UV light. It should also be noted in handling guidelines that Pb-based pesticide residues have been found on all sections of the object. The backing cloth should be used in handling to minimize direct exposure. Suggested environmental conditions, based on the nature of the materials, is a 60-70°F with a maximum RH of 55% (Storch 2003; Freund *et al.* 2008).

Figures 6.13 and 6.14: Hand-stitching through existing holes in carved elements (left) and loose anchoring around cords in beaded sections (red arrow, right) were used to secure the object to its fabric mount.

Figures 6.15 and 6.16: Before (above) and after (below) images of bone apron, Fowler # X69.300 A; the fabric mount physically stabilizes the object and facilitates handling, storage, transport, and display.

Materials:

Nikon D70 Digital SLR camera, Nikon Inc., Melville, NY.

Nikon D90 Digital SLR IR/UV modified camera, Nikon Inc., Melville, NY.

Camera Control Pro 2 software, Nikon Inc. Melville, NY.

XNiteBP1 band pass filter, LDP LLC, Carlstadt, NJ.

Peca camera lens filters, Peca Products, Inc., Beloit, WI.

SPEX Mini-Crimescope 400, SPEX Forensics (Horiba Instruments), Edison, NJ.

Meiji binocular microscope EMZ-TK, Meiji Techno, Tokyo, Japan.

Olympus BX51 microscope, Olympus Corp. Of America, Center Valley, PA.

Bruker Tracer III-IV+ portable handheld XRF, Bruker Corporation, Billerica, MA.

S1PXRF software, Bruker Corporation, Billerica, MA.

Microscope adapter (Olympus BX-51), Martin Microscope Company, Easley, SC.

Cargille Meltmount, Cargille Industries, Cedar Grove, NJ.

VHX-1000 series digital microscope, Keyence Corporation Of America, Itasca, IL.

Rigaku Spider R-Axis X-ray diffraction unit, Rigaku Corporation, The Woodlands, TX.

Jade 8 XRD software, Jade Software Company, Toronto, Canada.

ColorpHast pH-indicator strip, Merck Inc., Darmstadt, Germany.

Jasco FT/IR-420 spectrometer/Spectrum Manager software, Jasco, Inc., Easton, MD.

PerkinElmer Spectrum (v.4.3.3) software, PerkinElmer, Inc., Waltham, MA.

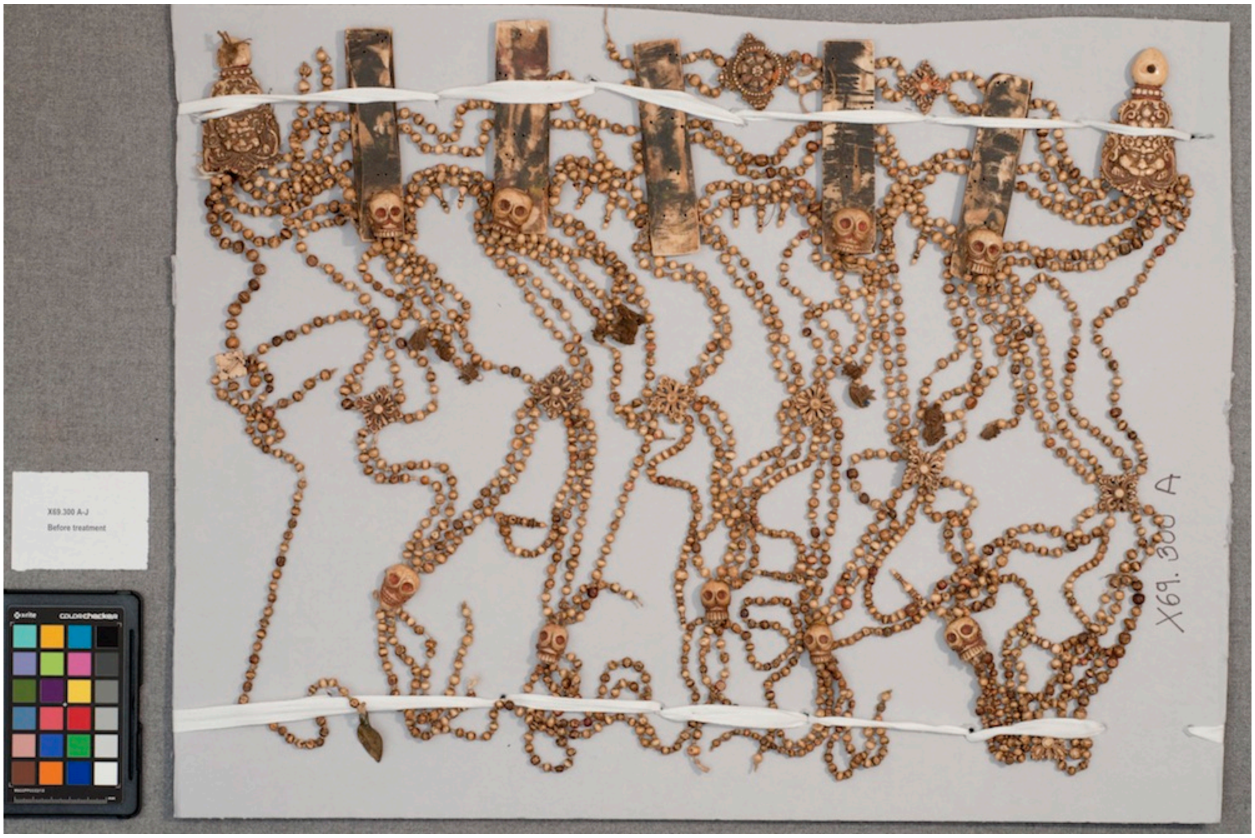
PVA-AYAF resin pellets, Talas, Brooklyn, NY.

Sunbrella outdoor fabric, Glen Raven Custom Fabrics, LLC., Glen Raven, NC.

UV-resistant polyester sewing thread, Coats and Clark, Inc., Greenville, SC.

Beckman ф 340 pH meter (with temperature), Beckman Coulter, Inc., Brea, CA.

Appendix A: Condition report and treatment proposal



Object: Costume

Culture: Tibetan/Newari (?)

Dimensions: Variable

Object no.: X69.300 A-J

Materials: Human bone, yarns, pigment, cuprous alloy

Date: Unknown

Owner: Fowler Museum at UCLA

Date of exam: 31 January 2013

Conservator: Ayesha Fuentes

1. Description

The object is an assemblage of fragments from a beaded Himalayan apron and associated accessories (Figure A.1). Individual components range in shape from small, round beads (approximately 1 cm diameter) to ornately carved plaques several centimeters wide, positioned at regular intervals within a yarn lattice. The piece is in good condition, preserved as several fragments with surfaces that range from polished to heavily stained.

2. Materials and techniques

It is the goal of this thesis to learn more about the materials and techniques of this specific object and to comment on evidence of its material history and previous uses. Traditionally, the plaques, beads, and associated ornaments of this assemblage are carved from human bone, though substitutions of ivory or animal bone are known in other examples (Loseries-Leick 2008). The beads and plaques are joined by fibrous yarn which are tied to fix them in place. There are also small metal ornaments and seemingly random deposits of paint or pigment. Small, woven textile fragments attached to the object indicate that it previously had a textile component, which is also common to these objects. There is very little art historical or technical scholarship on the construction of bone ornaments in the Himalayan region; related texts tend to articulate concepts of the objects' significance as a component of traditional iconographies within Vajrayana Buddhist arts

Figure A.1: Bone apron worn around the waist by traditional practitioner. Crown, arm bands, and other accessories (such as pectoral ornament, seen here) may also be worn as part of same ensemble. (Image from Loseries-Leick 2008)

Appendix A: Condition report and treatment proposal

(Huntington and Bangdel 2003).

Based on initial observations, the object is primarily composed of bone or a substitute of similar properties in terms of color, texture, opacity, and workability. The identification of bone is facilitated by areas of exposed cancellous bone in cross section or on the reverse of larger carved plaques. Beads, plaques, and other carved elements are almost all made of this same hard, dense, off-white material though the color and texture of each varies according to pigments, stains, or other residues. There does not seem to be any deliberate or iconographic application of small areas of pigment; colors on the surface of the object appear randomly distributed. The arrangement of colored residues are likely not the result of weathering or loss in an original painted layer. Beads and plaques have been strung on fiber yarns in pattern determined by the ritual tradition in which the object was made (Huntington and Bangdel 2003).

In visual comparisons to other bone aprons from the same area and religious tradition, key diagnostic features of the objects' iconography are missing: namely, the five ornately carved 'shields' along the object top, now represented by flat, rectangular pieces stained slightly black to which the ornate shields were likely fastened (see '3.2.1 Condition: Apron- Structure'). This is supported by the general trend toward pastiche in the preparation of bone aprons in North American collections (see 'Survey of similar objects, etc' in later version of this report). Because the material culture of Vajrayana Buddhism relies heavily on strict iconometric regulation (Lama 1983; Loseries-Leick 2008), it should be possible to infer the specific ritual tradition to which a given bone apron correlates based on the carved decoration and represented figures on the object. Because this piece is fragmentary and original components have been removed (e.g. carved shields along top row of apron), this type of iconographic assignation is somewhat problematic.

To better discuss and analyze the object, it was first reorganized into an arrangement that corresponds to its original use and (presumed) composition. This rearrangement is based on literature

Appendix A: Condition report and treatment proposal

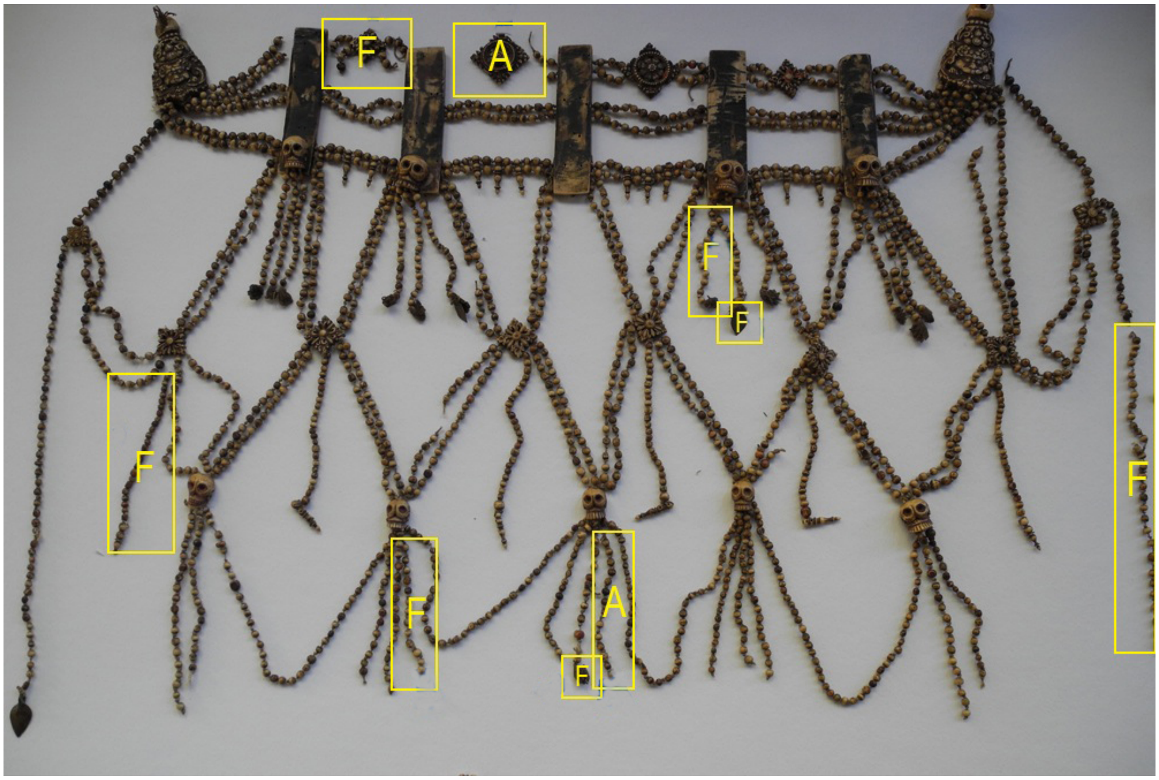


Figure A.2: Apron (Fowler # X69.300 A) with beaded fragments from other sections (Fowler #'s X69.300 A and F, respectively). Fragments have been rearranged to represent presumed original position within the object.

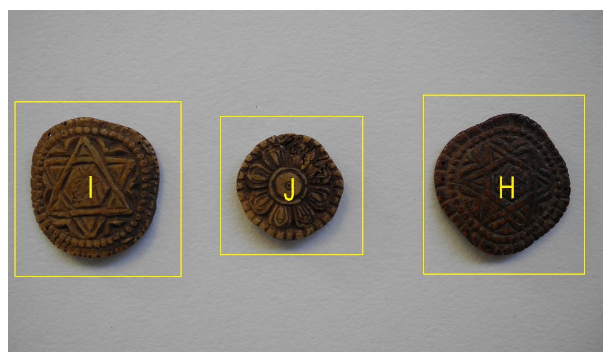


Figure A.4 (above): Additional bone ornaments with unspecified relationship to ensemble (Fowler # X69.300 H-J).

review as well as observations of similar objects in North American and UK collections. It is further supported by observed technical and material similarities in fragments in terms of the knotting pattern of the yarns between beads and bead size or color. The reorganization and distribution of individual pieces has been mapped in Figures A.2-4, with respective Fowler accession numbers. This representation was key to understanding the object in its fragmentary state and identifying individual components of the costume including an apron, skull crown, arm band, and other fragments with unidentified function. The discussion on the object condition and technical features that follows will identify sections of the costume in terms of both their function (i.e. 'crown') and/or Fowler accession numbers.

3. Condition

The condition of the object is generally fair. It is physically and chemically stable with few structural instabilities though insufficient support to the flexible elements might aggravate incipient damages from original use or further disrupt the surface. Thumbnails of sections will be provided next to the condition assessment for clarity.

3.1 Apron (Fowler # X69.300 A and F)

3.1.1 Structure

Yarns connecting the various elements have been broken in several places and some beaded sections of yarn have been lost. Broken yarns are prevalent along the top of the apron, particularly on the proper right (PR) side. The upper proper left (PL), near the carved corner piece, has several broken attachment points as well. Further breakages are found in the beaded length of yarn along the PL side, in

Appendix A: Condition report and treatment proposal

Figure A.5: Locations of broken yarns between beaded sections; some breakages associated with loss of section.

Figure A.6: Arrow indicates position of an earlier repair using thread to secure a fragile connection point; the thread is different in ply, finish, and color from surrounding yarns.

the far and middle PL short elements that extend from beneath the plaques, and in areas around the five skull plaques in the bottom row. For detailed locations of broken attachments, see Figure A.5. There are also some, short lost sections of beads and yarn but these may correspond to remaining fragments associated with the object which have yet to be re-placed. Some old breaks have been previously mended with thread (Figure A. 6) which differs in finish and color from the other yarns in the object.

Figure A.7: Holes of the front surface of flat, rectangular piece which occupies position of 'shield', an ornately carved element common in other examples of aprons from this tradition.

Connections are made by yarns strung through holes in the material and tied to fasten. Almost every plaque — including the skulls and smaller cross pieces in the mid-section and the large, flat and darkened pieces at top — has holes through which no yarns are connected. This may reflect rearrangement of the connections at some point in the life of the object or the absence of original material. Skull-shaped elements along the top row have been tied to the flat pieces; additional holes in the flat pieces likely indicate the previous connections of carved pieces which have been removed, lost, or destroyed (Figure A.7).

Structural problems within individual pieces are few. The upper PR corner piece has been broken along the outside edge, the fragment tied in place with yarns. Also along the top, in the PR corner, a re-placed section (originally part of Fowler # X69.300 A fragments) has evidence of previous adhesive repair to the element. There are small losses on a few individual pieces but these have all been darkened with the same layer of dark brown grime or finish as the rest of the object surface, suggesting that they are not new.

Appendix A: Condition report and treatment proposal

Figure A.8: Distribution of colored residues or stain on material. Dark red squares indicate areas of staining (Figure A.9) or red paint; orange and yellow are pigment deposits (Figure A.10).

3.1.2 Surface

The entire surface of the object exhibits a similar finish in terms of the mottling of dark-brown and black residues with occasional areas of red staining and pigment or paint deposit (Figure A.8). There is no apparent pattern to the general distribution of colored materials except a prevalence of red material on the skull-shaped plaques, particularly in or around the recesses of their eyes. Colored materials are both stain (Figure A.9) and accumulated paint or pigment (Figure A.10), typically in recessed areas of the carved decoration. In some areas, colors have been deposited over each other, areas of red stain, or the dark brown layer. There is very little color on the reverse of the object, only small areas of red staining.

Metallic components (Figure A.11) have some compact corrosion layers and spot of lighter green but closer examination is needed to determine their condition. They appear stable.

Appendix A: Condition report and treatment proposal

Figure A.9: Arrow indicates position of red stain on bead; all areas described as 'red stain' appear similarly.

Figure A.10: Pinkish-orange pigment or paint deposited in recessed areas of carved element, a pattern common to areas with color.

The surface of the individual components is generally highly polished. Some areas, such as the reverse of larger plaques on the upper section, have potential evidence of wear and high polish from use. On some beads in the mid-PR bottom row of hanging beaded yarns have a small amount of crystalline, light grey substance forming within microscopic cracks.

Figure A.11: One of three similarly shaped metallic components on the apron.

3.3 Crown (Fowler # X69.300 B)

3.3.1 Structure

The bone material in this section is particularly rich in diagnostic information consistent with bone and particularly the cranium, including growth lines and cross sections revealing both cortical and cancellous bone.

There are broken yarn attachments on either side of the plaque to the PL of center. The surviving attachment here is fragile. There is a small *vajra,* or thunderbolt, shaped carving attached to the PR side of this piece with yarn. This same piece has a break along the base of the plaque, across the carved skeletal face (Figure A. 12).

Figure A.12: Broken plaque on skull crown (Fowler # X69.300 B).

As with plaques in the apron (Section 3.2), there are several holes to which no yarn is attached, indicating the object may have been rearranged or additional elements lost.

3.3.2 Surface

Pigments or paints are identical in appearance to those found on the apron and in a similar random distribution of small deposits in areas of recess. Areas of material with no coloration range in color from tan to dark brown. The lower section of the center plaque has a thicker, matte black surface deposit.

The reverse of the object reveals that areas of relief are highly polished and there is little stain or pigment. There is an area of black deposit on the mid-PR plaque. There are also less dense surfaces, which may represent the way in which the bone was prepared during object production or deterioration phenomena. A closer examination and consultation with appropriate resources is needed.

3.4 Arm band (Fowler # X69.300 C)

There are no broken connections in this section of the costume. However, some fragments in the assemblage (i.e. Fowler # X69.300F) may be associated with this section. The PL side plaque has empty connection holes. This same piece has a small loss at the edge. Some beads in this section may be substitutions of wood or other material as they vary significantly in terms of finish, density, and color.

The surface of the object exhibits the same distribution of small areas of red staining on both beads and plaques. The plaques also have some paint/pigment deposits in colors similar to those seen in other sections. There are some older abrasions and surface disruptions that might represent tool marks on the central plaque. These have collected the same dark brown layer seen on the rest of the object surface. The reverse of carved plaques reveals features potentially useful for diagnosing the material (i.e. growth lines).

3.5 Other associated fragments (Fowler # X69.300 D - J)

The following objects are fragments or sections belonging to the ensemble but with as-yet-undetermined function.

3.5.1 Fowler # X69.300 D

There is a fragile yarn attachment on the PL plaque. All plaques have holes to which no yarn is attached. The surface is consistent with others within this costume assemblage in terms of light-dark brown color, red staining, and small deposits of paint in similar colors. The reverse of the object shows diagnostic features of bone as well as some areas of black deposit. The PL plaque also has some small spots of white, crystalline material which may be a deterioration phenomenon. Microscopic documentation and examination is needed.

Appendix A: Condition report and treatment proposal

3.5.2 Fowler # X69.300 E

This section has two components with similar appearance and condition. Each plaque on both components has empty holes, indicating lost elements or rearrangement of the elements. There is a consistent distribution of red staining and pigment/paint deposit. On the flat, rectangular plaque of one section there is an area of green staining unique to this assemblage. The surface is generally polished with the brown layer in recessed areas.

3.5.3 Fowler # X69.300 F

This represents a collection of beaded fragments, some of which have been reintegrated into other areas of the assemblage (Figures 2 and 3). These are consistently light to dark brown in color with small areas of red stain. A collection of 11 beads on a newer, whiter yarn has been included in this section.

3.5.4 Fowler # X69.300 G

There is a broken yarn attachment to one side of a flat, rectangular side piece. The central component of this section is made with a material that is denser than the rest of the assemblage. Both flat pieces have additional, empty holes with no yarns attached.

Appendix A: Condition report and treatment proposal

Figure A.13: White, crystalline accretion on the reverse of central element of X69.300 G.

There is a similar distribution of red staining and small areas of pigment and a polished surface with light to dark brown color. The exception is the central, round plaque which is darker in color with brown, orange and black residues. The reverse — and to lesser extend the obverse — of this piece also has a widespread formation of white, crystalline material on the surface (Figure A.13). There is evidence of tool marks on the reverse of the flat, rectangular pieces.

3.5.5. Fowler # X69.300 H-J

These three elements are similarly round and detached from any other section. Each has empty holes in four ‘corners’ to which no strings are currently attached, though there are fibers in the holes of # X69.300 I. All three of these sections have an inconsistent thickness across the breadth of the piece, revealing less processing of the original material in manufacture. Fowler # X69.300 J has an inconsistent finish on the carved surface where one area is more porous than the rest. This may indicate deterioration phenomena or be original to the object. All three of these elements have similar surface appearance, though slightly varied in color, with polish on areas of relief and traces of similar paints or pigments to the rest of the assemblage.

Appendix A: Condition report and treatment proposal

4. Technical investigation and treatment proposal

The purpose of this research is to learn more about the materials and technology that have shaped this object and to assess its condition. The proposed scientific investigation utilizes both non-invasive imaging and spectroscopic techniques and minimally invasive analysis for the characterization of the fibers, beads, carved plaques, textile fragments, and applied colorants or residues found on the assemblage. This includes a thorough examination of the surface as well as the substrate and its attempted confirmation as human bone or an alternative material. Following a policy of minimum intervention, the emphasis of this project is a thorough characterization and assessment of the materials and stabilization, rather than treatment. The proposed investigation and treatment includes:

Non-invasive methods:

Documentation

- Comprehensive documentation and condition report
- Digital photography (cm)
    - Reflected ultraviolet (UV) and visible (Vis) light
    - Florescence photography (UV and Vis-induced)
- Digital reflected photomicrography (mm and micron)
    - Construction of textile fragments
    - Surface condition of metallic elements
    - White, crystalline surface deposits on # X69.300 G and areas of apron
    - Pigments applied in layers
    - Tool markings
    - Bone surfaces where structural diagnostic features are revealed or deterioration is suspected
- Reflectance Transformation Imaging (RTI)
    - Morphological and manufactured features of carved plaques

Appendix A: Condition report and treatment proposal

X-Ray Florescence (XRF) spectroscopy

- Examination of elemental composition of surface, particularly in colored areas

Consultation with appropriate experts on bone surface features

- Tom Wake, zooarchaeologist at Cotsen Institute of Archaeology, UCLA
- Wendy Teeter, physical anthropologist, at Wendy Teeter Center/Cotsen Institute of Archaeology

Minimally invasive methods (requiring micro-sampling of materials):

Polarized light microscopy (PLM)

- Fiber analysis of yarn and textile
- Pigment examination

X-ray diffraction (XRD) spectroscopy

- Pigments
- Crystalline accretions on bone surface, particularly # X69.300 G

Fourier-transform infrared (FTIR) spectroscopy

- Analysis of compact dark brown surface residue pervasive on object

Treatment

- Stabilization with appropriate adhesive of broken component on skull crown (# X69.300 B)
- Solubility testing of adhesive residue on apron top component and replacement with suitable material if necessary
- Preparation of stabilizing and compact storage mounts for object which reflect the use and shape of individual sections
- Create recommendations on handling and display based on the findings of materials' analysis and comparison with similar objects in other collections as well as research into the assemblage's construction and function within its original ritual setting

Appendix A: Condition report and treatment proposal

References:

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Appendix B1: Before treatment

X69-300_A_BT_1

Appendix B1: Before treatment

X69-300_A_BT_02

X69-300_B_BT_01

Appendix B1: Before treatment

X69-300_B_BT_02

X69-300_C_BT_01

Appendix B1: Before treatment

X69-300_C_BT_02

X69-300_D_BT_01

Appendix B1: Before treatment

X69-300_D_BT_02

X69-300_E_BT_01

Appendix B1: Before treatment

X69-300_E_BT_02

X69-300_F_BT_01

Appendix B1: Before treatment

X69-300_F_BT_02

X69-300_F_BT_03

Appendix B1: Before treatment

X69-300_G_BT_01

X69-300_G_BT_02

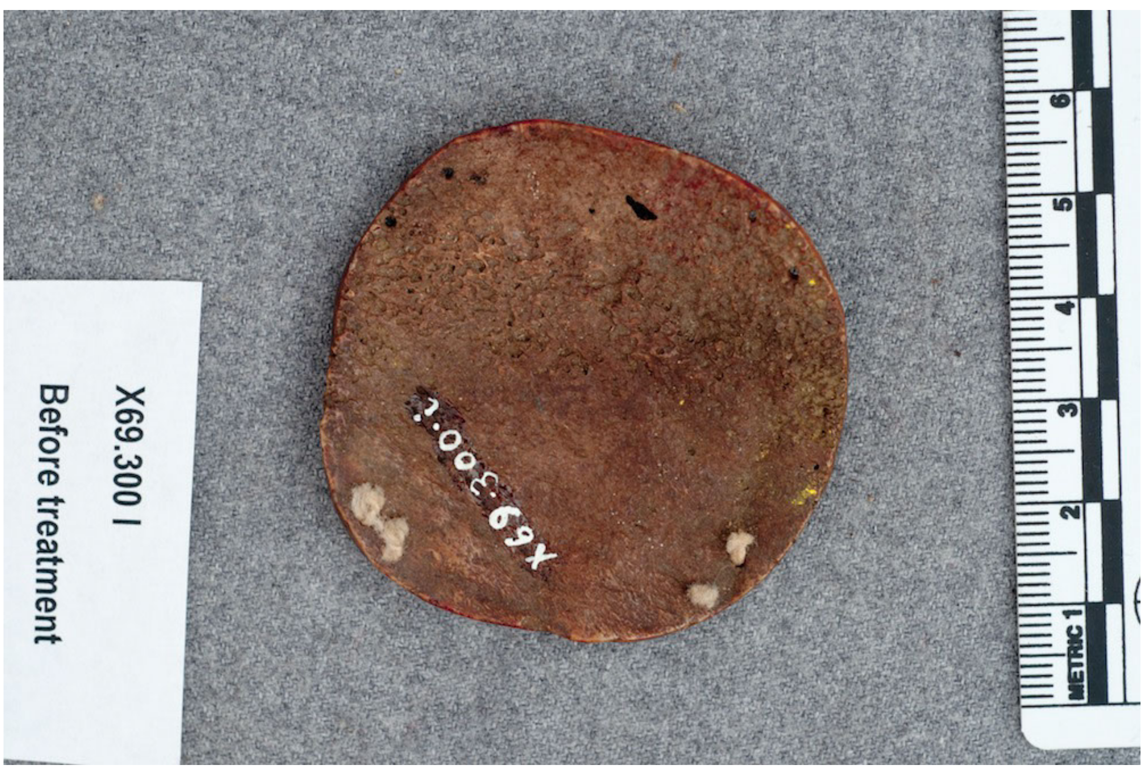
Appendix B1: Before treatment

X69-300_H_BT_01

X69-300_H_BT_02

Appendix B1: Before treatment

X69-300_I_BT_01



X69-300_I_BT_02

Appendix B1: Before treatment

X69-300_J_BT_01

X69-300_J_BT_02

Appendix B2: After treatment

X69-300_A_AT_01

Appendix B2: After treatment

X69-300_A_AT_02

X69-300_B_AT_01

Appendix B2: After treatment

X69-300_C_AT_01

X69-300_D_AT_01

Appendix B2: After treatment

X69-300_E_AT_01

X69-300_F_AT_01

Appendix B2: After treatment

X69-300_F_AT_02

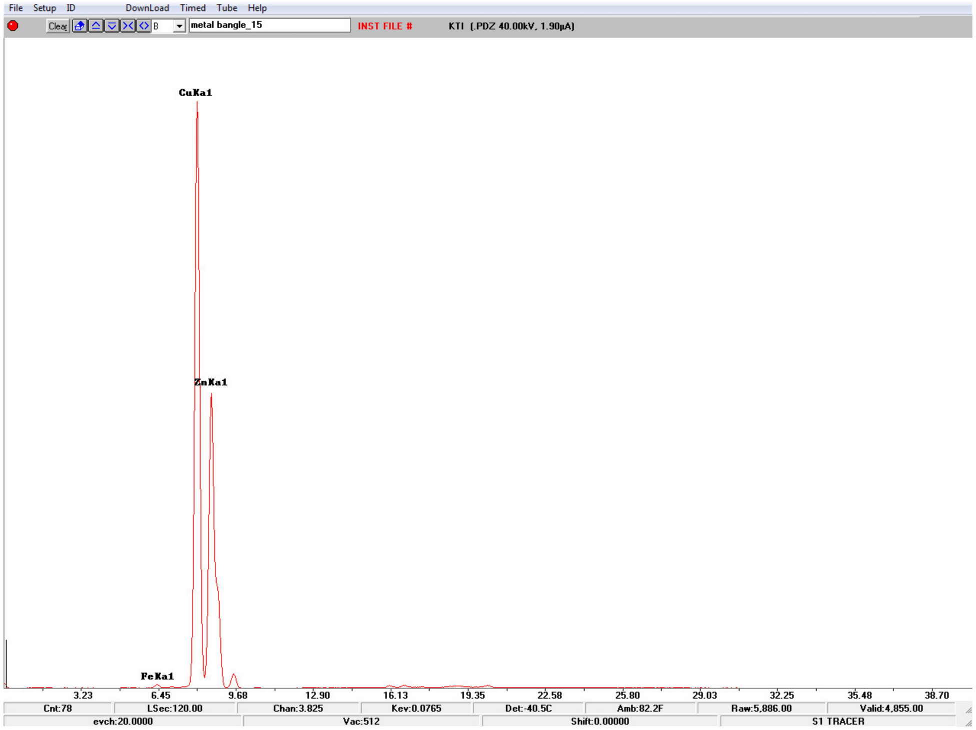
X69-300_G_AT_01

Appendix B2: After treatment

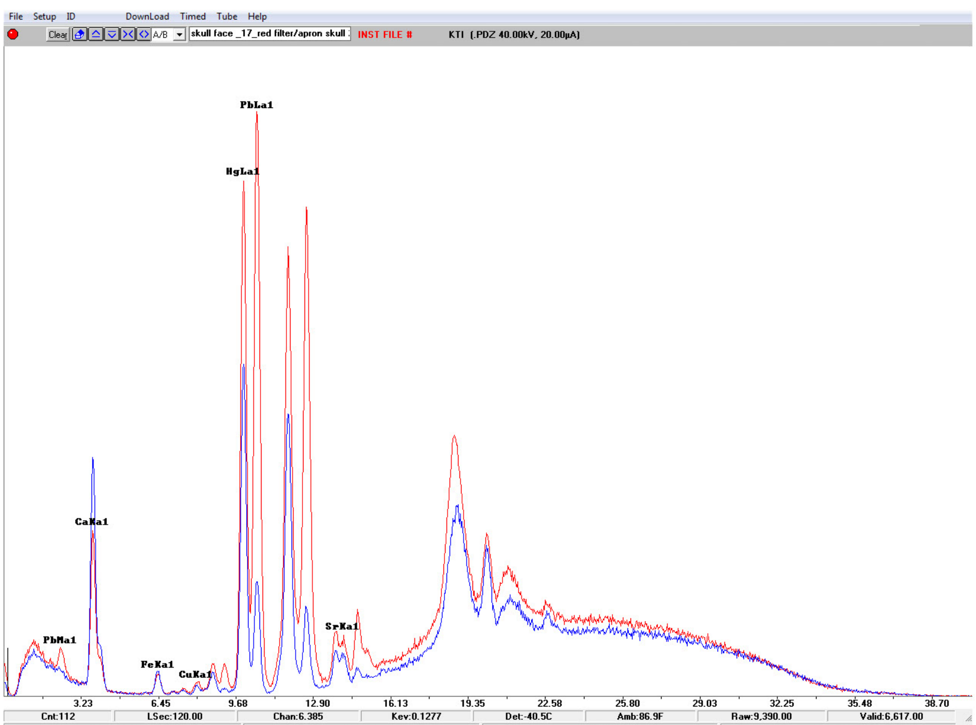
X69-300_H-J_AT_01

X69-300_H-J_AT_02

Appendix C: XRF Spectra

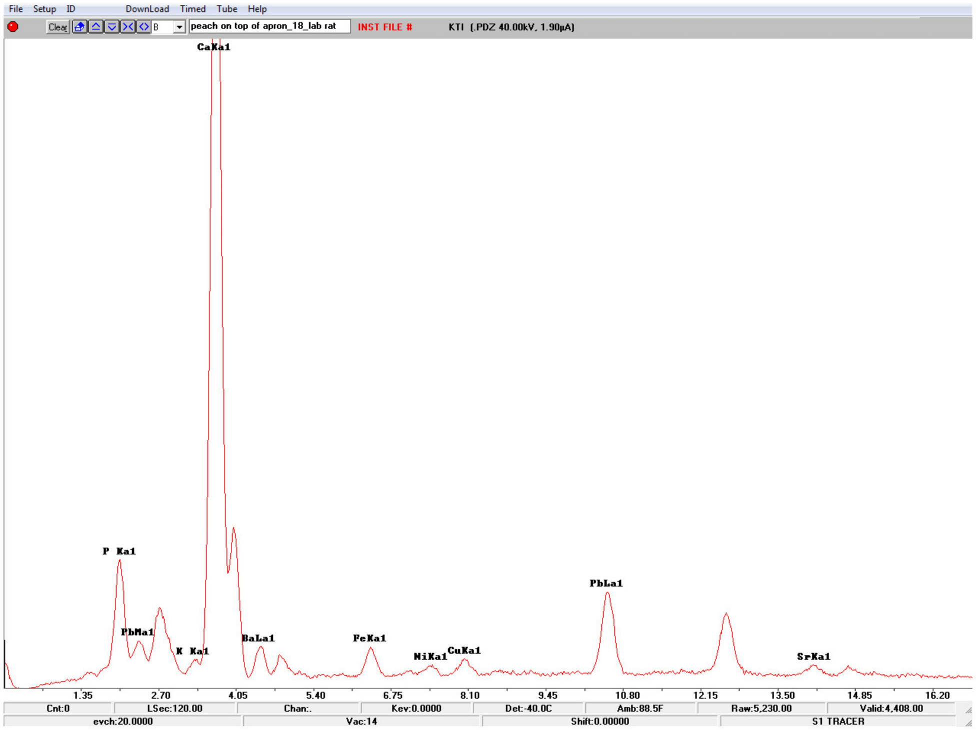


15_metal bangle

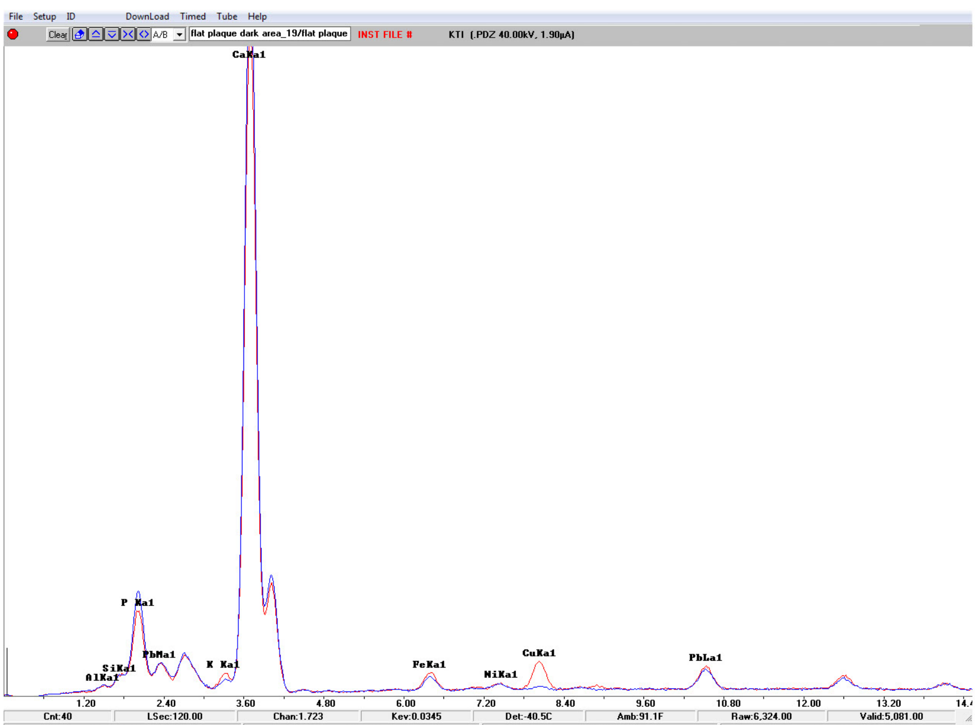


17 (red) and 33 (blue)_skulls on apron bottom red comparison_detail_overlay_red filter

Appendix C: XRF Spectra

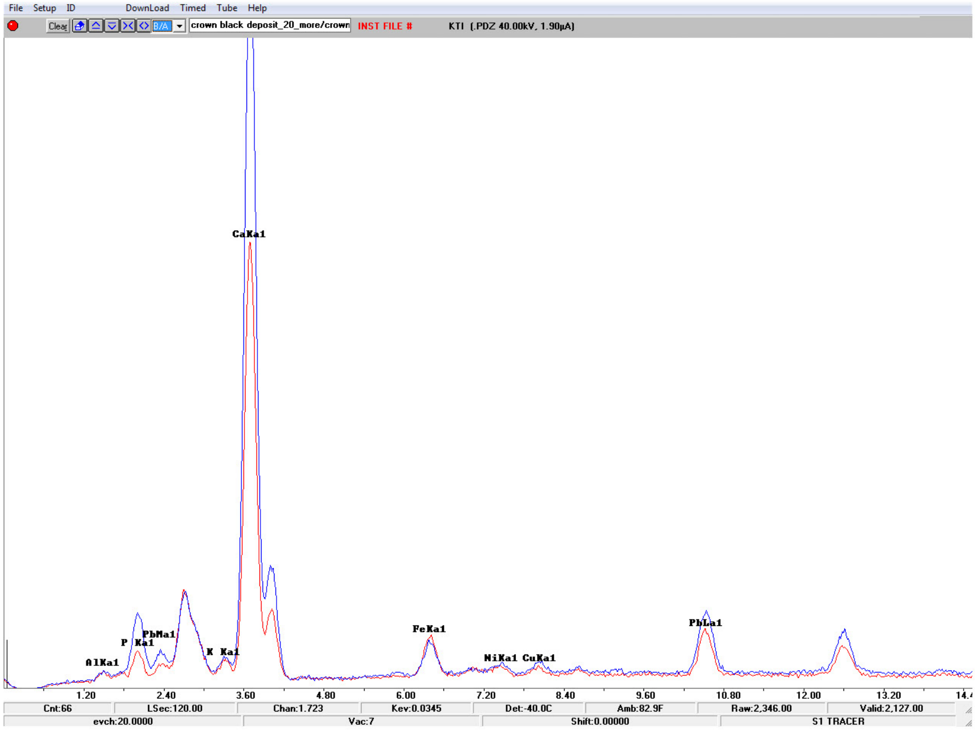


18_peach on apron top_detail_no filter

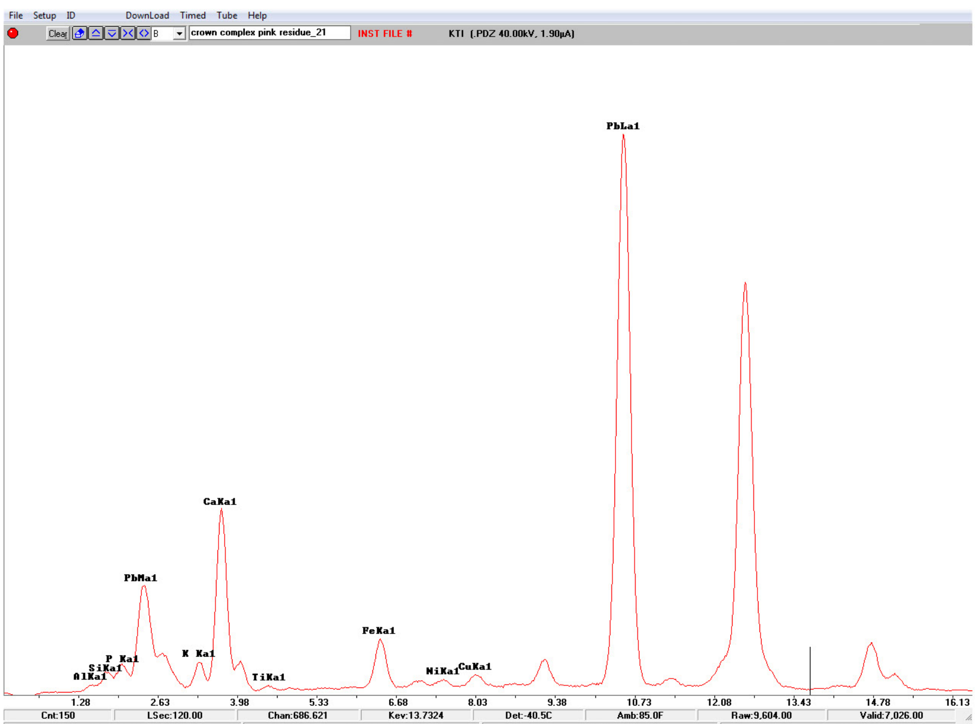


19_black stain on substrate (red) vs area with no black stain (blue)_detail_overlay

Appendix C: XRF Spectra

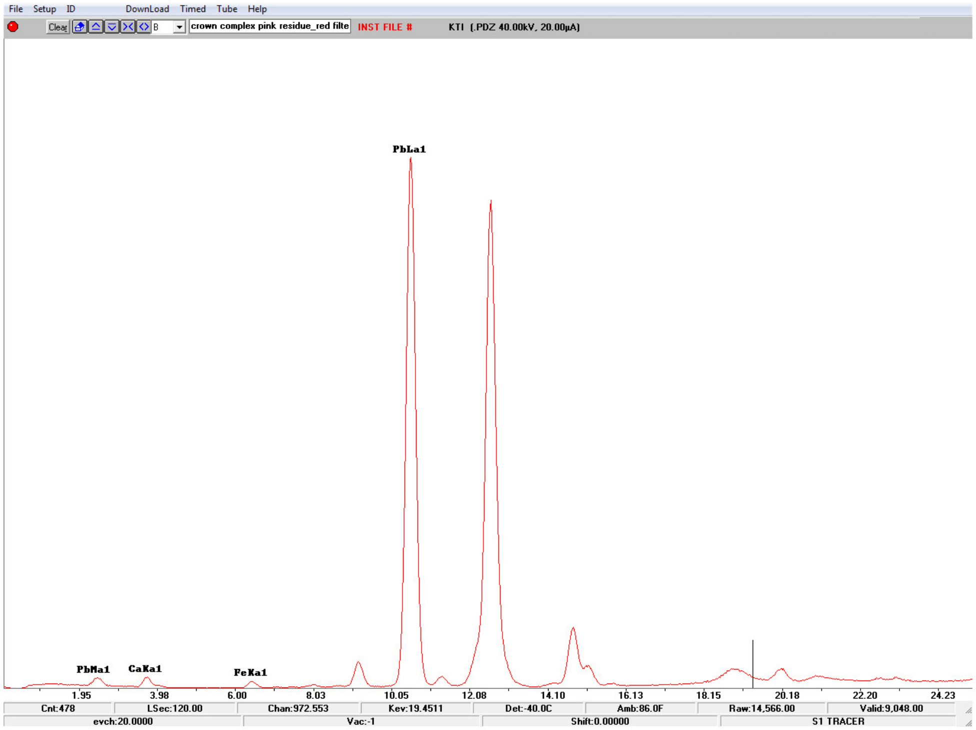


20_crown plaque with dark stain (red) and without (blue)_detail_overlay

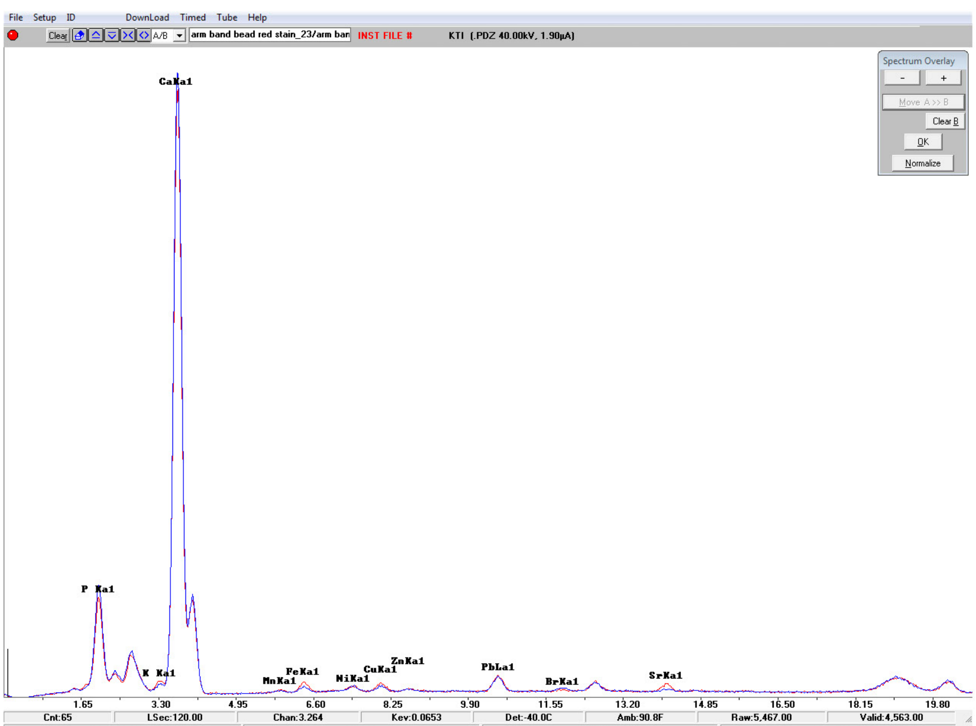


21_peach on crown face_detail_no filter

Appendix C: XRF Spectra

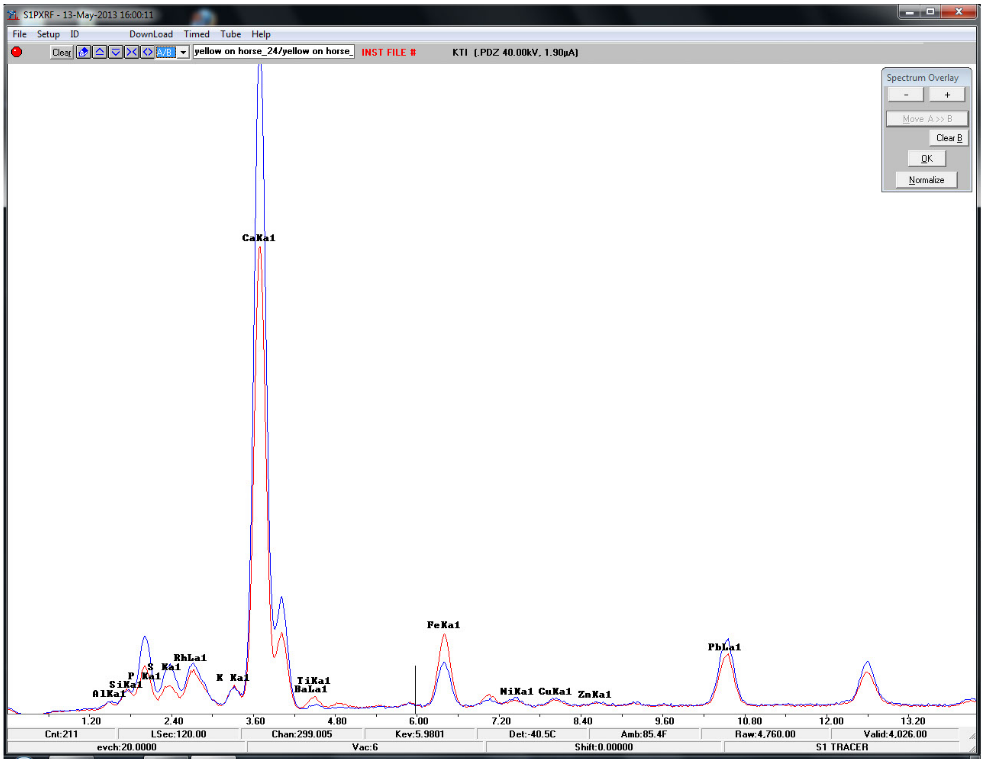


21_peach on crown face_detail_red filter

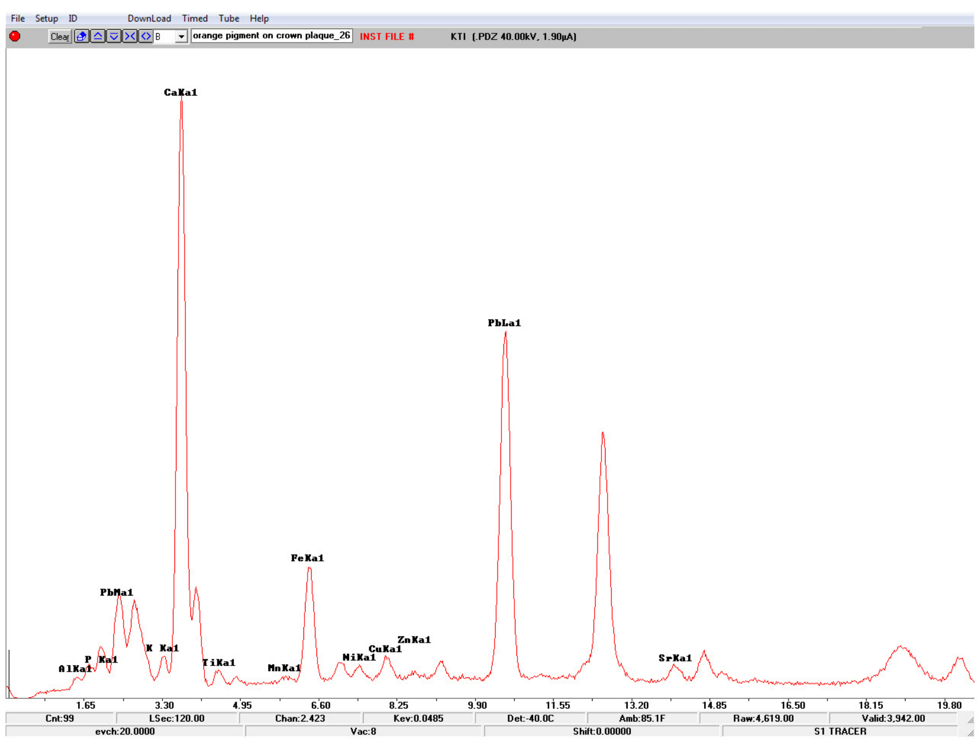


23_bead with red stain (red) and without (blue)_detail_overlay

Appendix C: XRF Spectra

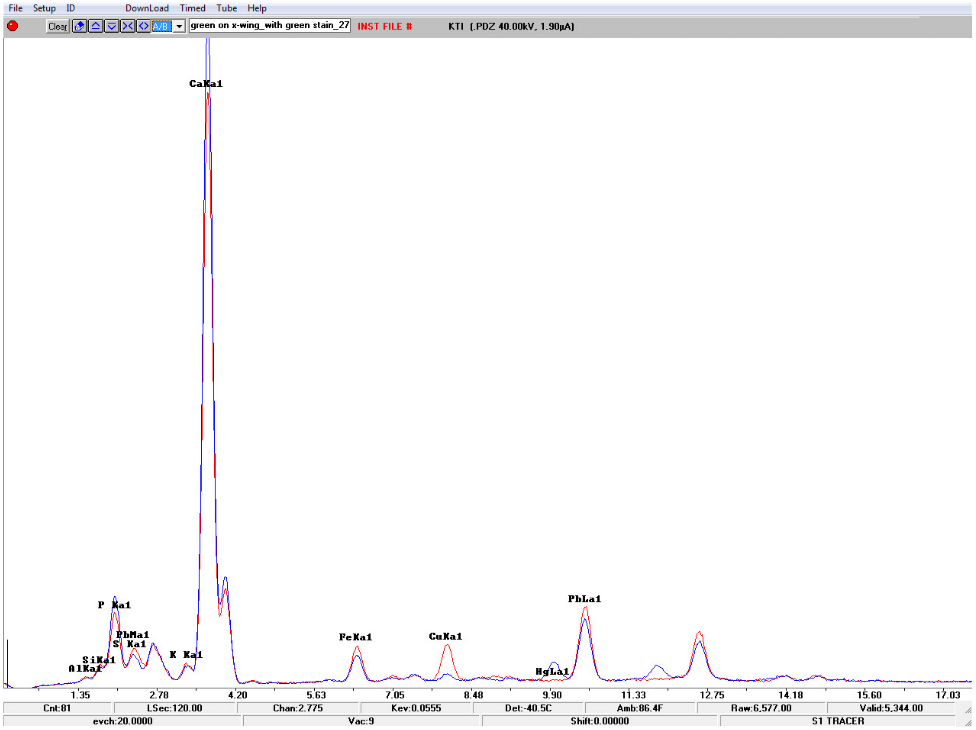


24_yellow (red) and adjacent area no yellow (blue) on horse_detail_overlay

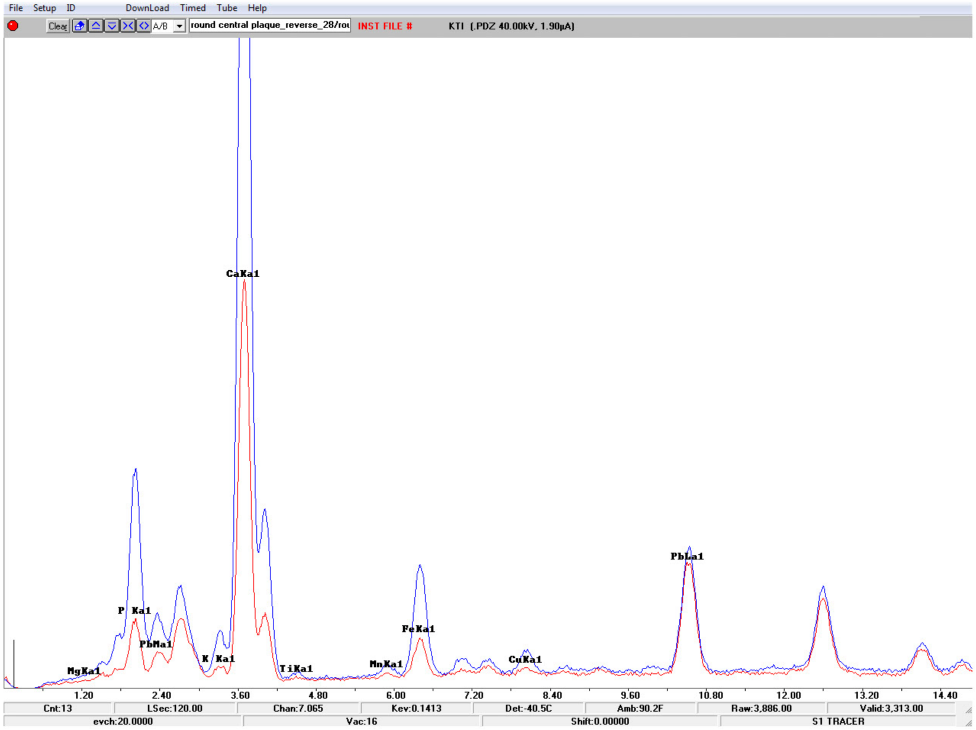


26_orange on crown_detail

Appendix C: XRF Spectra

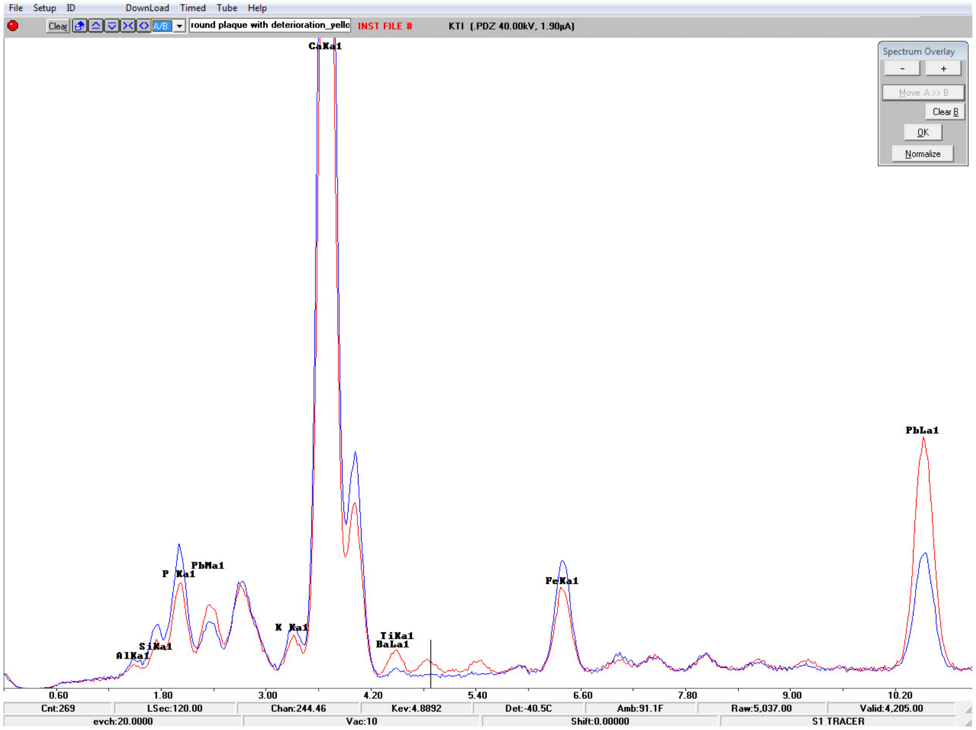


27_green (red) and adjacent area without (blue)_detail_overlay

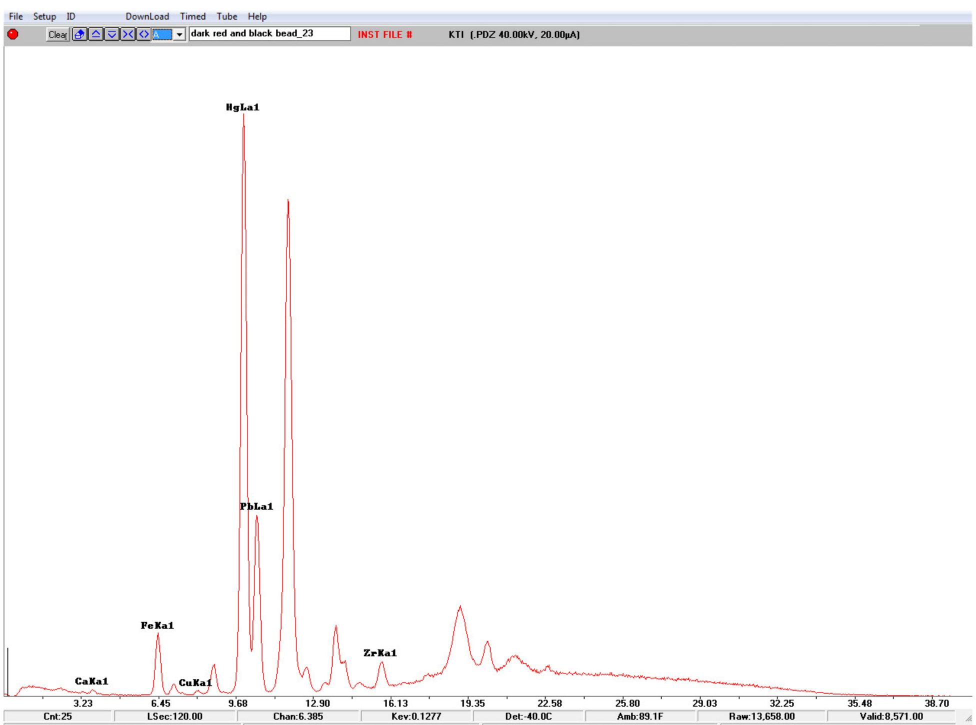


28_X69-300_ivory_reverse (red) vs front (blue)_detail_overlay

Appendix C: XRF Spectra

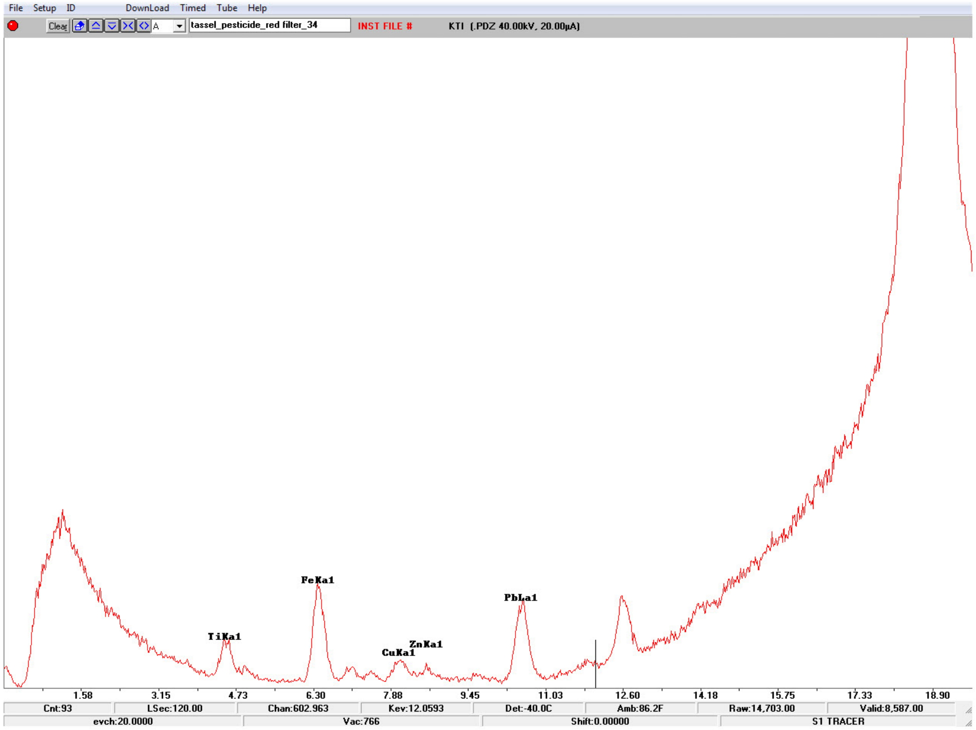


29_yellow (red) and adjacent with no yellow (blue) on round element_detail with Ba L lines

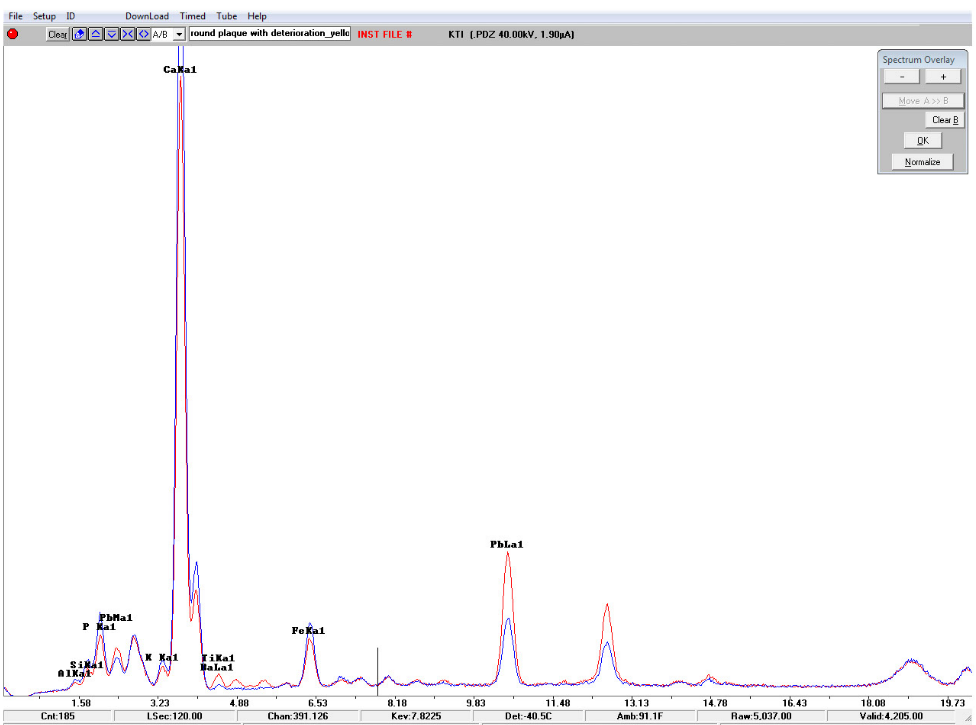


30_dark red and black bead_detail_red filter

Appendix C: XRF Spectra

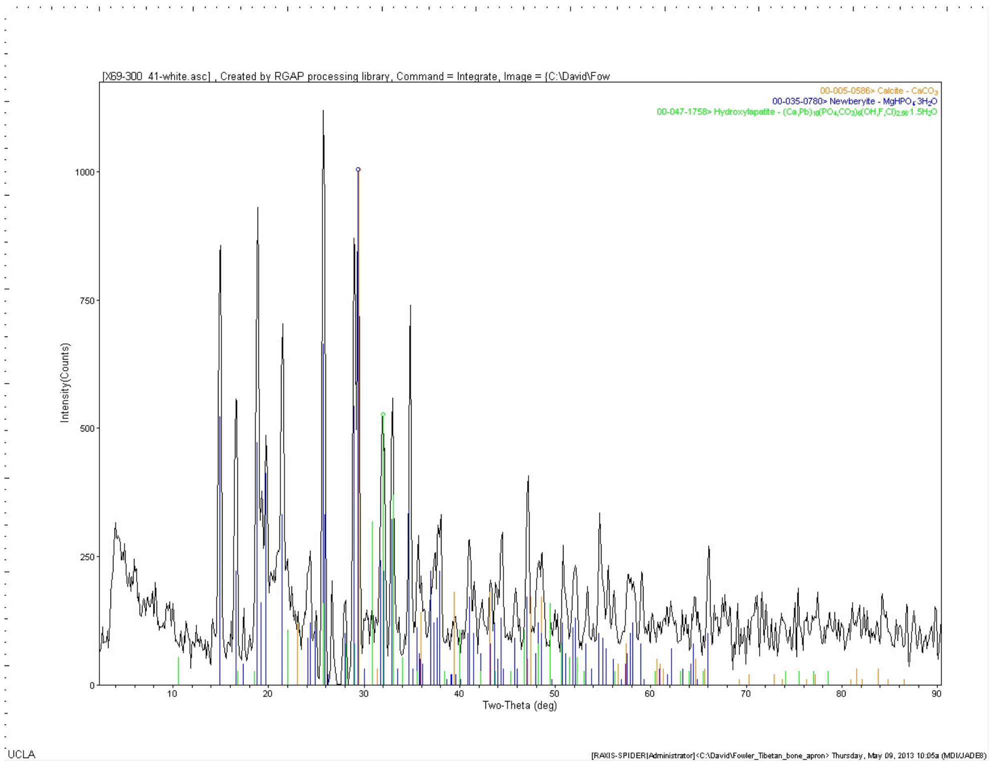


34_tassel_pesticide check_red filter

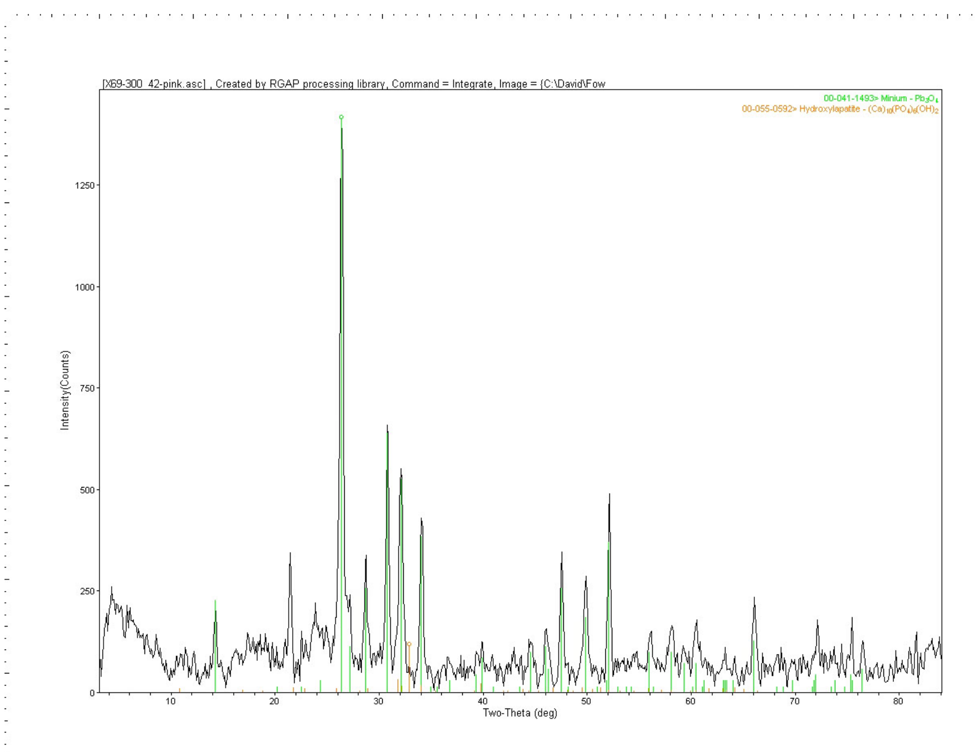


yellow on round element_detail

Appendix D: XRD Spectra

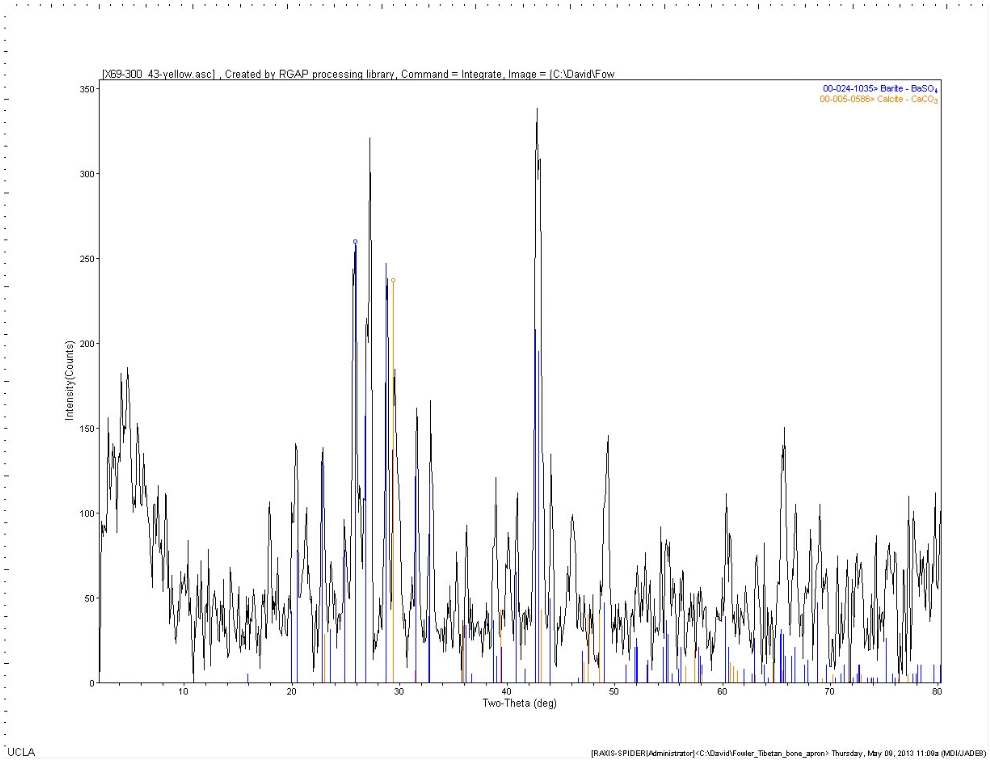


X69-300_41-white

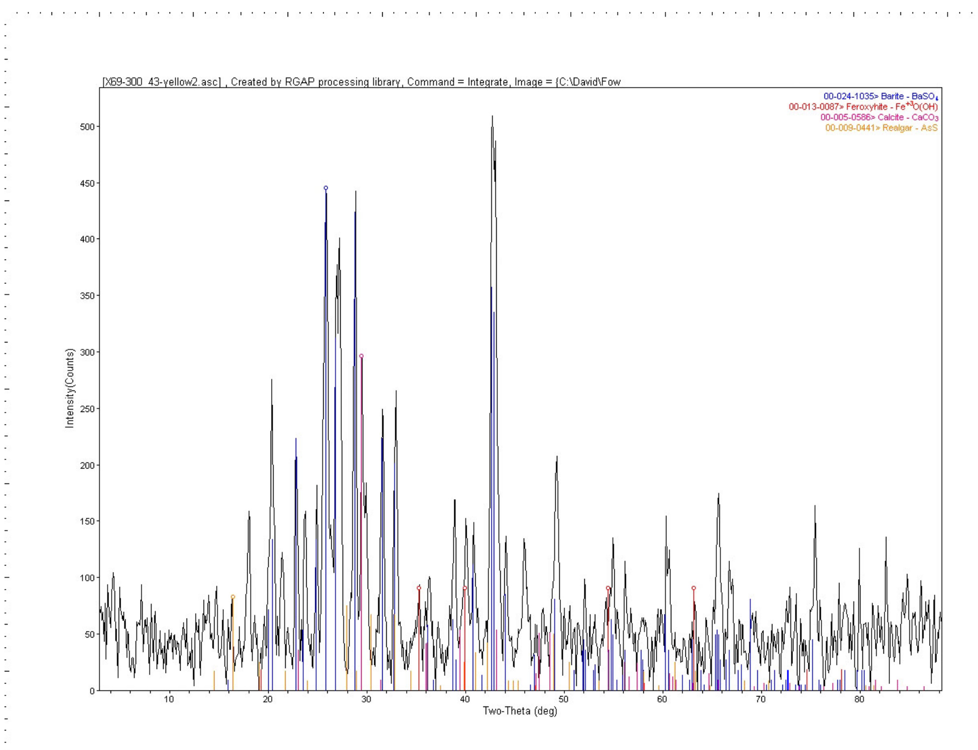


X69-300_42-pink

Appendix D: XRD Spectra

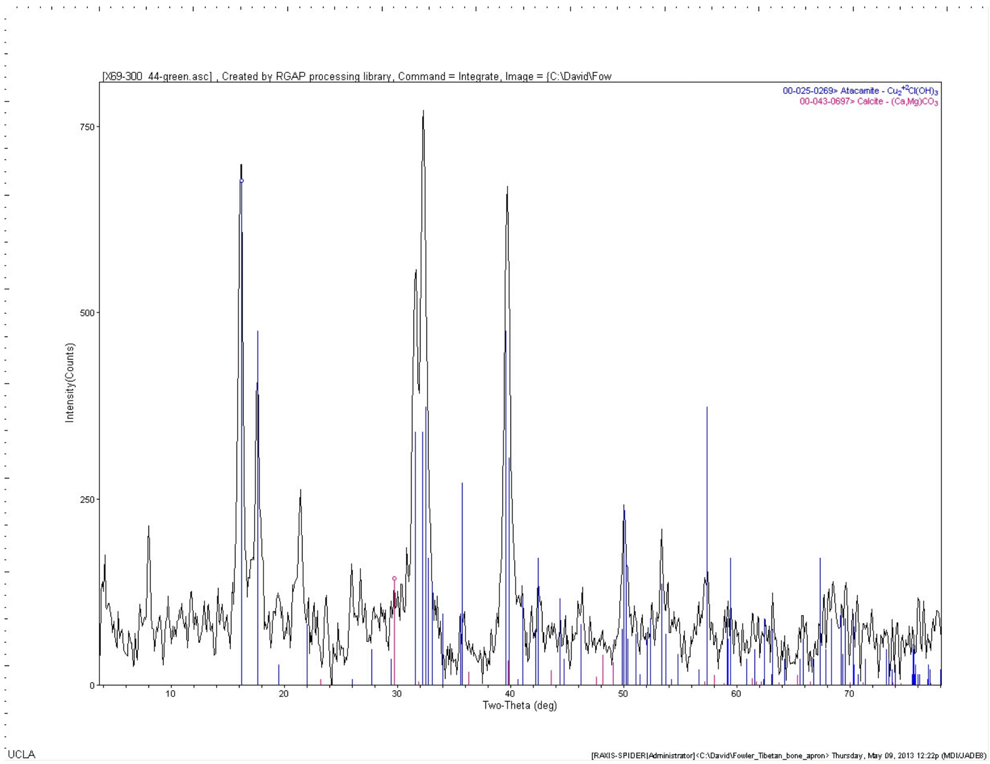


X69-300_43-yellow

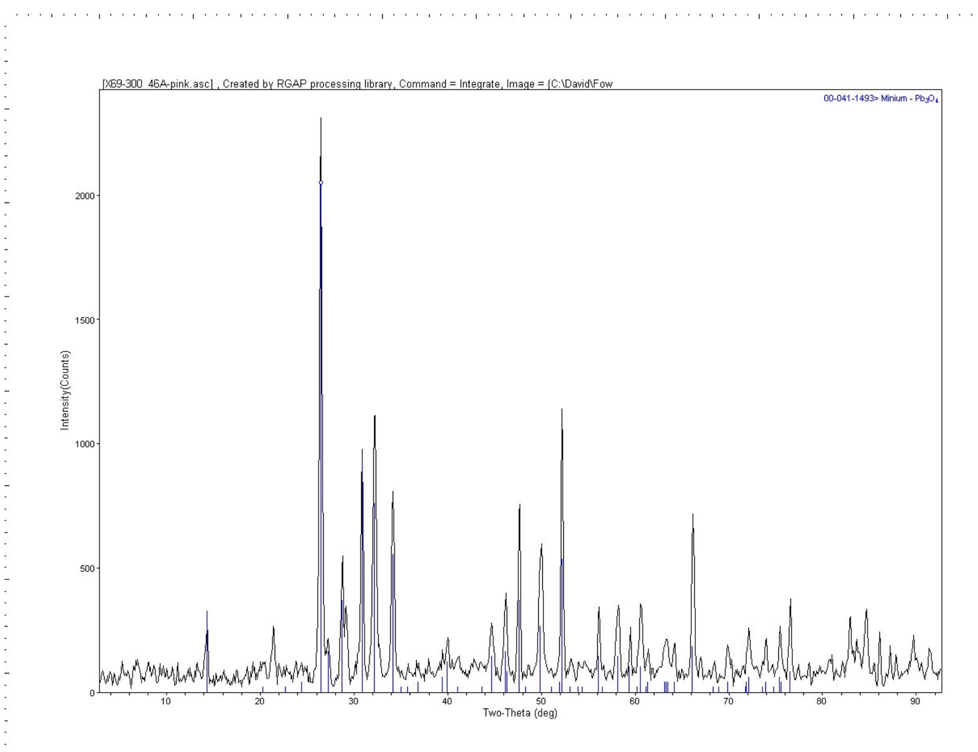


X69-300_43-yellow2

Appendix D: XRD Spectra

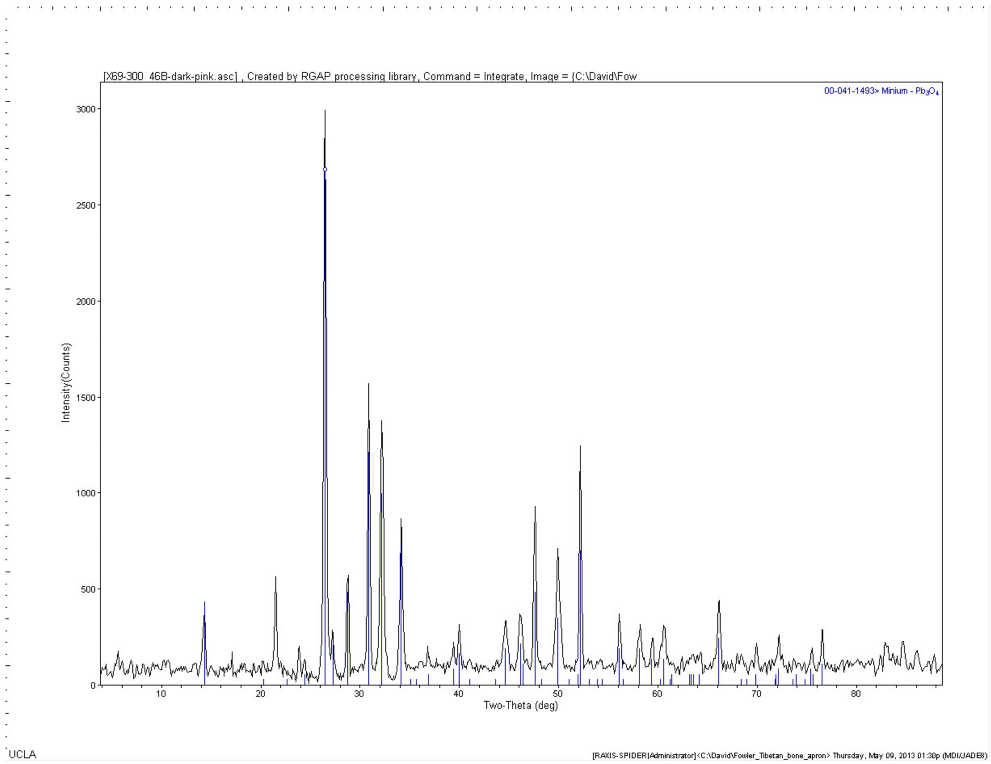


X69-300_44-green

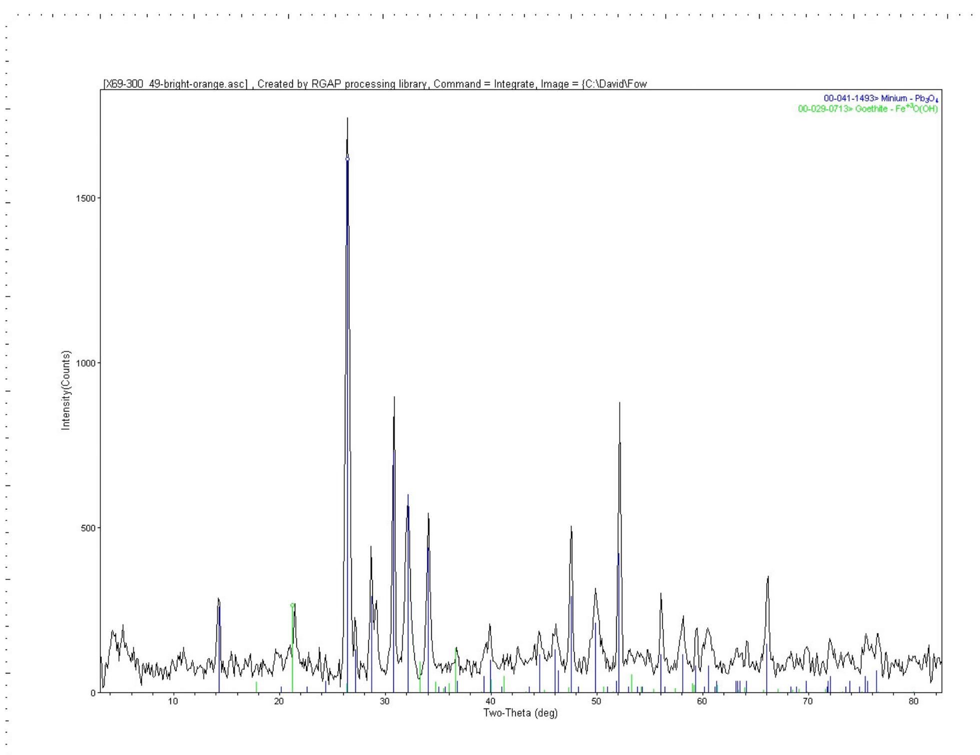


X69-300_46A-bright orange

Appendix D: XRD Spectra

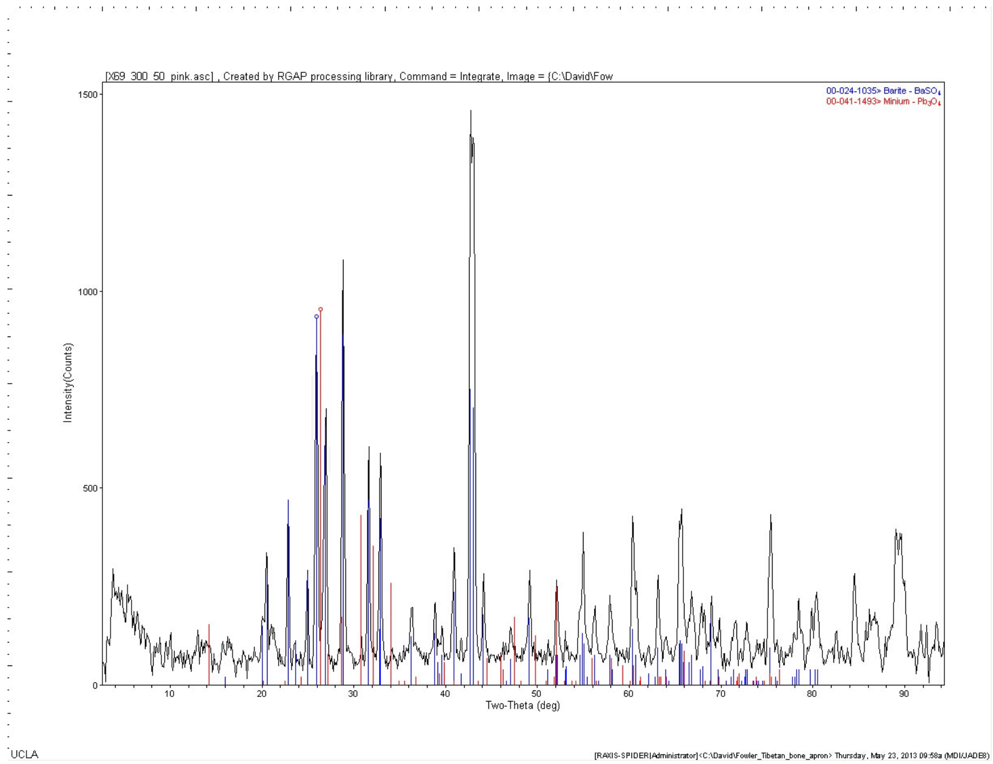


X69-300_46B-dark-pink

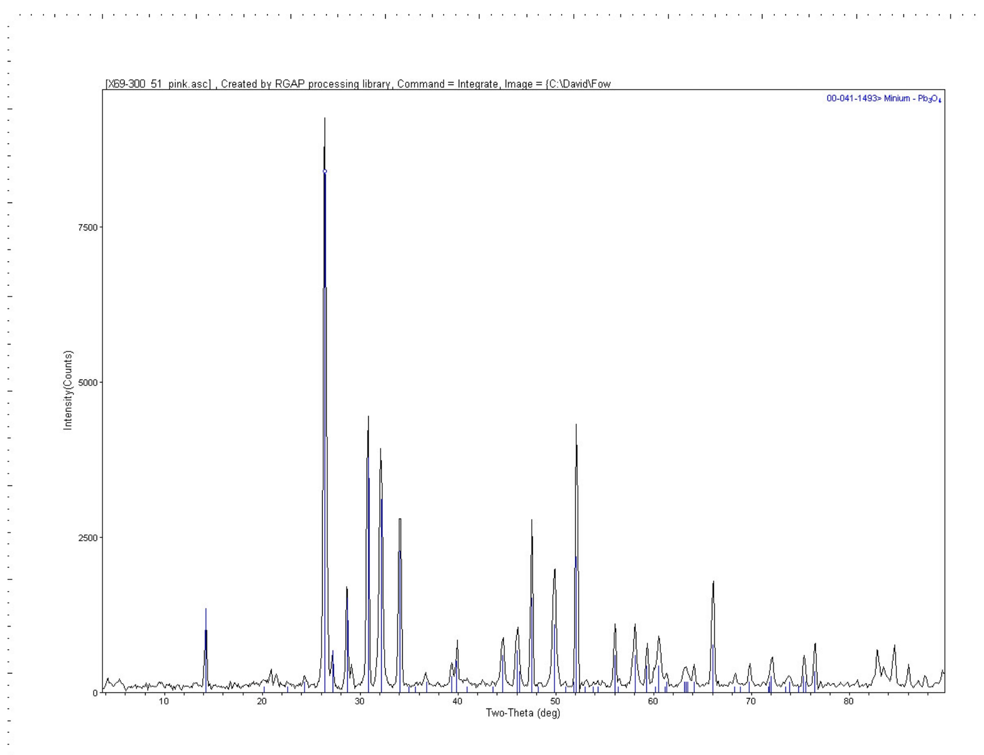


X69-300_49-pink

Appendix D: XRD Spectra

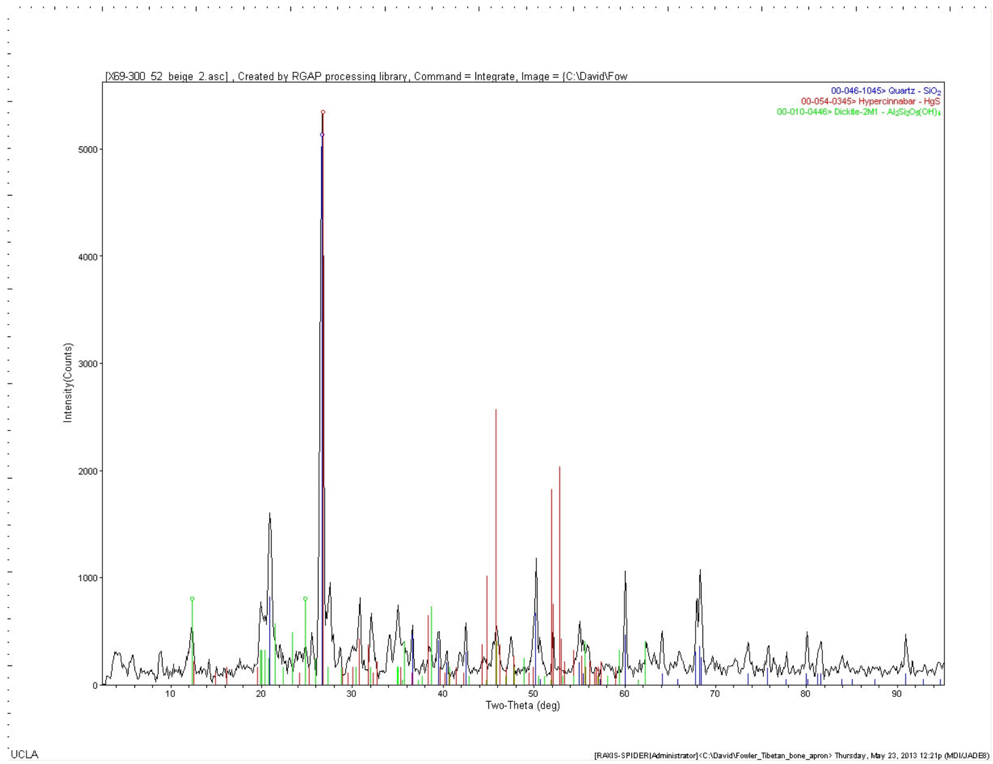


X69-300_50_pink

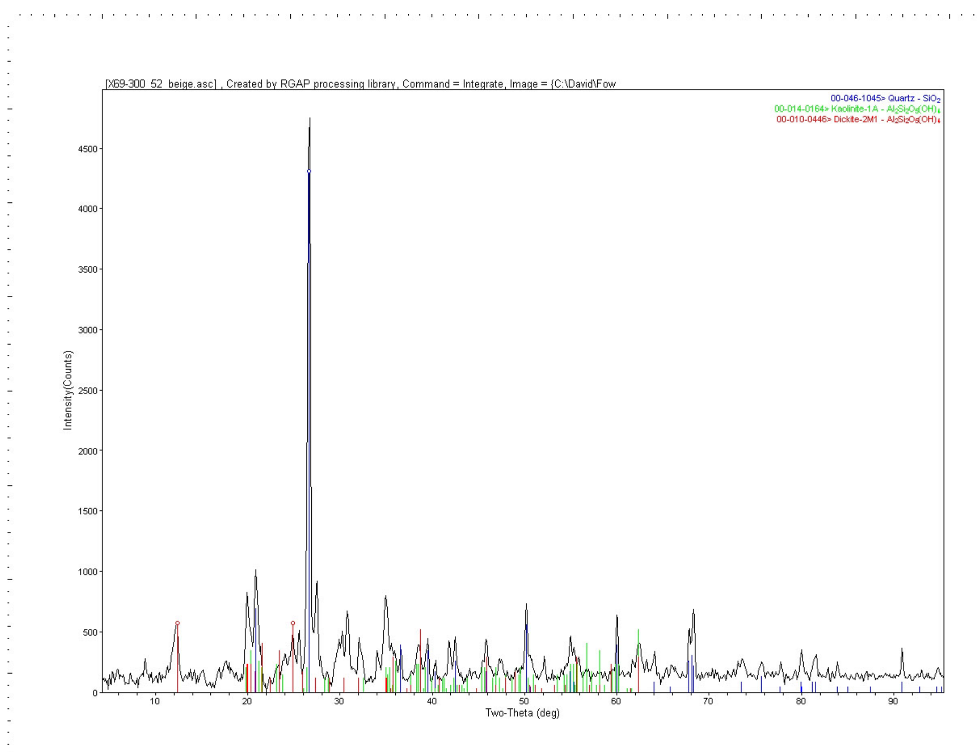


X69-300_51_pink

Appendix D: XRD Spectra

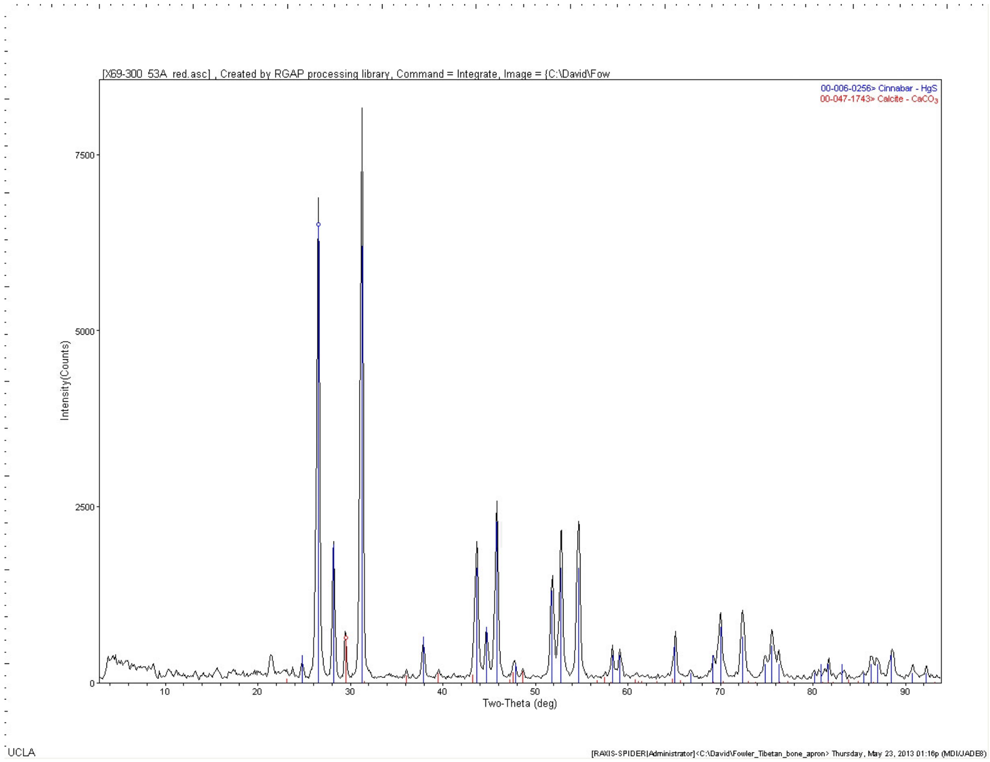


X69-300_52_beige_2

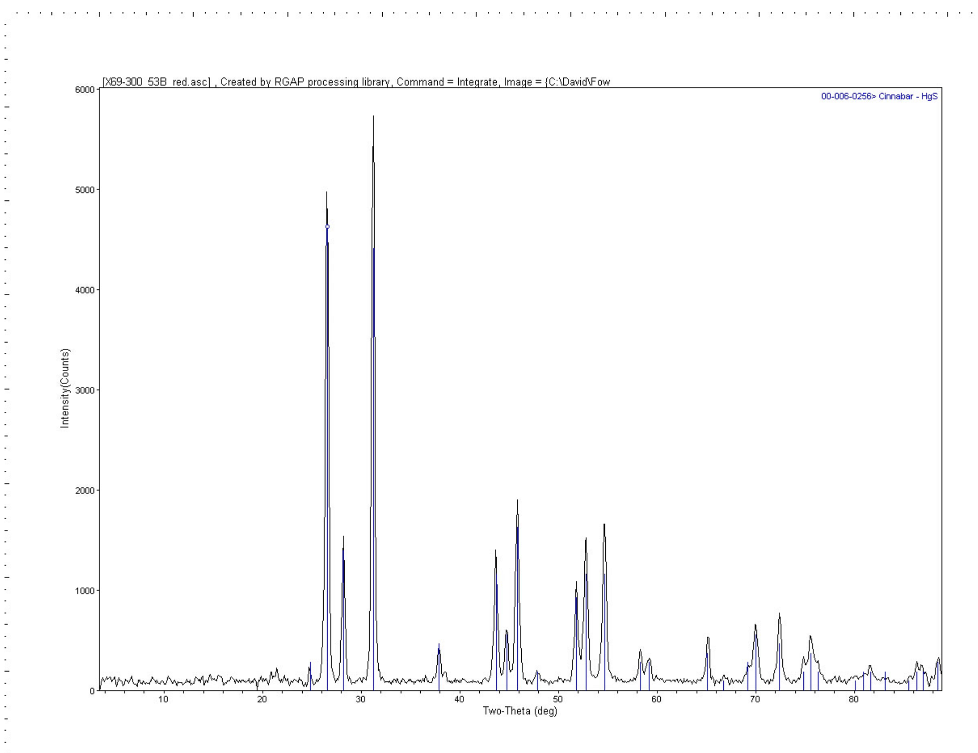


X69-300_52_beige

Appendix D: XRD Spectra

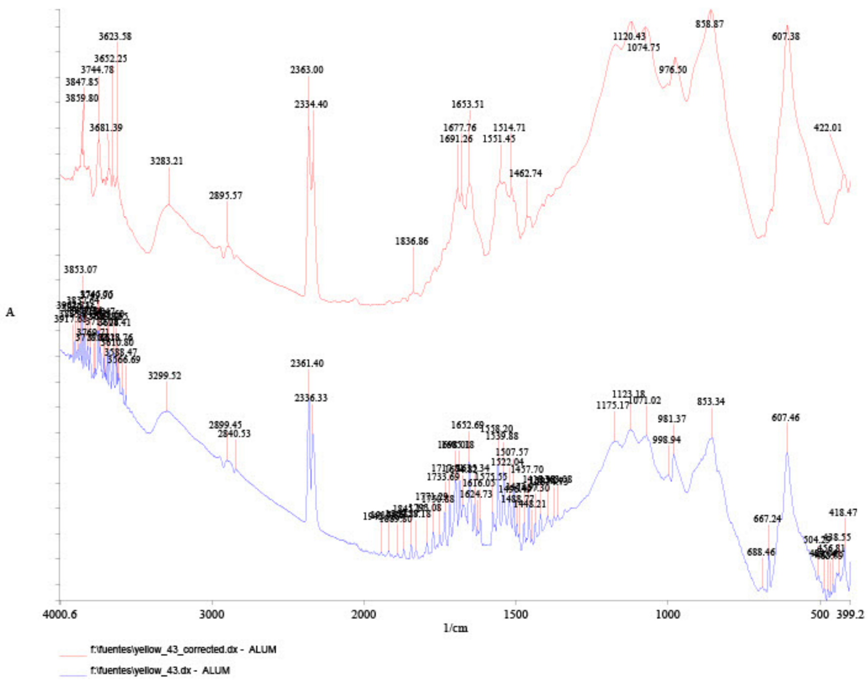


X69-300_53A_red

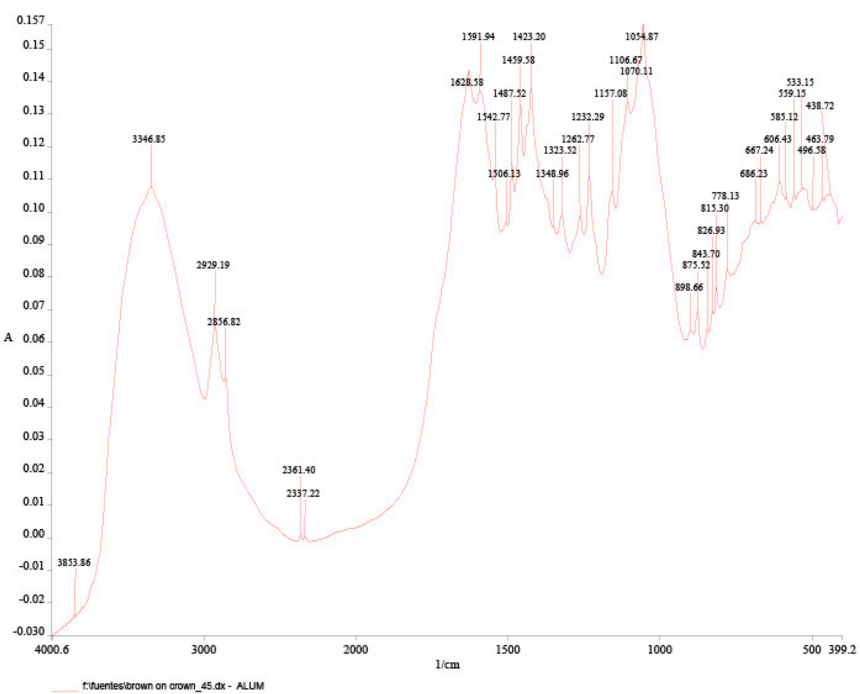


X69-300_53B_red

Appendix E: FTIR Spectra, measured in absorption

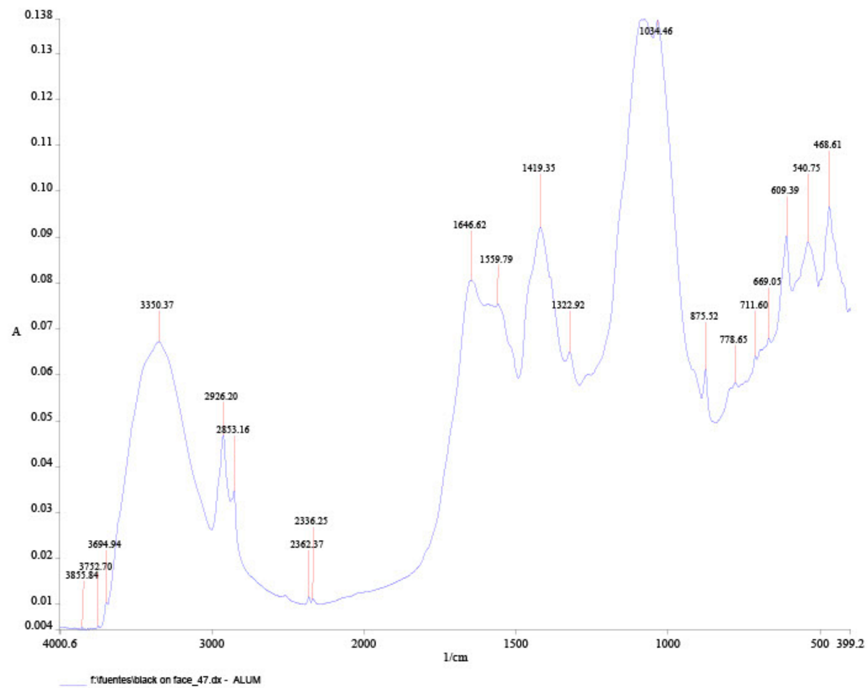


43_yellow_smoothed (red) and without smoothing (blue)

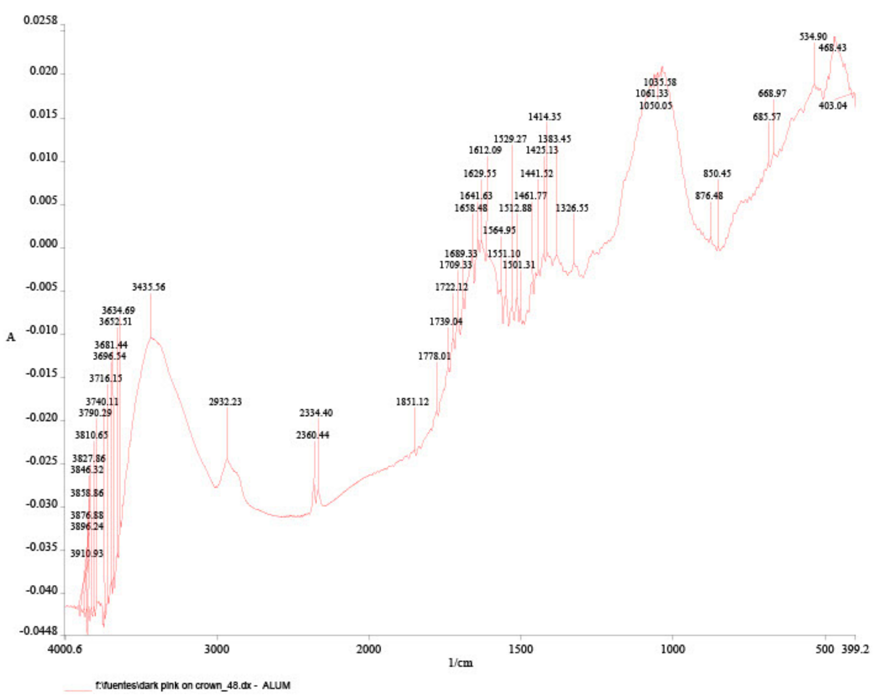


45_brown on crown

Appendix E: FTIR Spectra, measured in absorption

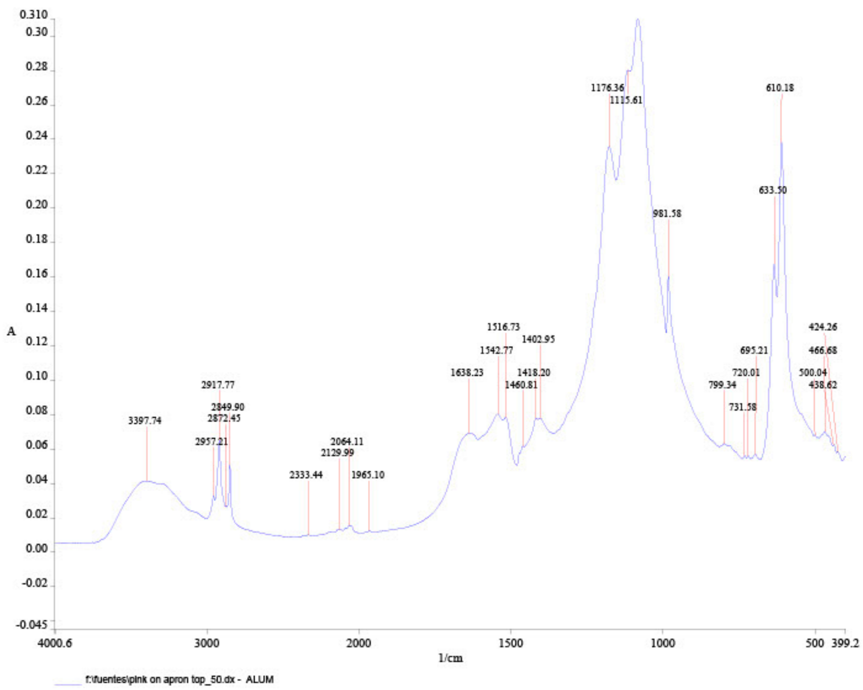


47_black



48_dark pink

Appendix E: FTIR Spectra, measured in absorption

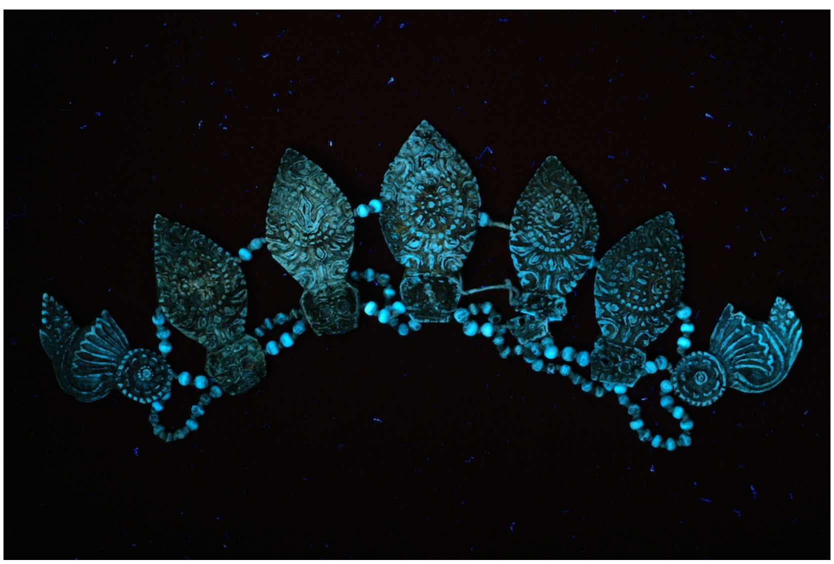


50_pink on apron

Appendix F: Identification of human bone as a material in cultural objects

In museum practice, modified human bone is most often handled as an anthropological or archaeological artifact and less as a raw material for objects of cultural value. The following describes some of the criteria by which this assortment of bone ornaments was determined to be human and is intended to serve as a template for conservators or other non-specialist investigators interested in determining the species of origin for bone objects. The emphasis here is on noninvasive methods; during the course of this project no sampling was intended or undertaken to determine the special origin of the substrate materials.

Hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$] is the primary mineral component of bone. In this project, the presence of bone was first suggested by UV-induced visible fluorescence, where it fluoresces bright white (Figure F.1) and supported by XRF with the emission of characteristic x-rays for Ca and P (Figure F.2; see Section 3.4.1 as well as Appendix C). (Note that the white fluorescence of bone under UV light cannot be used exclusively to diagnose the presence of bone as other minerals fluoresce similarly.) XRF readings taken from the ivory



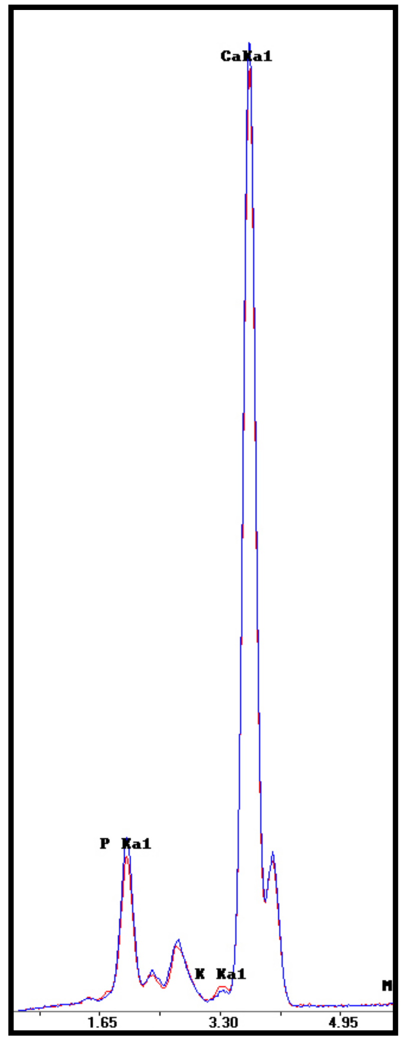
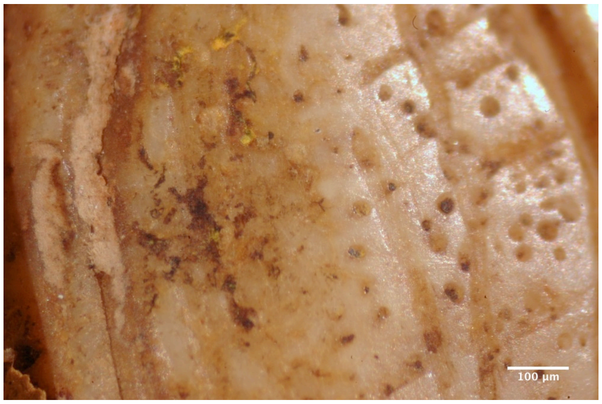


Figure F.1 (left): UV-induced visible fluorescence image (λex=300-400nm, 400-700nm capture) of crown (Fowler # X69.300B) showing blue-white fluorescence of bone mineral; dark areas are due to thicker layers of surface residue.

Figure F.2 (right): Detail from an overlay of two XRF spectra with signals for Ca and P (Bruker handheld XRF, 40 keV, 1.9 μA, no filter, no vacuum, 180 seconds).

Appendix F: Identification of human bone as a material in cultural objects



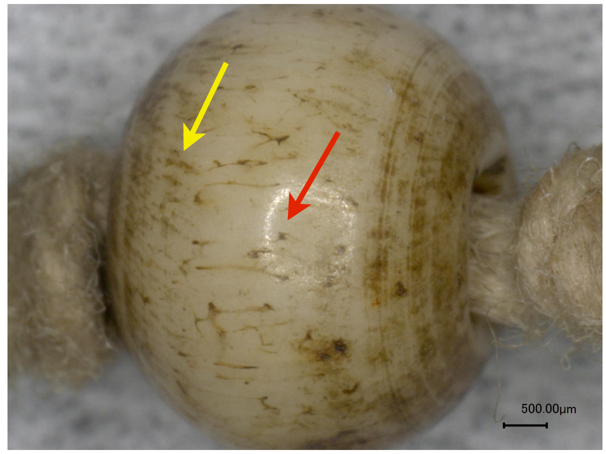


Figure F.3 (left): Haversian pits visible at low magnification on the transverse (exterior) surface of cortical bone on the central plaque of the arm band (Fowler # X69.300 C).

Figure F.4 (right): Haversian canals seen in the longitudinal plane (red arrow), parallel to the axis of the bone grain (yellow arrow).

component on Fowler # X69.300 G displayed Ca and P from dahllite [$Ca_{10}(PO_4)_6(CO_3)H_2O$], the main mineral component of ivory. Microscopic features must be used to distinguish between ivory and bone and the presence of Haversian pits in cortical or compact bone (the dense, outer layer) confirms the use of bone in the object (Espinoza and Mann 1999).

Haversian pits, or canals, are indicative of the Haversian system of bone formation and are critical in making determinations about the species of bone origin. These can be seen in cortical bone in transverse section (parallel to exterior surface) as dark apertures (Figure F.3) or in longitudinal section as lines parallel to bone grain (Figure F.4). Generally only humans, nonhuman primates and small mammals exhibit Haversian systems - also referred to as secondary osteons - exclusively (Hiller and Bell 2007). Other species, including large mammals, have both Haversian systems and plexiform bone, a formation without layers of concentric lamellae of bone mineral around a pit and, in transverse section under high magnification, resembles softly contoured and spongy stratigraphic layers with a ‘maze-like’ appearance (Figure F.5). Plexiform bone tends to have a linear orientation of osteons in comparison to bone with Haversian systems - also called lamellar bone - which has a more random distribution of canals surrounded by concentric layers of bone material. Generally speaking, adult humans do not have plexiform bone, except in areas of trauma where bone is quickly regrown and the presence of plexiform formations in cortical bone would exclude a human origin (Greenlee and Dunnell 2010).

Appendix F: Identification of human bone as a material in cultural objects

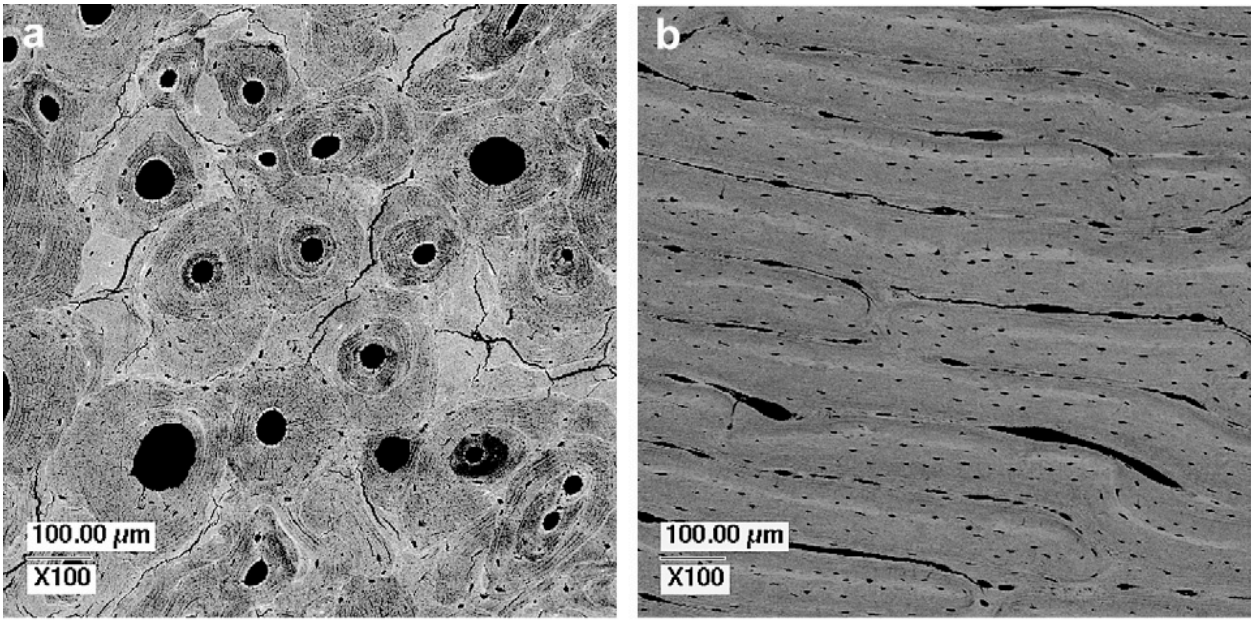


Figure F.5: Concentrically formed secondary osteons indicative of Haversian system in an adult human (left) vs plexiform bone, with linear, banded arrangement of primary osteons in a pig (right) (Greenlee and Dunnell 2010).

With scanning electron microscopy (SEM), it is possible to examine the concentration of Haversian pits on the surface of a cortical bone, as well as average canal and/or system diameter (total diameter of concentric lamellae surrounding a pit, *i.e.* the diameter of the secondary osteon). These three features can be used to determine that a bone *may* be human, based on size and distribution, but cannot be used exclusively to determine the species of bone. Human Haversian system density is similar to that of chimpanzees; canal diameter is similar but generally larger than sheep and the range of human Haversian system diameter is within that of both goats and sheep and is similar to cow (Hiller and Bell 2007). It should be noted that humans have the greatest range of variation in the size of these morphological features (Greenlee and Dunnell 2010). These specific criteria of micro-structure can be assessed non-invasively with access to a polished transverse surface and sufficient magnification (> 500x). Thin sections are also an option (as is DNA testing) where

Figure F.6: Cortical bone used as substrate in the object was consistently between 3 and 19 mm thick with an average thickness of 6-8 mm.

Appendix F: Identification of human bone as a material in cultural objects

Figure F.7: This piece was likely made from the lower limb of an adult human; note the thickness of the cortical layer and removal of porous, fragile cancellous material (Fowler # X69.300 A, reverse).

Figure F.8: This piece is an average of 5 mm thick with a curve and the characteristic patterning of capillary beds (instead of cancellous material) on the reverse indicating that it is a human cranium (Fowler # X69.300 C, reverse).

Figure F.9: The thickness of the cortical section of this bone (with cancellous material removed) and its density is indicative of human lower limb (Fowler # X69.300 D, reverse).

sampling is desired or permitted.

To better determine the species of origin for bone, gross morphological features are most useful. The cortical layer of human bone, especially in lower limbs and the cranium, is remarkably thick and dense amongst vertebrate species (Teeter, personal communication; Wake, personal communication). In the bone ornament ensemble examined here, the substrate for all components were between 3 and 19 mm thick (Figure F.6). The porous, cancellous (interior) bone had been removed by the original fabricators (Figure F.7) and only the cortical layer — wherein lies the diagnostic information discussed here — was used. In sections believed to be crania (4-6 mm thick with curved shape) the interior face (the reverse of the carved surface) was marked by the vascular morphology of capillary beds characteristic of the human cranium (Figure F.8). It is therefore the consistent thickness of areas of cortical bone — relative to its shape, density and micro-morphological features — that is most useful in diagnosing a human origin.

In summary, human bone can be distinguished from other vertebrates through micro-morphological features in cortical areas such as the presence of Haversian systems - and absence of plexiform formations

Appendix F: Identification of human bone as a material in cultural objects

- and their average diameter (190-325 μm), the average canal diameter (30-175 μm) and system density (5-42 per mm²) (Hiller and Bell 2007). These should be evaluated in relation to macroscopically observed features like a sustained area of thick (> 4 mm), dense and non-porous cortical bone. Cortical bone diameter can distinguish lower limbs (Figure F.9) and curved pieces that might be crania should be evaluated for the patterning of capillary beds on the interior surface. Because of their size and thickness, lower limbs and crania are, for the purposes of cultural objects, the most useful, durable, and likely materials (Teeter, personal communication; Wake, personal communication). If there is any ambiguity, the best suggestion for conservators is to consult with a professional forensic anthropologist or zooarchaeologist who can interpret bone features at a macro or microscopic level and provide the best estimation of the species of origin.

	Method of analysis	What to look for
Is it bone?	XRF	Ca and P
	UV-induced visible fluorescence	Bright white
	Microscopy (low magnification)	Haversian pits/canals on transverse surface of cortical bone
Is it human?	Macroscopic examination	Average thickness of cortical bone between 4 and 16 mm; Capillary bed patterning on curved cortical surfaces (average thickness 4-7 mm) strongly indicate human crania
	Microscopy (high magnification)	Absence of plexiform (maze-like formation) bone
	Microscopy (high magnification)	Average canal diameter (30-175 μm) Average system diameter (190-325 μm) Average system density (5-42 per mm²)
	Microscopy (high magnification)	Random distribution of systems/pits or short linear arrangements of osteons

Table F.1: Summarizing the distinction of human from other species by non-invasive examination of macro and micro-morphological features of cortical bone.

Appendix G: Analysis of lac resin with experimental and UV-induced visible fluorescence imaging

During review and documentation of the condition of the object, a red stain was noticed on several components of the bone ensemble (Figures G.1 and G.2). The stain is most often on beads but also the reverse and sides of carved plaques (Figure G.3), though never on the obverse face. With microscopy, the stain was observed as a coloration of the substrate surface and not as a distinct layer of applied material with appreciable thickness. Under UV-induced visible fluorescence imaging, areas of the red stain appeared as shades of orange, red, and purple, ranging in intensity from dull where trace amounts were present to bright where the stain survived as a thick layer (Figures G.4 and G.5). The orange-colored fluorescence is a noted feature of shellac (Koob 1998). Shellac is a resin produced by the lac insect (*Kerria lacca*), a native to areas of south and southeast Asia, and comes in colors ranging from yellow to brown to scarlet.

There is ample evidence for the historical and continued use of lac dye, the colorant in shellac, used in the material cultural of the Himalayan region, most notably as an ink for thangka paintings (Jackson and Jackson 1976; Jackson and Jackson 1984; Mass *et al.* 2009). Jackson and Jackson (1976) provide a detailed explanation of the refinement of stick lac (raw, resinous material excreted on sticks) into lac dye by master dye-makers in the Himalayan region. The stick lac is refined by heating in solution and the addition of a

Figure G.1: Red stain on bead.

Figure G.2: Red stain on bead is thicker in protected areas (red arrow).

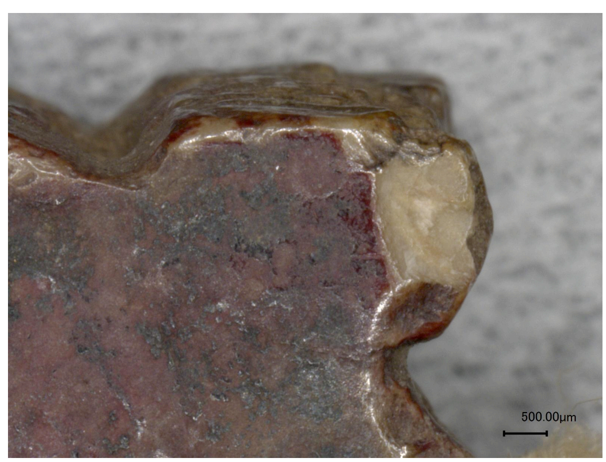


Figure G.3: Red stain on reverse of plaque (Fowler # X69.300 D).

Appendix G: Analysis of lac resin with experimental and UV-induced visible fluorescence imaging

Figure G.4 (above): Reflected visible light shows red staining irregularly applied to the beads

Figure G.5 (below): UV-induced visible fluorescence imaging (λex=300-400nm, 400-700nm capture) show variety of colors included orange (red arrow) and purple (yellow arrow)

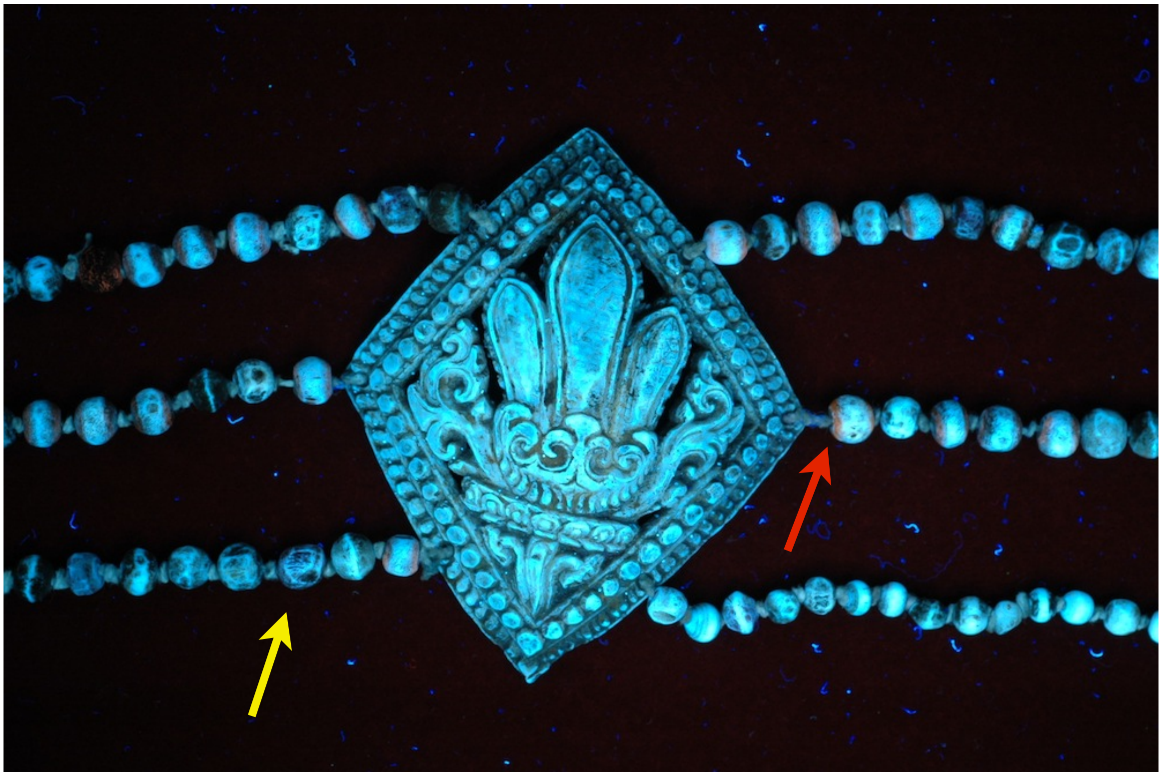


Figure G.6: Solution without added sodium bicarbonate (left) is brownish-orange after three hours of cooking; on the right the more basic solution is purple

Figure G.7: Two solutions have been cooked a total of 6 hours and are dark red/purple in color; the color of the water in the boiler reveals that the dye is water soluble

basic (ph>7) material such as the native *zhu-mkhan* (species unknown) leaf or soda. The authors note that the cooking time and temperature are crucial for controlling the color of the dye.

To gain a better understanding of the processes described by Jackson and Jackson (1976) and their relationship to the object, an experimental was undertaken to refine stick lac resin into lac dye. Approximately 10 mL of stick lac resin (20% w/v solution with ethanol) was divided into two test tubes and placed in a double boiler over low heat (50°C) for three hours. The resin in ethanol was a brown, opaque solution with 1-3mm sized black and dark brown particles. Approximately 3 mg of sodium bicarbonate ($NaHCO_3$) was added to one test tube at the beginning of heating; after three hours without coming to a boil, this solution was a dark purple color and the other was brownish-orange (Figure G.6). These solutions were left for three days, after which the solution to which the soda had been added was further divided into three parts. The first part was left as it was at the end of the first cooking; the second was put in a test tube in double boiler; the third was also placed in a test tube in the double boiler with the addition of a further 3 mg of sodium bicarbonate. Each tube was given an additional 2 mL of deionized water. These two were cooked for an additional three hours without boiling. After heating, both were dark red/purple in color (Figure G.7) and left to cool. All four solutions were tested with a Beckman ϕ 340 pH meter with pH probe; the results are given in Table G.1, below.

The four solutions were painted onto a chicken bone that had been manually sanded and polished (Figure G.8). Like human bone, chicken bone is composed largely of hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$]. The bone, with four solutions of lac resin dried on the surface, was documented with reflected visible light

Appendix G: Analysis of lac resin with experimental and UV-induced visible fluorescence imaging

Solution number	Color	Length of cook time	Amount of $NaHCO_3$ added	pH
1	Dark orange/brown	3 hrs	0 mg	4.8
2	Red orange	3 hrs	3 mg	5.8
3	Purple	6 hrs	3 mg	9.4
4	Maroon/purple	6 hrs	6mg	9.9

Table G.1: Tabulated results of experimental refinement of stick lac resin

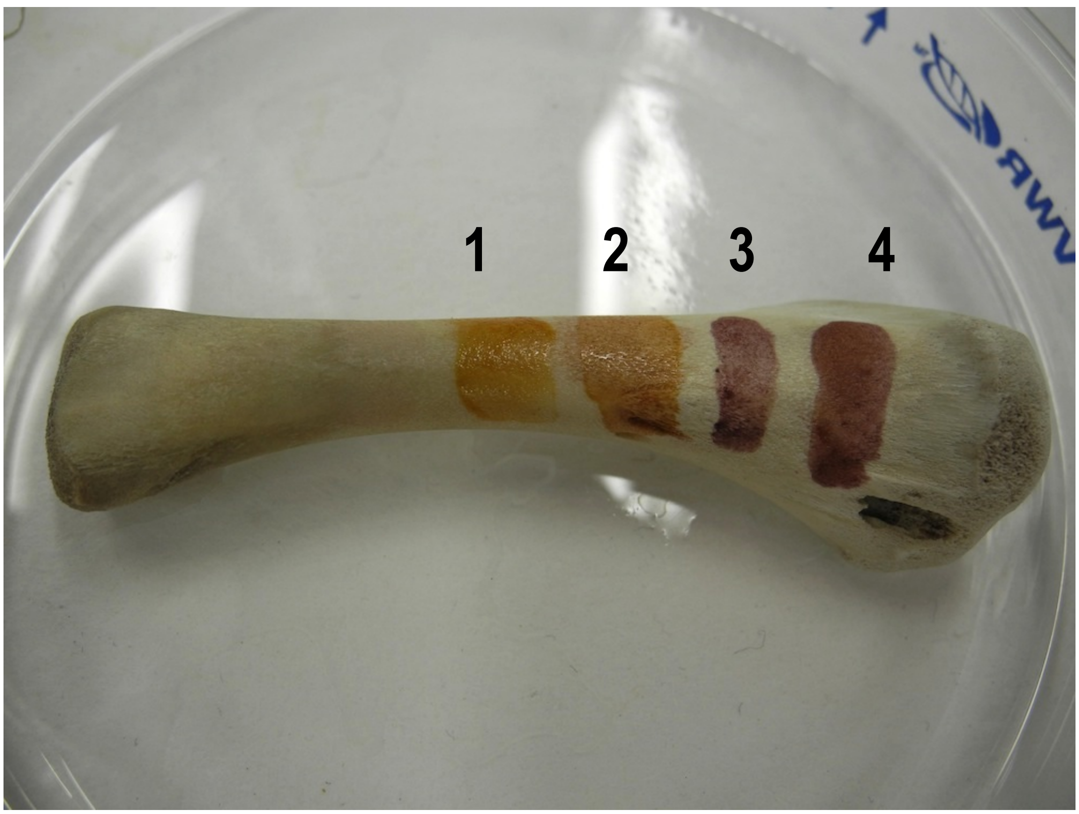


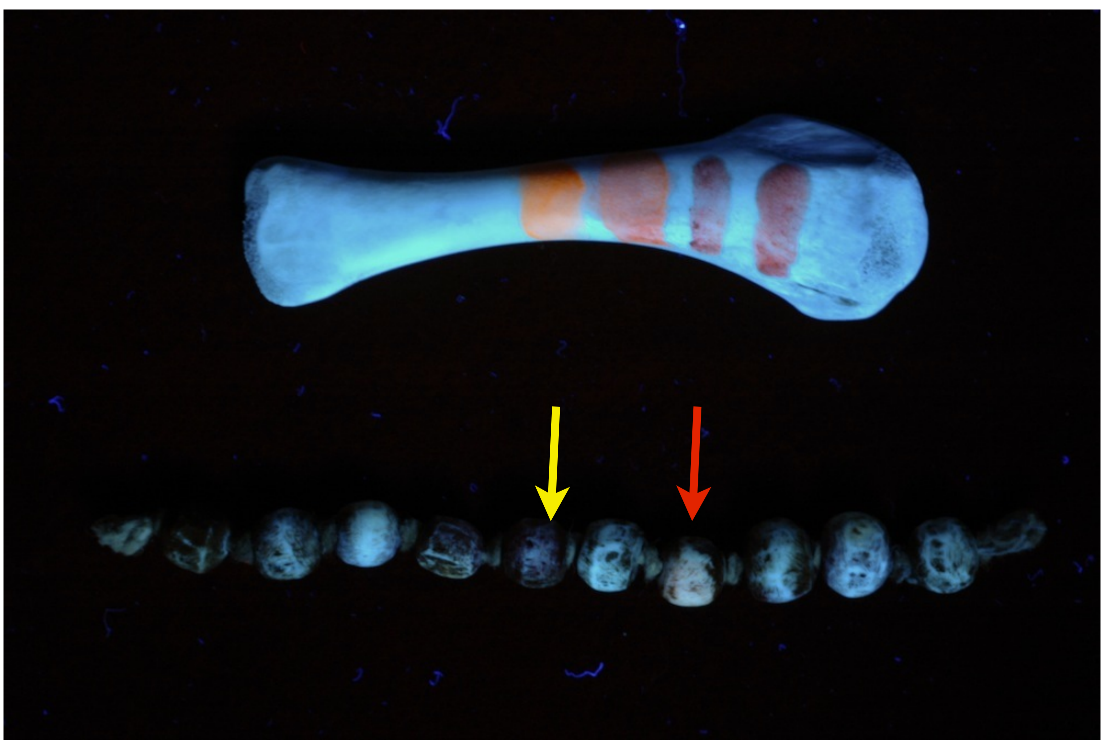
Figure G.8: Each lac resin solution has been applied to the surface of a polished chicken bone with a synthetic bristle brush; the position of each solution has been numbered according to the information in Table G.1

and UV-induced visible fluorescence, in comparison with a section of beads from the object with red staining (Figures G.9 and G.10). Though the fluorescence of the beads was faint, close examination reveals areas of orange and purple fluorescence. The experimental chicken bone also displayed chromatic variations relative to the preparation of the resin, with different shades of orange and red.

Appendix G: Analysis of lac resin with experimental and UV-induced visible fluorescence imaging

Figure G.9 (above): Reflected visible light shows red staining on beads and painted chicken bone.

Figure G.10 (below): UV-induced visible fluorescence imaging (λex=300-400nm, 400-700nm capture) shows variety of colors on chicken bone and, faintly, on beads included orange (red arrow) and purple (yellow arrow).



Appendix G: Analysis of lac resin with experimental and UV-induced visible fluorescence imaging

It can be suggested that there is more than one type of lac dye present on the object, where different colors under UV-induced visible fluorescence may correspond to different dye batches or methods of preparation. It is difficult to assess chromatic variations in reflected visible light because of the condition of the object surface. Variations in color may, however, also be attributed to other materials on the surface of the object mixed with or laid over the red stains, the age of the red stain, the amount of surviving stain given the object's use in its original setting, or other factors not reviewed here.

PMG: photomicrograph, XRF: x-ray fluorescence spectroscopy, MCT: micro-chemical test, PLM: polarized light microscopy, FT: flame test, XRD: x-ray diffraction, FTIR: Fourier-transform infrared spectrometry

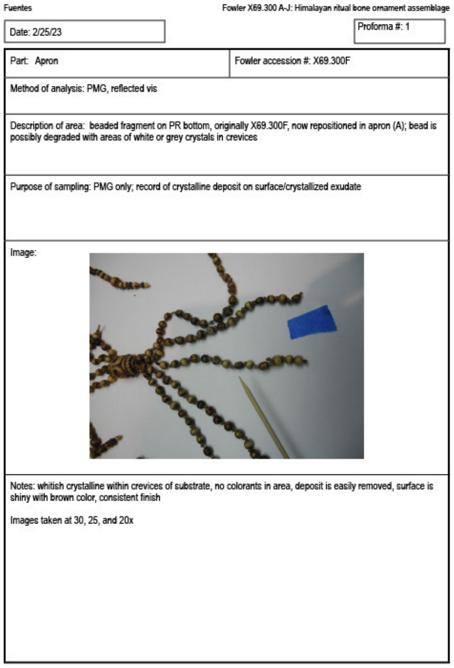
Proforma #	Type of analysis recorded	Material type/Target	Object type	Fowler #
26	XRF	Orange deposit	Plaque	X69.300 B
27	XRF	Green deposit	Plaque	X69.300 E
28	XRF	Substrate	Plaque (ivory)	X69.300 G
29	XRF	Yellow deposit	Plaque	X69.300 J
30	XRF	Red layer	Beads	X69.300 C
31	MCT	Dark brown grains from cancellous bone (proteins)	Crown plaque	X69.300 B
32	MCT	Dark brown grains from cancellous bone (proteins)	Crown plaque	X69.300 B
33	XRF	Red deposit	Plaque	X69.300 A
34	XRF	Fiber (pesticide residues)	Tassel	X69.300 A
35	PLM	Fiber identification	Tassel, cordage	X69.300 A
36	PLM	Fiber identification	Cordage	X69.300 A
37	PLM	Fiber identification	Cordage	X69.300 A
38	PLM	Fiber identification	Tassel	X69.300 D
39	PLM	Fiber identification	Tassel	X69.300 F
40	PLM	Fiber identification	Detached textile fragment	N/A
41	PLM, MCT, XRD	White-grey deposits	Plaque (ivory)	X69.300 G
42	XRD	Pink deposit	Plaque	X69.300 D
43	PLM, XRD, FTIR	Yellow deposit	Plaque	X69.300 C
44	XRD	Green deposit	Plaque	X69.300 E
45	FT, FTIR	Light brown deposit	Crown plaque	X69.300 B
46	XRD	Orange/pink deposit	Plaque	X69.300 B
47	FT, FTIR	Black layer	Crown plaque	X69.300 B
48	FT, FTIR	Dark pink deposit	Crown plaque	X69.300 B
49	XRD	Peach deposit	Crown plaque	X69.300 B

PMG: photomicrograph, XRF: x-ray fluorescence spectroscopy, MCT: micro-chemical test, PLM: polarized light microscopy, FT: flame test, XRD: x-ray diffraction, FTIR: Fourier-transform infrared spectrometry

Proforma #	Type of analysis recorded	Material type/Target	Object type	Fowler #
50	FT, XRD, FTIR	Peach deposit	Plaque	X69.300 A
51	XRD	Dark pink deposit	Plaque	X69.300 A
52	FT, XRD	Off-white deposit	Plaque	X69.300 A
53	XRD	Red deposit	Plaque	X69.300 A
54	FT, PLM	White, waxy spots	Plaque	X69.300 D

PMG: photomicrograph, XRF: x-ray fluorescence spectroscopy, MCT: micro-chemical test, PLM: polarized light microscopy, FT: flame test, XRD: x-ray diffraction, FTIR: Fourier-transform infrared spectrometry

Appendix H: Proformas



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/25/23 — Proforma #: 1

Part: Apron — Fowler accession #: X69.300F

Method of analysis: PMG, reflected vis

Description of area: beaded fragment on PR bottom, originally X69.300F, now repositioned in apron (A); bead is possibly degraded with areas of white or grey crystals in crevices

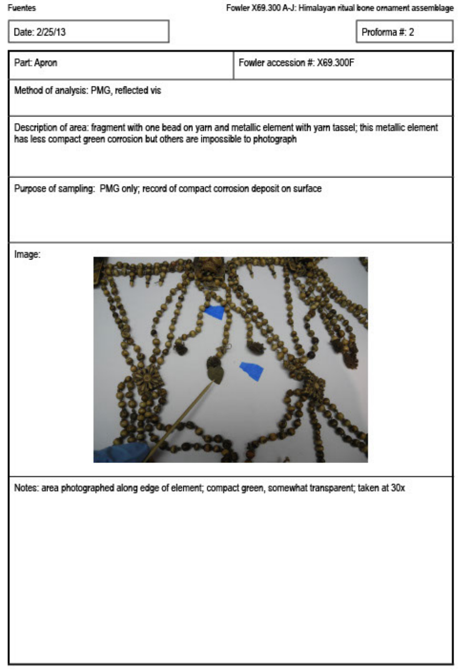
Purpose of sampling: PMG only; record of crystalline deposit on surface/crystallized exudate

Image:

Notes: whitish crystalline within crevices of substrate, no colorants in area, deposit is easily removed, surface is shiny with brown color, consistent finish

Images taken at 30, 25, and 20x

proforma_01



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/25/13 — Proforma #: 2

Part: Apron — Fowler accession #: X69.300F

Method of analysis: PMG, reflected vis

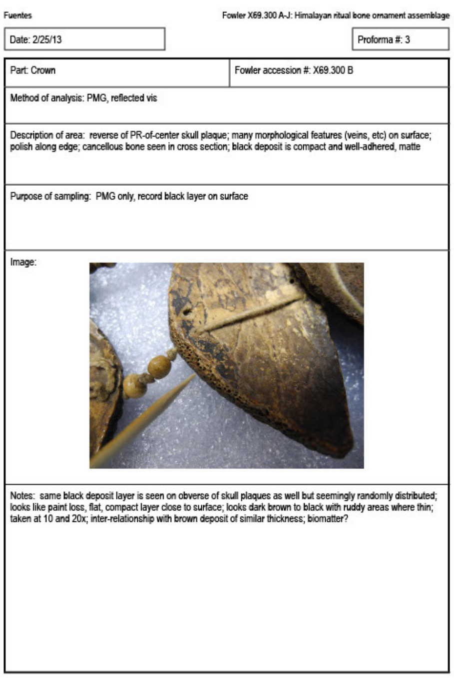
Description of area: fragment with one bead on yarn and metallic element with yarn tassel; this metallic element has less compact green corrosion but others are impossible to photograph

Purpose of sampling: PMG only; record of compact corrosion deposit on surface

Image:

Notes: area photographed along edge of element; compact green, somewhat transparent; taken at 30x

proforma_02



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/25/13 — Proforma #: 3

Part: Crown — Fowler accession #: X69.300 B

Method of analysis: PMG, reflected vis

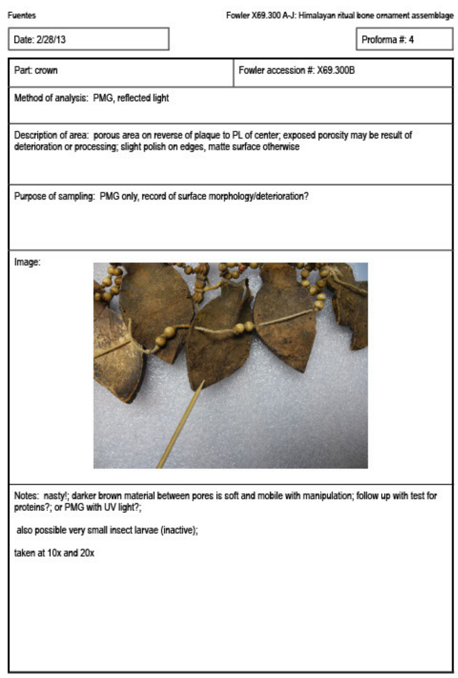
Description of area: reverse of PR-of-center skull plaque; many morphological features (veins, etc) on surface; polish along edge; cancellous bone seen in cross section; black deposit is compact and well-adhered, matte

Purpose of sampling: PMG only, record black layer on surface

Image:

Notes: same black deposit layer is seen on obverse of skull plaques as well but seemingly randomly distributed; looks like paint loss, flat, compact layer close to surface; looks dark brown to black with ruddy areas where thin; taken at 10 and 20x; inter-relationship with brown deposit of similar thickness; biomatter?

proforma_03



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 4

Part: crown — Fowler accession #: X69.300B

Method of analysis: PMG, reflected light

Description of area: porous area on reverse of plaque to PL of center; exposed porosity may be result of deterioration or processing; slight polish on edges, matte surface otherwise

Purpose of sampling: PMG only, record of surface morphology/deterioration?

Image:

Notes: nasty!; darker brown material between pores is soft and mobile with manipulation; follow up with test for proteins?; or PMG with UV light?;

also possible very small insect larvae (inactive);

taken at 10x and 20x

proforma_04

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 5

Part: Crown — Fowler accession #: X69.300 B

Method of analysis: PMG, reflected light

Description of area: obverse surface with dark brown, black layer and red paint; area of possible loss or deposit or both; area around PR eye of central skull plaque

Purpose of sampling: PMG only, reflected light

Image:

Notes: dark layer is thin, compact, but with varied thickness; some dirt? (quartz or similar crystal at bottom of eye recess; paint or powdered pigment over dark layer; should this also have protein test? Or UV exam under microscope?

7x

proforma_05

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 6

Part: arm band — Fowler accession #: X69.300 C

Method of analysis: PMG, reflected light

Description of area: bead to the side of central curved plaque (see image); red staining on sides, exposed tool marks and/or pores in polished area at center; high polish

Purpose of sampling: PMG only, record of stain and worn area with tool marks/features

Image:

Notes: marks run in two directions; diagonally and also parallel to threading hole; diagonal may be tool marks or evidence of use while parallel are incipient cracks or canals? In cortical bone;
Taken at 15x only

proforma_06

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 7

Part: Arm band

Method of analysis: PMG, reflected light

Description of area: polished carved surface on central plaque of arm band in trident; area has been carved and polished with some deposit of beige material in crevices

Purpose of sampling: PMG only, record of morphological features

Image:

Notes: pits on polished surface with dark matter in some recessed areas; other lines and features, possibly result of processing which produces polished surface but not completely flat

Taken at 10x;

Some yellow pigment beneath in crevices, recesses with dark material on top

proforma_07

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 8

Part: arm band — Fowler accession #: X69.300 C

Method of analysis: PMG reflected vis

Description of area: reverse of central plaque, raised area around aperture; likely result of fabrication and displacement of bone material during carving

Purpose of sampling: PMG only, record of bevel/raised area around carved opening

Image:

Notes: raised edge/kerf looks polished; was this moved when bone was still soft and then hardened? How fresh would the bone have to be to move it in this way?

10x

proforma_08

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 9

Part: Unidentified accessory	Fowler accession #: X69.300 D
Method of analysis: PMG, reflected vis	
Description of area: reverse of plaque nearest tassel and textile fragment with white crystalline material on surface; red stain also on surface with dark brown layer as well	
Purpose of sampling: PMG only, record of white substance on surface	

Image:

Notes: there's a hair tied into the yarn here; white crystals are in clusters on top of red, brown layer
Material is waxy-ish, can be moved but is well adhered to surface

7x, 20x

proforma_09

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 10

Part: Unidentified accessory	Fowler accession #: X69.300 D
Method of analysis: PMG, reflected vis	
Description of area: fabric fragment attached to tassel at one end of accessory	
Purpose of sampling: PMG only, record of fabric weave and color	

Image:

Notes: yarns are white and brown with black and red yarns in tassel; fabric is gray-brown, plain woven; yarns are z-twist, single ply; yarns in tassel are Z-twist, 4-S-ply;

7x, 15x

proforma_10

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 11

Part: Unidentified accessory	Fowler accession #: X69.300 D
Method of analysis: PMG, reflected vis	
Description of area: beads with 'turned' marks, parallel along circumference of beads, possible tool marks	
Purpose of sampling: PMG only, record of common striations observed on other beads in object	

Image:

Notes: typical 'turning' marks, evidence of manufacture

Two beads with knotted yarn in between

7x

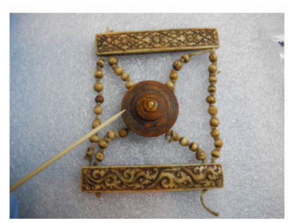
proforma_11

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 — Proforma #: 12

Part: Unidentified accessory	Fowler accession #: X69.300 G
Method of analysis: PMG, reflected vis	
Description of area: obverse surface of round central component of section; material is unique in appearance, thickness; very dense with warm, orange-ish brown color with some black, grey deposits on surface and spots of white crystalline material	
Purpose of sampling: PMG only, record of surface and formation of white crystalline material	

Image:



Notes: spots of white crystalline material on protected areas of carving less likely to have been abraded; some evidence of red pigment as well and dark brown/black layer on surface beneath white crystalline spots; areas of high relief are polished

Also some beige deposits (dirt/dust?)

Surface then black then beige then white spots

7x, 30x

proforma_12

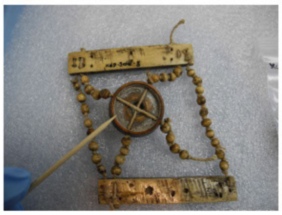
Appendix H: Proformas

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 | Proforma #: 13

Part: Unidentified accessory	Fowler accession #: X69.300 G
Method of analysis: PMG, reflected vis	
Description of area: reverse surface of round central component of section; material is unique in appearance, thickness; very dense with warm, orange-ish brown color with some black, grey deposits on surface and islands of white crystalline material	
Purpose of sampling: PMG only, record of surface and formation of white crystalline material	

Image:



Notes: white crystalline material on reverse is more than obverse face; surface is less polished with concentric incipient cracks of unknown origin; surface is matte with gray-brown-tan color; white material on top

Also seen on sides of same component
Well-adhered but easily disturbed
Definitely needs follow up sampling and ID of substrate material
Shells/bubbles! Like iron corrosion with pcpt'd mineral in solution then dries out and leaves shells

7x, 20x, 35x (shells)

Definitely needs follow up with digital microscope

proforma_13

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 2/28/13 | Proforma #: 14

Part: Unidentified accessory	Fowler accession #: X69.300 J
Method of analysis: PMG, reflected vis	
Description of area: carved observe surface of component not associate with other sections/fragments; pattern of canals in carved surface possibly from deterioration or natural morphology of bone; some yellow pigment on surface as well	
Purpose of sampling: PMG only, record of morphology	

Image:

Notes: possibly dark brown, aged biomatter in canals but may also be residue from use or manufacture; pigment is topmost layer; disruption in carved surface is unique to object where most carved surfaces are relatively complete and without noticeable deterioration, canals are up to a few mm deep but do not go through substrate

7x, 10x

proforma_14

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/6/13 | Proforma #: 15

Part: apron	Fowler accession #: X69.300 A
Method of analysis: XRF Ti filter, no vacuum, 40kV, 1.9 mA	
Description of area: cuprous? Metal bangle on PR bottom of apron; slightly gold in color	
Purpose of sampling: XRF spectrum only, evaluate alloy elements (qualitative only)	

Image:

Notes: Cu and Zn with some Fe

proforma_15

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/6/13 | Proforma #: 16

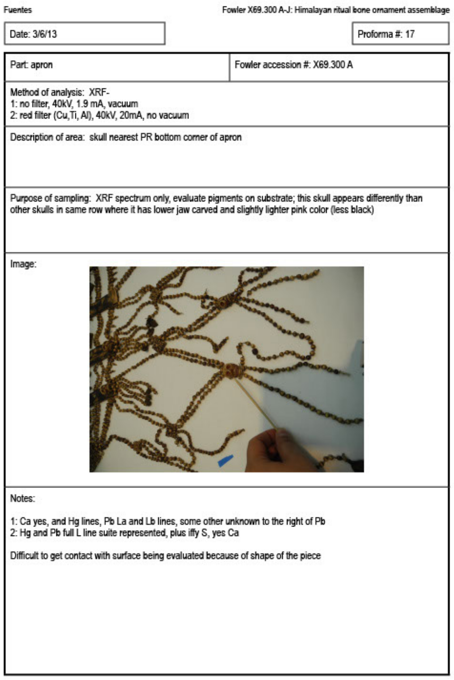
Part: apron	Fowler accession #: X69.300 A/F
Method of analysis: XRF Ti filter, no vacuum, 40kV, 1.9 mA	
Description of area: cuprous? Metal bangle near top of apron, fragment that was repositioned	
Purpose of sampling: XRF spectrum only, evaluate alloy elements (qualitative only)	

Image:

Notes: Cu and Zn

proforma_16

Appendix H: Proformas



Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/6/13 | Proforma #: 17

Part: apron | Fowler accession #: X69.300 A

Method of analysis: XRF-
1: no filter, 40kV, 1.9 mA, vacuum
2: red filter (Cu,Ti, Al), 40kV, 20mA, no vacuum

Description of area: skull nearest PR bottom corner of apron

Purpose of sampling: XRF spectrum only, evaluate pigments on substrate; this skull appears differently than other skulls in same row where it has lower jaw carved and slightly lighter pink color (less black)

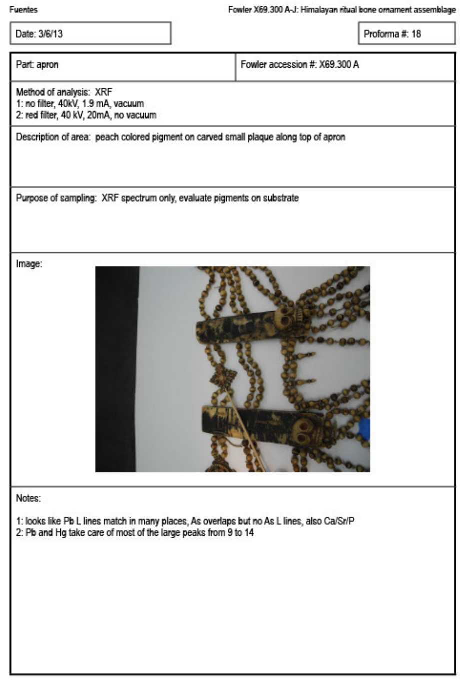
Image:

Notes:

1: Ca yes, and Hg lines, Pb La and Lb lines, some other unknown to the right of Pb
2: Hg and Pb full L line suite represented, plus iffy S, yes Ca

Difficult to get contact with surface being evaluated because of shape of the piece

proforma_17



Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/6/13 | Proforma #: 18

Part: apron | Fowler accession #: X69.300 A

Method of analysis: XRF
1: no filter, 40kV, 1.9 mA, vacuum
2: red filter, 40 kV, 20mA, no vacuum

Description of area: peach colored pigment on carved small plaque along top of apron

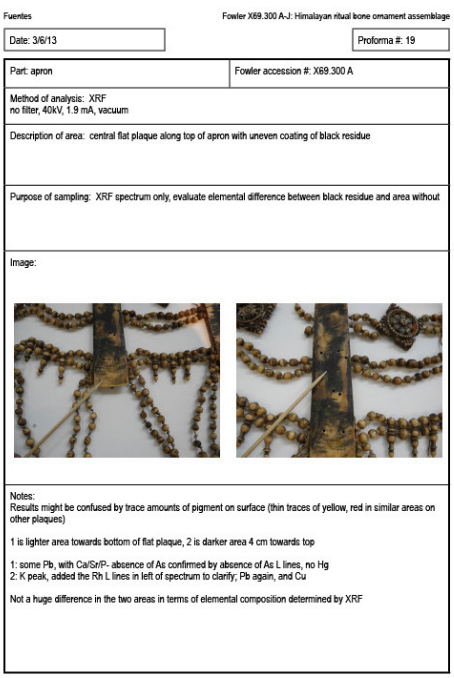
Purpose of sampling: XRF spectrum only, evaluate pigments on substrate

Image:

Notes:

1: looks like Pb L lines match in many places, As overlaps but no As L lines, also Ca/Sr/P
2: Pb and Hg take care of most of the large peaks from 9 to 14

proforma_18



Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/6/13 | Proforma #: 19

Part: apron | Fowler accession #: X69.300 A

Method of analysis: XRF
no filter, 40kV, 1.9 mA, vacuum

Description of area: central flat plaque along top of apron with uneven coating of black residue

Purpose of sampling: XRF spectrum only, evaluate elemental difference between black residue and area without

Image:

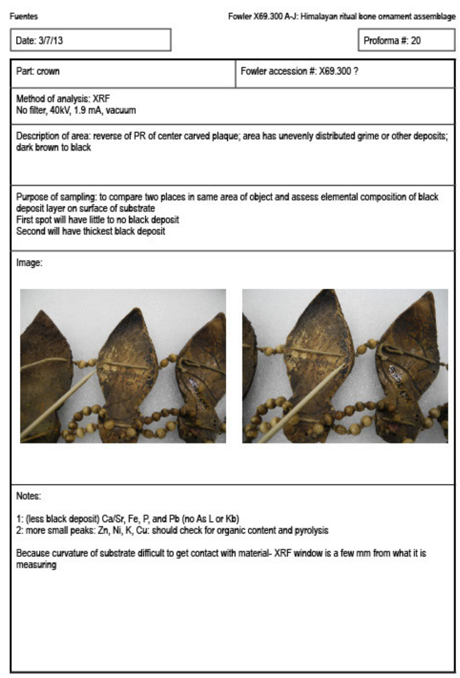
Notes:
Results might be confused by trace amounts of pigment on surface (thin traces of yellow, red in similar areas on other plaques)

1 is lighter area towards bottom of flat plaque, 2 is darker area 4 cm towards top

1: some Pb, with Ca/Sr/P- absence of As confirmed by absence of As L lines, no Hg
2: K peak, added the Rh L lines in left of spectrum to clarify; Pb again, and Cu

Not a huge difference in the two areas in terms of elemental composition determined by XRF

proforma_19



Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 | Proforma #: 20

Part: crown | Fowler accession #: X69.300 ?

Method of analysis: XRF
No filter, 40kV, 1.9 mA, vacuum

Description of area: reverse of PR of center carved plaque; area has unevenly distributed grime or other deposits; dark brown to black

Purpose of sampling: to compare two places in same area of object and assess elemental composition of black deposit layer on surface of substrate
First spot will have little to no black deposit
Second will have thickest black deposit

Image:

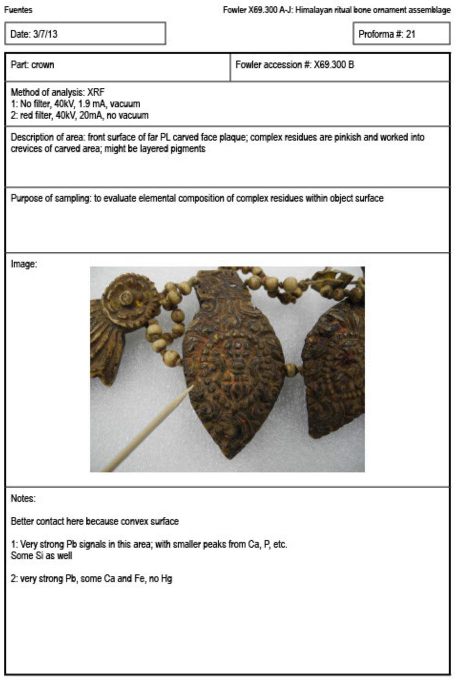
Notes:

1: (less black deposit) Ca/Sr, Fe, P, and Pb (no As L or Kb)
2: more small peaks: Zn, Ni, K, Cu: should check for organic content and pyrolysis

Because curvature of substrate difficult to get contact with material- XRF window is a few mm from what it is measuring

proforma_20

Appendix H: Proformas



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 21

Part: crown	Fowler accession #: X69.300 B

Method of analysis: XRF
1: No filter, 40kV, 1.9 mA, vacuum
2: red filter, 40kV, 20mA, no vacuum

Description of area: front surface of far PL carved face plaque; complex residues are pinkish and worked into crevices of carved area; might be layered pigments

Purpose of sampling: to evaluate elemental composition of complex residues within object surface

Image:

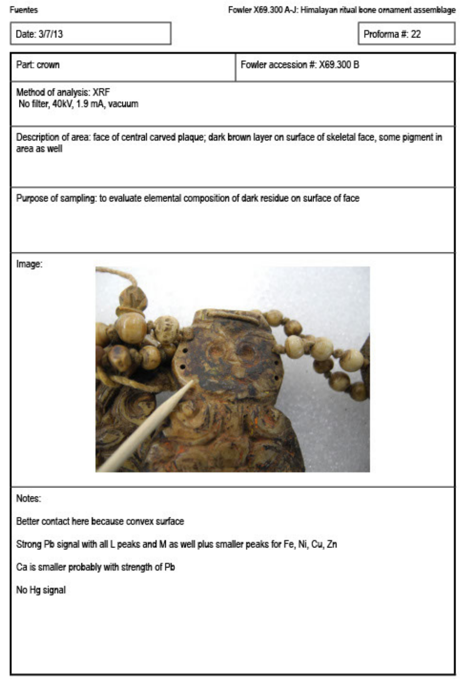
Notes:

Better contact here because convex surface

1: Very strong Pb signals in this area; with smaller peaks from Ca, P, etc.
Some Si as well

2: very strong Pb, some Ca and Fe, no Hg

proforma_21



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 22

Part: crown	Fowler accession #: X69.300 B

Method of analysis: XRF
No filter, 40kV, 1.9 mA, vacuum

Description of area: face of central carved plaque; dark brown layer on surface of skeletal face, some pigment in area as well

Purpose of sampling: to evaluate elemental composition of dark residue on surface of face

Image:

Notes:

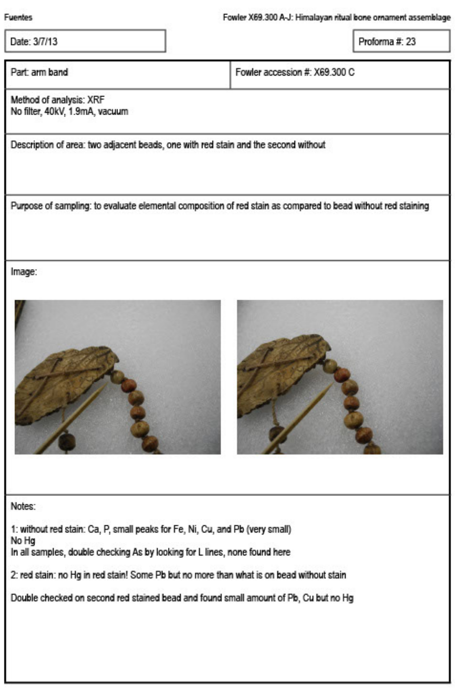
Better contact here because convex surface

Strong Pb signal with all L peaks and M as well plus smaller peaks for Fe, Ni, Cu, Zn

Ca is smaller probably with strength of Pb

No Hg signal

proforma_22



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 23

Part: arm band	Fowler accession #: X69.300 C

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: two adjacent beads, one with red stain and the second without

Purpose of sampling: to evaluate elemental composition of red stain as compared to bead without red staining

Image:

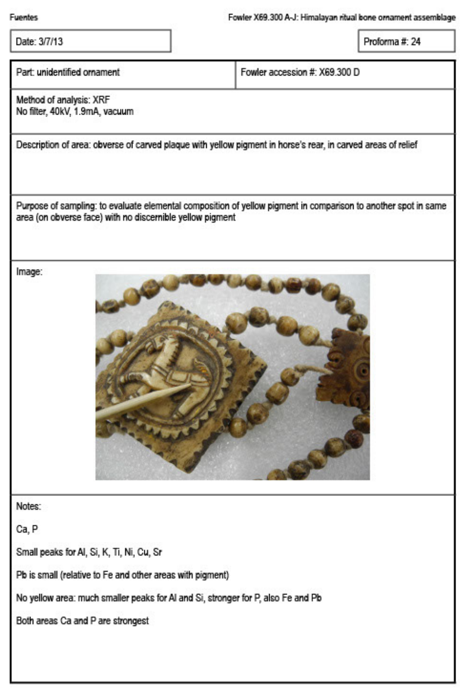
Notes:

1: without red stain: Ca, P, small peaks for Fe, Ni, Cu, and Pb (very small)
No Hg
In all samples, double checking As by looking for L lines, none found here

2: red stain: no Hg in red stain! Some Pb but no more than what is on bead without stain

Double checked on second red stained bead and found small amount of Pb, Cu but no Hg

proforma_23



Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 24

Part: unidentified ornament	Fowler accession #: X69.300 D

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: obverse of carved plaque with yellow pigment in horse's rear, in carved areas of relief

Purpose of sampling: to evaluate elemental composition of yellow pigment in comparison to another spot in same area (on obverse face) with no discernible yellow pigment

Image:

Notes:

Ca, P

Small peaks for Al, Si, K, Ti, Ni, Cu, Sr

Pb is small (relative to Fe and other areas with pigment)

No yellow area: much smaller peaks for Al and Si, stronger for P, also Fe and Pb

Both areas Ca and P are strongest

proforma_24

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 25

Part: unidentified ornament — Fowler accession #: X69.300 D

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: obverse of carved plaque with black layer and red pigment; over these layers there are white deposits of white crystalline material

Purpose of sampling: to evaluate elemental composition of layers close to surface with goal of eventually determining their relationship to white deposits

Image:

Notes:

Ca, P, Al (have I just overlooked this on other spectra), with Fe, Pb, Zn, Cu, Ni

No Hg

Is the surface layer organic? Pyrolysis needed

proforma_25

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 26

Part: Crown — Fowler accession #: X69.300 B

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: obverse of far PR plaque (not skeletal face) with bright orange pigment within crevices

Purpose of sampling: to evaluate elemental composition of bright orange pigment on surface

Image:

Notes:

Stronger Pb peak; no As L lines

Funny lines between Rh L and P are often Pb M lines
No Hg

Contact is not close but spectrum looks good; placement also not precise with small areas of pigment on surface

proforma_26

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 27

Part: Unidentified ornament (x-wing) — Fowler accession #: X69.300 E

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: face of flat piece on the side, carved, with green stain or deposit on surface

Purpose of sampling: to evaluate elemental composition of green stain as compared to similar area adjacent without green staining

Image:

Notes:

With green stain:

Pb M lines might hide S lines since so much heavier

Possible a Mn peak, small. Cu peak seems stronger here than other positions

No green stain: has Hg? Red pigment in area. Smaller Cu! Green is likely Cu related based on comparison
Still has Pb L and M, small Al shoulder shows again. Might also be everywhere but I'm not always checking

proforma_27

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13 — Proforma #: 28

Part: Unidentified ornament (round center) — Fowler accession #: X69.300 G

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: round center piece of ornament, especially dense, orange-brown material with white crystalline deposits on surface

Purpose of sampling: to evaluate elemental composition of substrate; compare elemental composition of front vs back of plaque

Image:

Notes:

Front: Ca and P! Its bone. With Pb and Fe and other trace elements (Mn, Al, Si, Ni, etc)

Side (good contact with window): little more Pb/Si than the front but may be better contact, different signals

Reverse (void between window and material): same thing with a little more Pb

Is this Pb starting to look like pesticide? Maybe the white deposit is Pb related?

proforma_28

Appendix H: Proformas

Fuentes
Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13
Proforma #: 29

Part: Unidentified ornament (round)
Fowler accession #: X69.300 J

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: round, unidentified ornament with carved front surface; area is possibly deteriorated or has canals from morphology of substrate material with yellow pigment distributed across the canals

Purpose of sampling: to evaluate elemental composition of yellow pigment in relation to another spot in same area with no yellow pigment

Image:


Notes:

With yellow: no As beta peak yes to all of Pb L peaks
Same but with trace Cr, Mn, Ti.

No yellow: less Si and Al? Cr seems to have disappeared, Pb M still there

proforma_29

Fuentes
Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 3/7/13
Proforma #: 30

Part: arm band
Fowler accession #: X69.300 C

Method of analysis: XRF
No filter, 40kV, 1.9mA, vacuum

Description of area: bead with unusual dark red and black, opaque appearance

Purpose of sampling: to evaluate elemental composition of bead and determine is made from bone or substitute material

Image:

Notes:

Definitely Hg, see spectrum

No visual indication this bead is bone, appears to be substitute material

proforma_30

Fuentes
Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/11/13
Proforma #: 31

Part: crown
Fowler accession #: X69.300 B

Method of analysis: Protein micro-chemical spot test (Biuret test)
Reagents: 2% aq sln $CuSO_4$ (w/v), 1.2 M NaOH aq sln (Odegaard Carrol Zimmt 2005 [2000])

Description of area: reverse of crown component where cancellous bone is exposed, under microscope appears porous with dark brown/black soft material within pores; this material is mobile; bone is not polished in this area, rough, matte texture

Purpose of sampling: to determine the nature of the soft material within pores and confirm biomatter residue

Image:

Notes: dark brown/black material is highly mobile, very small particles (<.5mm) are separated from the object with movement or handling; hypothesis is that it is residual from processing/production

Measured against rabbit skin glue as known positive (7.5 % w/v sln in DI water)

Sample taken by sweeping area with synthetic bristle brush

Microscopic inspection of particles (45x) reveals some light red-brown, translucent pieces as well, smaller pieces; also larger dark brown masses have white crystals emerging from surface (some salt content, activity as well?)

Known positive is good

Results are inconclusive; some proteins present (purple seen in smaller phases of sample) but other, larger pieces mostly fell apart/started to solubilize in solution, pieces on edges (less liquid) are purple

proforma_31

Fuentes
Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/11/13
Proforma #: 32

Part: crown
Fowler accession #: X69.300 B

Method of analysis: test using CaO (s) and pyrolysis, colorpHast pH strip (Odegaard Carrol Zimmt 2005 [2000])
Determines presence of amine

Description of area: reverse of crown component where cancellous bone is exposed, under microscope appears porous with dark brown/black soft material within pores; this material is mobile; bone is not polished in this area, rough, matte texture

Purpose of sampling: to determine the nature of the soft material within pores and confirm biomatter residue

Image:

Notes: dark brown/black material is highly mobile, very small particles (<.5mm) are separated from the object with movement or handling; hypothesis is that it is residual from processing/production

Measured against rabbit skin glue as known positive (7.5 % w/v sln in DI water)

Sample taken by sweeping area with synthetic bristle brush

Results are inconclusive; insufficient sample size

Might do some FTIR instead?

proforma_32

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/11/13 — Proforma #: 33

Part: apron	Fowler accession #: X69.300 A

Method of analysis: XRF-
1: no filter, 40kV, 1.9 mA, vacuum
2: red filter (Cu,Ti, Al), 40kV, 20mA, no vacuum

Description of area: skull with red pigment 2nd to far PR near bottom of apron

Purpose of sampling: to compare with data from adjacent skull at far PR (see proforma 17_XRF); this skull matches others in this line and appears part of this set where other skull at far PR appears differently

Image:

Notes:

1: both Hg and Pb present with trace Ni, Cu
2: confirmed Hg and Pb

Ca definitely present as well

proforma_33

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/11/13 — Proforma #: 34

Part: Apron	Fowler accession #: X69.300A

Method of analysis: XRF
red filter (Cu,Ti, Al), 40kV, 20mA, no vacuum

Description of area: yarn tassel at end of line of beads at top of apron, PR

Purpose of sampling: check for presence of lead or other heavy metals in cloth, looking for pesticide residues

Image:

Notes: Pb La and Lb are present, of similar intensity to Fe (with red filter)

Yes possibly treated with pesticides at some point but will ask

proforma_34

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/15/13 — Proforma #: 35

Part: Apron	Fowler accession #: X69.300A

Method of analysis: PLM, transmitted light

Description of area: tassel on far PL beneath top row where plaques are missing; clumps of three tassels; tassel is brownish-grey in color with lighter white-grey tied around

Purpose of sampling: to determine type of fiber used for construction of tassels

Image:

Notes:

Brownish grey: under crossed polar bright blue birefringence every 90 degrees; marks are fairly large, smooth, widely spaced and mostly perpendicular to axis of growth
Z-twist, single ply

White-grey: mixture of two fiber types; some fibers much smaller, flatter; more like flattened tube; marks and birefringence on larger fibers; no scales/marks on smaller fibers; under crossed polars can definitely see different birefringence (bright blue, pink central component) and marks of larger fibers: two fibers are closely associated in material; Z-twist, 2-S ply
Could also be contamination?

proforma_35

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/15/13 — Proforma #: 36

Part: Apron	Fowler accession #: X69.300A

Method of analysis: PLM, transmitted light

Description of area: knot of yarns emerging from face of top PR-most element of apron
String is: Z-twist, 6-S-ply

Purpose of sampling: to determine type of fiber used for construction

Image:

Notes:

Smaller, flatten tube-like fibers with birefringent scaled/regular intervals on larger fibers; no markings at 200x; straight, not much twisting in large fibers; dark, consistent central component

proforma_36

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/18/13 — Proforma #: 37

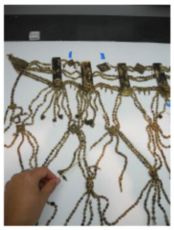
Part: Apron — Fowler accession #: X69.300A

Method of analysis: PLM, transmitted light

Description of area: yarn connecting beads in apron lattice; white (dirty off white); S twist, 2-Z ply

Purpose of sampling: to determine type of fiber used for construction

Image:



Notes:

Regular interval markings perpendicular like others; regular intervals with strong central component, very straight; birefringence is alternating yellow and pink/blue in regular intervals; looks like loose spiral?;

At 200x, very straight though; also some cotton?

At 500x, central line parallel to axis, starting to look very hemp like; having trouble getting an exposure at this magnification

proforma_37

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/20/13 — Proforma #: 38

Part: Ornament (horse) — Fowler accession #: X69.300D

Method of analysis: PLM, transmitted light

Description of area: tassel at the end of the section with piece of woven material (brown) and colored yarns; yarns are pink/red, brown and black; all are single ply Z twist, loosely twined together to make multi-colored yarn/ tassel

Purpose of sampling: to determine type of fiber used for construction of pink/red, brown, and black yarns

Image:

Notes:

black: Same perpendicular markings; no extinction, birefringence primarily blue with slight, loose spiraling of blue/ multicolored sections; (also blue from dye?); central articulation (medulla-like) is evident in 500x mag; (can't take photo because I need a new cover slip)

Brown (which may be faded pink/red): center line parallel axis is evident; as a irregular perpendicular marks; birefringence is primarily yellow with blue and pink; no extinction though flickering; crossing marks very close, forming x's; transparent in plane polarized light (slightly grey)

Pink/red: mix; some look flattened tube or just flat, mostly white in crossed polars, little birefringence;
also the fiber with perpendicular marks, looks blue in crossed; no extinction but same alternation between yellow and blue areas of birefringence; those with cross markings are transparent in plane polarized; too indistinct to photograph at 500x

proforma_38

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/20/13 — Proforma #: 39

Part: Unassigned fragment — Fowler #: X69.300 F

Method of analysis: PLM, transmitted light

Description of area: cordage attached to fragment of beads with blue color; coarser than other fibers, resembles hemp or flax at macro level, single ply S-twist

Purpose of sampling: to determine type of fiber used for construction

Image:

Notes:

Has irregular, frequent cross markings much like hemp; extinction at every 90 degrees
Compare PMG with cross polars and extinction to similar in reference; hemp is v. Likely

Has strong central channel (pink) like other material

proforma_39

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 4/20/13 — Proforma #: 40

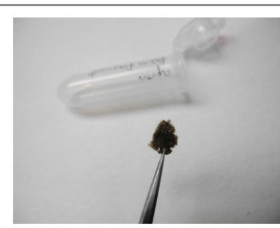
Part: Apron — Fowler #: X69.300 A

Method of analysis: PLM, transmitted light

Description of area: fabric fragment detached from apron in handling; has three colored parts- brown, blue and white; fabric is plain-woven- stitched together

Purpose of sampling: to determine type of fiber used for construction on brown part only

Image:



Notes:

Pink with bright yellow periodic (every 90 degrees)- no extinction?
Consistent perpendicular marks and blue birefringence with polars crossed

linear element; cross hatchings are more irregular and closely spaced than other unidentified bast fiber

proforma_40

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/2/13 — Proforma #: 41

Part: ornament	Fowler accession #: X69.300 G
Method of analysis: XRD, PLM, MCT	
Description of area: Reverse of central element in unidentified ornament section; material is hard, dense, shiny and orange-brown in color (vs. Off white of most other substrate material); this section has white deposit or efflorescent on both obverse and reverse but more evident on reverse; substrate material is matte and slightly greyish in this area	
Purpose of sampling: to determine mineral composition of white deposit/efflorescence	

Image:

Notes:

White material is crystalline under microscope with shells (similar in appearance to akaganeite where mineral is pcpt'd in solution and liquid evaporates); see PMGs for visual documentation of this

Material is very powdery- PLM will also be used to examine phases

PLM: phase one: crossed: appears translucent white and yellow, brown; wave-like partial extinction as stage is rotated; plane appears dark, high relief; poorly formed crystals, soft shapes with undetermined structure

Phase two: opaque dark brown particulate, not crystalline

2nd dispersion sample with more sample in there: still poorly formed and blurry crystals, some phases of thin, short, whisker looking crystals as well

proforma_41

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/2/13 — Proforma #: 42

Part: ornament	Fowler accession #: X69.300 D
Method of analysis: XRD	
Description of area: pink deposit on central element (with image of carved horse); pink deposit is on the edge of the plaque, seemingly deposited randomly; pink color looks a combination of red and beige material;	
Purpose of sampling: to determine mineral composition of pink deposit	

Image:

Notes:

Material is powdery, thin layer on surface; powder is not uniformly shaped; possible organic component (somewhat stringy, irregular shape)

proforma_42

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/2/13 — Proforma #: 43

Part: arm band	Fowler accession #: X69.300 C
Method of analysis: XRD, PLM, FTIR	
Description of area: yellow deposit on side 'face' plaque; towards edge of plaque and randomly deposited; yellow (ochre in color) with no priming layer or other pigments in immediate region	
Purpose of sampling: to determine mineral composition of yellow deposit (XRD and PLM); to determine whether there is a proteinaceous binder in the deposit of pigment (paint vs. Pigment)	

Image:

Notes:

Material is powdery; thin layer; not strongly adhered to surface; suspect no binder present

PLM- phase one: medium-low relief (complicated by closely associated yellow-brown material), translucent in plane polars, RI is slightly less than medium; (PMG), full extinction every 90 degrees; colorless in plane and cross polars,

Phase two: dark brown opaque particles, not crystalline

Pigment compendium notes that barite is found in association with a variety of ores

proforma_43

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/2/13 — Proforma #: 44

Part: ornament	Fowler accession #: X69.300 E
Method of analysis: XRD	
Description of area: green deposit on x-wing ornament; forest green color, thinly applied to surface; fairly coherent and lighter green (seafoam color) where disturbed by sampling; color does not correspond to carved image	
Purpose of sampling: to determine mineral composition of green material	

Image:

Notes:

Maybe combination of indigo and other but XRD indicates Cu

proforma_44

Appendix H: Proformas

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/2/13 | Proforma #: 45

Part: crown	Fowler accession #: X69.300 B

Method of analysis: pyrolysis, FTIR, micro-solubility testing

Description of area: beige-brown deposit on obverse of central plaque, color similar to that of substrate; fairly well-adhered to surface and coherent (comes off in pieces, less powdery than other samples); color is uniform throughout material though slightly darker at top of layer; material is worked into areas of depression, crevices

Purpose of sampling: to determine composition of brownish material

Image:

Notes:

Pyrolysis: clearly organic, burned very quickly with little ash left behind

Material is beige with spots of darker brown, particularly in raised areas

Micro-solubility test showed some part is soluble in warm DI water, another is very very slightly soluble in acetone Used colophony and gum arabic as known positives; indicates potential presence of gums and small amount (possibly) of tree resin;

proforma_45

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13 | Proforma #: 46

Part: crown	Fowler accession #: X69.300 B

Method of analysis: XRD (2x)

Description of area: end component of crown with decorative motif (no skull); bright orange material (also occurs on skull 2nd to PR of apron top plaques, there over yellow); randomly deposited within crevice; peach material nearby maybe similar material but is dull peach in color; both color deposits are opaque though thin

Purpose of sampling: to determine composition of bright orange material (A) in relation to adjacent peach colored material (B)

Image:


Notes:

A- fine powder, easily dislodged from substrate, color consistent throughout material layers

B- came off in flakes, more difficult to separate from substrate

proforma_46

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13 | Proforma #: 47

Part: crown	Fowler accession #: X69.300 B

Method of analysis: pyrolysis, FTIR

Description of area: central component of crown, obverse of skull face; black brown, compact layer of material

Purpose of sampling: to determine composition of black-brown material

Image:

Notes:

Material comes clean of bone substrate easily; lighter brown where disturbed

Pyrolysis: smell confirms burning protein, organic material

proforma_47

Fuentes | Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13 | Proforma #: 48

Part: crown	Fowler accession #: X69.300 B

Method of analysis: pyrolysis, FTIR

Description of area: dark pink area on center obverse of broken skull component; matte, surrounding area is pink with beige intermixed

Purpose of sampling: to determine composition of dark pink material; whether it has organic component as well as mineral

Image:

Notes:

Color is consistent throughout layers of material; somewhat well adhered to substrate

Pyrolysis confirms burning protein, material is combusted

proforma_48

Appendix H: Proformas

Fuentes

Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13

Proforma #: 49

Part: crown

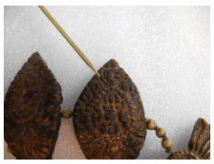
Fowler accession #: X69.300 B

Method of analysis: XRD

Description of area: bright peach at top of PL-most skull plaque; plaque also has intermingled beige, pink, and yellow residues, generally worked into carved crevices and depressions; also black on surface (consistent with appearance of substrate elsewhere); deposits are randomly distributed

Purpose of sampling: to determine mineral composition of peach material

Image:



Notes:

Well-adhered to surface, color consistent throughout layers

proforma_49

Fuentes

Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13

Proforma #: 50

Part: apron

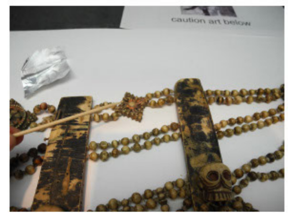
Fowler accession #: X69.300 A

Method of analysis: pyrolysis, XRD

Description of area: light peach at top apron on carved decorative element towards PL of top; light peach is deposited in crevices of carved surface, consistent color throughout

Purpose of sampling: to determine mineral composition of peach material

Image:



Notes:

Well-adhered to surface, color consistent throughout layers

Pyrolysis indicates some organic content; FTIR will be used to determine if organic content here is similar to that of other sampled areas

During sampling for XRD it was noticed that there were black phases in the pink material; these were isolated and run separately

proforma_50

Fuentes

Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13

Proforma #: 51

Part: apron

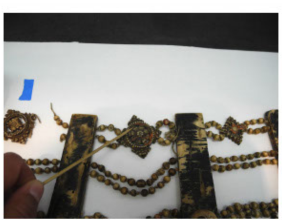
Fowler accession #: X69.300 A

Method of analysis: XRD

Description of area: peach color (slightly darker, resembles peach on surface of crown obverse); yellow deposits adjacent; randomly deposited on surface, not corresponding to carved design

Purpose of sampling: to determine mineral composition of peach material

Image:



Notes:

Difficult to sample; very well adhered to surface but comes off as a fine powder

proforma_51

Fuentes

Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13

Proforma #: 52

Part: apron

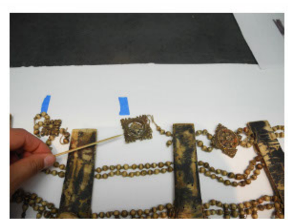
Fowler accession #: X69.300 A

Method of analysis: pyrolysis, XRD

Description of area: white-beige color on ornament not in original position along top of apron; material is very powdery and poorly adhered

Purpose of sampling: to determine composition of white beige material

Image:



Notes:

Pyrolysis: inconclusive, material turns grey when heated but does not combust

During mounting for XRD it was noticed there were small red/pink particles in with the beige; like most samples, the materials do not seem to be well-refined or processed

proforma_52

Appendix H: Proformas

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 5/8/13 — Proforma #: 53

Part: apron	Fowler accession #: X69.300 A

Method of analysis: XRD

Description of area: two PR-most skulls along bottom of apron (see corresponding XRF sampling); both have red pigment in eye sockets and other crevices; color on that farthest to the side is paler, no grey or black- rendering on this skull is different

Purpose of sampling: to compare composition of red pigments on each of two skulls

A- paler, skull farthest towards edge with different carving style
B- skull consistent with appearance of all other similarly sized skulls on object/apron

Image:

Notes:

A- material is much brighter where it has been disturbed by sampling

B- somewhat brighter where disturbed, grey areas adjacent; layer is thin, well-adhered to substrate

proforma_53

Fuentes — Fowler X69.300 A-J: Himalayan ritual bone ornament assemblage

Date: 6/8/13 — Proforma #: 54

Part: ornament (with horse)	Fowler accession #: X69.300???

Method of analysis: flame test

Description of area: reverse of bone plaque; area has evidence of red lac stain as well as black deposit over and intermixed with red lac layer; tiny white spots over black and red layers

Purpose of sampling: to determine nature of material

Image:

Notes:

With flame test seems to have melted partially and deposited waxy layer on glass slide, under 3D MS looks remarkably waxy and is definitely not crystalline (PLM)

Tried to determine melting temp with MS and hot stage but was unsuccessful; took image, was finely particulate at 200x.

Not enough sample to conduct extensive testing or run FTIR;

Was very crumbly and waxy in manipulation with steel tools under magnification

proforma_54

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