AN INVESTIGATION OF THE METALLIC DECORATION IN EIGHTEENTH CENTURY AMERICAN JAPANNING

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Abstract

The goal of this project is to investigate the types of metals used in the decoration of American japanned furniture. Several different analytical techniques were examined to identify whether the metal is a paint, powder, or leaf, and to determine the composition of the metal. In preparation for the analysis, x-ray fluorescence and scanning electron microscopy with energy dispersive x-ray spectrometry were evaluated for their usefulness in characterizing the metals. Finish samples from nine japanned high chests were first mounted and examined with ultraviolet and normal light microscopy and then with energy dispersive x-ray spectrometry. The results of these experiments were compared to the decorative processes described in the existing japanning and varnishing handbooks from the seventeenth and eighteenth centuries.

Introduction

"Japanning" on furniture is a decorative technique derived from the Japanese lacquer panels imported into Europe through the Portuguese and Dutch trade beginning early in the seventeenth century, and later by the British East India Company. The popularity of oriental goods was on the rise when direct trade with Japan was halted with all but the Dutch East India Company in 1639. Europeans had already become used to this new market of exotic goods from the East creating a style known as chinoiserie. As trade with the east became more restricted, true japanese lacquer became increasingly difficult to buy.

The lacquer which is used to decorate the japanese panels derives from the sap of the *Rhus vemiciflua*, a tree which grows only in Japan, Korea and China. Other *Rhus* spp. are found in areas in southeast Asia which produce lacquer as well. The raw lacquer deteriorates quickly when exposed to air so that it is extremely difficult to ship long distances. It is also very irritating to the skin. European craftsmen developed "japanning" using varnishes, paints and other materials commonly available in an attempt to imitate the design and the depth of the true lacquer surfaces.

This type of decoration was particularly popular in America in the Boston area from as early as 1690 to as late as the third quarter of the eighteenth century. Early pieces of japanned furniture were imported from England. Boston was particularly receptive to this new fashion in furniture because of its commercial growth in the late seventeenth century, a time when chinoiserie was popular in London. Since Boston's economy was grounded in trade, shipping activities brought goods from London to Boston, and Boston dispersed goods to the other colonial ports. Boston also supported a substantial export business in furniture. Between 1725 and 1760, there were no less than 224 documented craftsmen working in the furniture industry. Of these, at least 13 were japanners.[2] The only other city in which a japanner has been documented is New York City.[3] Of the 13 Boston japanners, only three have signed their works: Thomas Johnston signed a flat-topped, 6-legged high chest presently owned by the Adams National Historic Site in Quincy, Massachusetts, and both William Randle and Robert Davis, Jr. signed a flat-topped, cabriole-legged high chest now in the Baltimore Museum of Art.

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[2] Brock Jobe, "The Boston Furniture Industry, 1720 - 1740," in *Boston Furniture of the Eighteenth Century*, Walter Muir Whitehall, ed. (Boston: Colonial Society of Massachusetts, 1974) pp.4-11.

[3] Dean Fales, Jr., *American Painted Furniture*, 1660-1880 (New York: E. P. Dutton and Co., Inc., 1972) p. 61.

The technique used by American japanners consists of a wood substrate (usually maple for the drawer fronts and a softwood for the rest of the case), a ground layer, a layer of background paint, a layer of clear resin, more layers of background paint, more layers of clear resin and resin based toners. The pictorial image was produced with metallic powders, paints, and leafs. Pigmented paints were not normally used. Occasionally, gray tones appear in the design, but these are likely to be tin or silver powder rather than a black, pigmented paint. The design was created with both flat and raised elements. The raised figures were built-up with a gesso putty, which was then gilded. The gesso putty was applied on top of the background, after the clear resin but before the toning layers were added. The gilding was applied with oil size and sealed with a clear resin. The toning layers were applied last. The metal was never intended to be left bare. The process can vary and can include many more layers than are mentioned here. It differs somewhat from the structure that is described by the English recipe handbooks such as John Stalker and George Parker's *A Treatise of Japanning and Varnishing* which was published in Oxford in 1688. The process for American japanning is based on the recent examination by conservators of several American high chests, and is simpler than the technique. Stalker and Parker recommend. No handbook has ever been found that describes American practices; however, copies of Stalker and Parker's *Treatise* existed in cabinetmaking shops in America. There were other handbooks published in London that contained information on japanning, including William Salmon's *Polygraphice* (1685, London) which consists of many volumes. The only direct connection that remains to the materials used by American japanners is Thomas Johnston's probate inventories. However, those materials listed are common to any painter or varnisher of the period.[4]

Stalker and Parker's *Treatise* contains an extensive list of metals used to create the flat and raised images. These include gold and silver (in leaf and powder form), "brass dust" which was also called "gold dust," "green-gold," "dirty-gold," "powder-tinn," and various types of "coppers."[5] This variety of metals suggests that different metals were used for their variation in color, not simply as a substitute for gold.

The variety of colors in the metals used in European japanning is visually obvious. In comparison, the metals used in American japanning appear to be more uniform. However, the condition of the majority of the japanned objects made in America is less than ideal. Many of them have undergone extensive restorations in order to save the fragile surfaces. The subtleties of the designs and the colors of the different metals have often become obscured by overpaint and overgilding, darkened varnishes and consolidation treatments. Fortunately, most of these treatments have been additive. In other words, much of the design remains underneath, even though its condition may be less than satisfactory.

To date, there has been no published technical examination of japanning on furniture. There has been some research done on the lives of the japanners by Hitchings (1973, 1974) and Randall (1974). There has been an attempt to link many of the objects together based on design similarities, and many authors have included japanning in their surveys of furniture: Fales (1972), Hecksher (1985), and Fairbanks (1981). The only attempt at an examination of technique can be credited to Hill (1976) although his analyses tend to rely more on similarities in design than to the use of materials.

This investigation has several goals. The first is to examine different analytical methods that can be used to characterize metals used in the decoration of furniture. The second is to test these methods to determine the composition of the metals used in eighteenth century American japanning. The third is to compare this information to the metals that are described in the period handbooks.

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[4] Sinclair Hitchings, "Thomas Johnston," in *Boston Prints and Printmakers*, Walter Muir Whitehall, cd. (Boston: Colonial Society of Massachusetts, 1973), pp. 126-128.

[5] John Stalker and George Parker, *A Treatise of Japanning and Varnishing* (Oxford, 1688: reprint, London: Alec Tiranti Ltd., 1971), pp. 5-6.

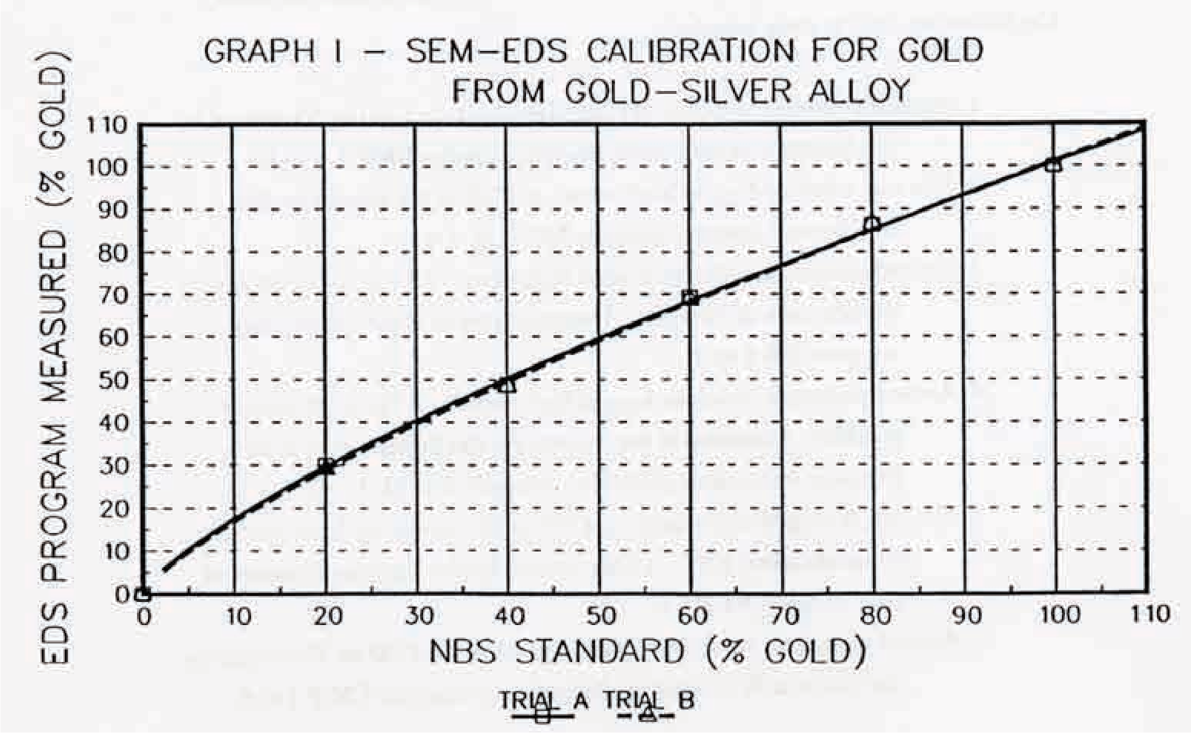
Procedure

A. Analytical Techniques

Before beginning to sample the japanned high chests, two different analytical procedures were tested, x-ray fluorescence (XRF) and scanning electron microscopy with energy dispersive x-ray spectrometry (SEM-EDS). The use of normal and ultraviolet light microscopy to characterize the metals used in furniture decoration has already been discussed by Bernstein (1991).

Samples of oil-gilded gold leafs of known composition on birch veneer were examined using XRF: 23.75K, 23K, 22.5K and 21.5K. One inch square birch veneers were sealed first with glue and then shellacked. Oil size was applied and then the leaf. The leafs were coated with another layer of shellac. The XRF system consists of a United Scientific DuBois object analyzer with a molybdenom x.,.ray tube, operated at 40 kV and 0.13 mA and a Tracor Northern energy dispersive detector attached to a TN-5502 x-ray analysis system. Spot sizes of approximately 0.5 to 1.0 cm were used. Spectra were acquired for a live time of 180 seconds. In all but one case, the XRF procedure was unable to detect the alloying metals. In the 21.5K leaf, silver was detected only as a trace. The thickness of the shellac coating and the thinness of the metal, 0.5 to 0.8 microns, were believed to be the sources of this difficulty. Because of these limitations, this XRF procedure was not considered to be an appropriate method for analyzing the samples taken from the high chests.

Following the XRF tests, samples of the prepared oil-gilded leafs and standards were prepared for examination with SEM-EDS. The instrument used was a JEOL JXA-840A Scanning Electron Microscope (SEM) with a Tracor Nort1)ern Microtrace energy dispersive spectrometer (EDS) and Tn-5502 x-ray analysis system. Elemental spectra were obtained at 20 kV for a 120-second live-time acquisition. Gold-silver alloy wires, brass and bronze standards from the National Bureau of Standards were prepared for calibration of the instrument. The standards were mounted in Bio-Plastic polyester resin and polished in water with 600 grit sandpaper followed by 0.5 micron microalumina powder. The mounted samples were coated with carbon before analysis. Two sites on each sample were analyzed, and the percentages of the elements found were determined using the Tracor Northern normalized standardless semi-quantitative program. This program uses raw data (as shown in the EDS spectra) and applies a ZAF correction to it.



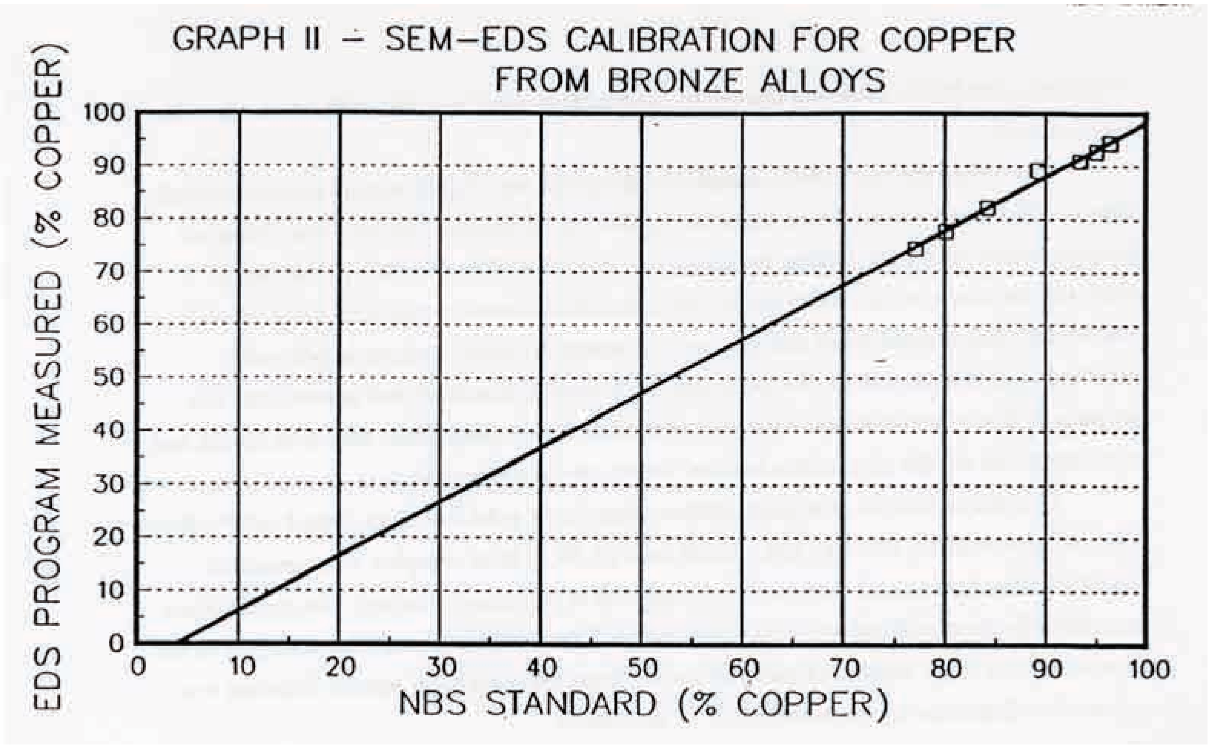
The data was plotted against the values reported by the National Bureau of Standards to determine the calibration curve for each element.

Following the calibration. samples of the prepared oil-gilded leafs were examined. The samples were prepared two ways. In the first set of samples, the leaf was extracted from the resin matrix by soaking in ethanol for one hour. These extracted leafs were mounted on a carbon stub with double-sided, conductive carbon tape and analyzed with SEM-EDS. The second set of samples were mounted as cross-sections in polyester, polished, and carbon-coated. For both sets. each sample was analyzed at two sites. The purpose of this was to detennine the ease of extracting the metal from the finish matrix and to compare the results of an extracted leaf versus one in cross-section in its resin matrix.

In order to test the procedure further, samples of gold leaf from Sepp Leaf Products were analyzed: 24K, 23.75K. 23K, 22.5K and 21.5K. These samples were mounted directly onto a carbon stub and each was analyzed at two sites as before. The results were compared to the specifications reported by Sepp. These leafs were used as examples of an ideal sample, a large amount of metal extracted from the resin layer matrix. This test was repeated to determine the reproducibility of the results.

After the method was tested and the SEM-EDS was calibrated, samples from objects were taken and mounted in polyester as cross-sections as described previously. The following objects were sampled:

1. Arched-pediment, cabriole-legged high chest - c.1740 to 50; owned by the Museum of Fine Arts, Boston; samples BMFA 1 to 8.
2. Flat-top, cabriole-legged high chest - c.1720 to 40; owned by the Shelburne Museum; samples HC A,B, 1-6.
3. Arched-pediment, cabriole-legged high chest - c.1740 to 50; owned by the Museum of Fine Arts, Houston (Bayou Bend Collection); samples BB 1 to 7.
4. Arched-pediment, cabriole-legged high chest - c.1733 to 45 owned privately, examined at the Society for the Preservation of New England Antiquities (SPNEA); samples P F, O, 1 - 6.
5. Flat-top, 6-legged high chest - c.1710 to 30, signed by John Scottow (cabinetmaker, 1701 - 1790);



owned by the Virginia Museum of Art; samples 91.8.1 to .17.

6. Arched-pediment, cabriole-legged high chest - c.1740 to 50; owned by the Colonial Williamsburg Foundation; samples CWF 1 to 6.
7. Rat-topped, cabriole-legged high chest - c.1720 to 1740; owned by the Winterthur Museum; samples 52.255.1 to .25.
8. Arched-pediment, cabriole-legged high chest - c.1740 to 50, signed by John Pimm (cabinetmaker); owned by the Winterthur Museum; samples HP 1 to 6.
9. Rat-top, cabriole-legged high chest - c. 1730, signed by William Randle and Robert Davis, Jr. (japanners); owned by the Baltimore Museum of Art, samples B 1 to 4.
10. Secretary cabinet - c.1690; owned by the Frick Art Museum (Pittsburgh, PA), examined at Deborah Bigelow and Associates.

Nine high chests and one secretary cabinet were sampled. All but the secretary cabinet, owned by the Frick Art Museum, are known to be American. The secretary cabinet, which is English, was used as model for a non-AmeriCan example. Characteristic areas on each high chest were sampled: the cornice molding, waist molding, stringing around the drawer fronts, flat design on the drawer fronts, raised design on the drawer fronts, flat design on the side of the high chests, and raised design on the sides of the high chests. The number of samples taken from each high chest varied depending on the ease in sampling the surfaces and on the number of samples and the areas that each institution allowed to be taken. An average of 8 samples was taken from each high chest.

After mounting, each cross-section was examined using normal and ultraviolet light microscopy. The microscope is a Leitz Laborlux 12 POL S. The reflected, normal light source was a Reichert-Jung fiber optic unit. The ultraviolet light was provided by an ultra-high-pressure, .100W mercury lamp. A Leitz A Cube was used to achieve a band pass of 340-380 nm with a suppression filter at 430 nm. The microscopy was used to determine the number of metal layers present in each cross-section and the type of metal used in each layer, i.e. leaf, powder (particulate or plate-like) or paint. A powder is defined as metal particles that lie on the surface of a resin layer. A paint contains metal particles suspended in the matrix of the medium, which is usually a natural resin. The particles appear randomly throughout the resin layer. The configuration of the whole layered structure, the metal layers as well as resin and paint layers, of the decoration was also determined. Each sample was photographed using Fujichrome Velvia slide film (ASA 5O).

Following microscopy, each sample containing metal was coated with carbon and analyzed using SEM-EDS.

Results

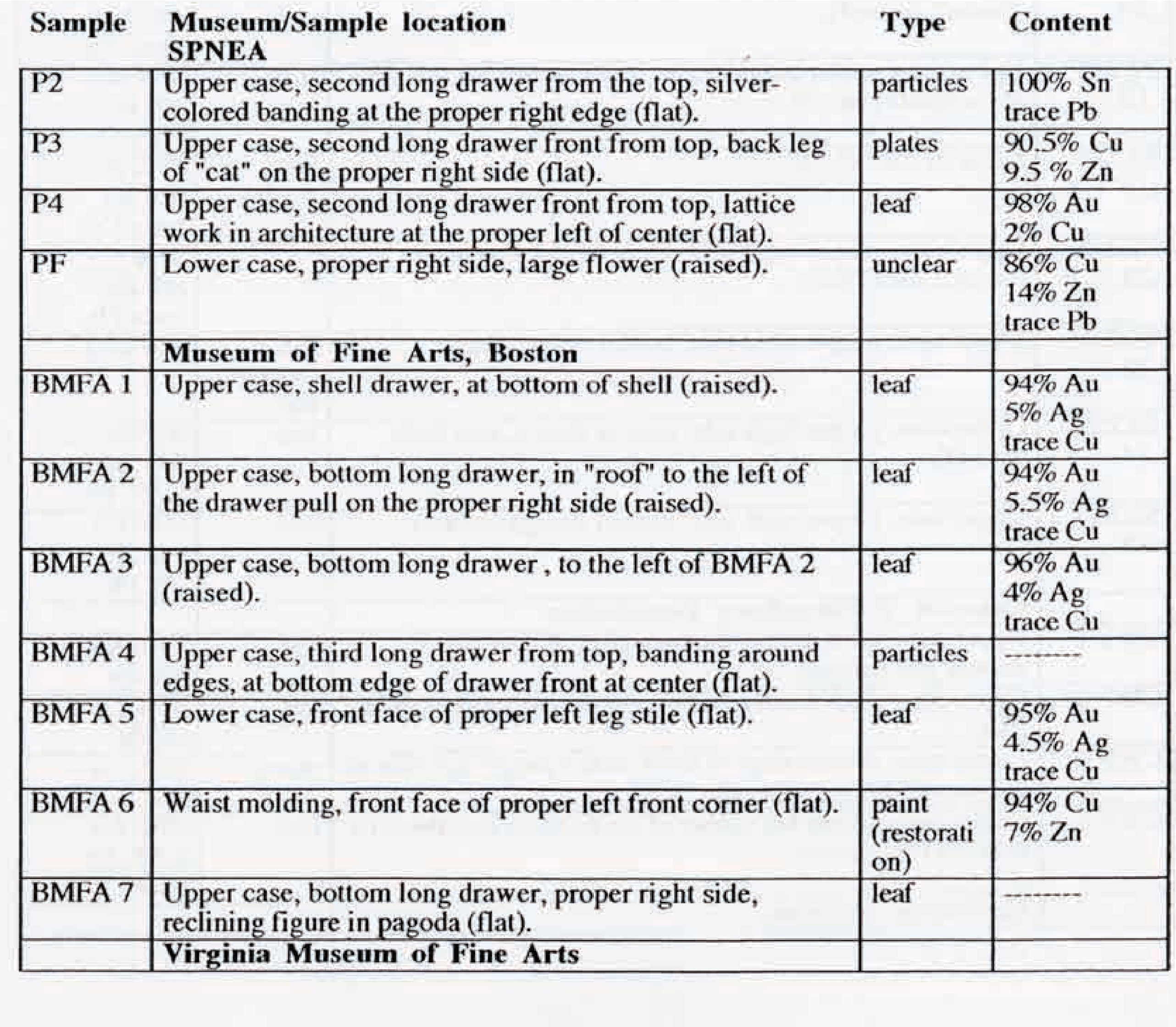
A. Microscopy

In most cases, normal light microscopy was sufficient for identifying the physical nature of the metal. A leaf appeared as a thin line. A powder appeared as a broken line on top of a resin layer. The powders have two distinct configurations, as flat, plate-like particles, or as more spherical particles. In a few cases, the form of metal was unclear. Some leafs which are thicker, or which appear wrinkled look very similar to a densely applied, particulate powder and vice versa. Most of the time, the image produced by the scanning electron microscope was able to clarify the difference. This is because the SEM produces an image of only the surface of the sample without the interference of particles lying underneath the surface of the mounting medium. In light microscopy, reflections from particles which lie below the surface of the mounting medium may obscure the shape of the metal particles. The metal found in sample PF from the high chest at SPNFA remains unclear.

Most samples contained a leaf or a powder. The use of a metal paint was rare. A paint is distinguished from a powder by the orientation of the particles in cross-section. Powder particles generally lie on top of a resin layer, more or less in a line. In a paint, the particles are suspended within the matrix of the resin layer. A modern metallic paint was found in a restored area from sample BMFA 6 from the high chest at the Museum of Fine Arts, Boston. A metallic paint was also used in the original decoration in samples taken from the high chest at the Virginia Museum of Fine Arts. This was an unusual paint. It appears to be plate-like particles in a green-colored resin, very likely the use of verdigris. This was found in samples 91.8.1, .2, .8, and .11. See Table I for the results for each sample that contains metal.

In general, the metals used for restoration are distinguished only by their position in the layers of the cross-section. Their morphology does not appear any differently than the metal used in the original metal layer. The sequence of layers in the cross-section is critical in identifying the metal as original or restoration.

TABLE I - COMPOSITION AND TYPE OF METAL IN EACH SAMPLE



Sample	Museum/Sample location	Type	Content
	SPNEA		
P2	Upper case, second long drawer from the top, silver-colored banding at the proper right edge (flat).	particles	100% Sn trace Pb
P3	Upper case, second long drawer front from top, back leg of "cat" on the proper right side (flat).	plates	90.5% Cu 9.5 % Zn
P4	Upper case, second long drawer front from top, lattice work in architecture at the proper left of center (flat).	leaf	98% Au 2% Cu
PF	Lower case, proper right side, large flower (raised).	unclear	86% Cu 14% Zn trace Pb
	Museum of Fine Arts, Boston		
BMFA 1	Upper case, shell drawer, at bottom of shell (raised).	leaf	94% Au 5% Ag trace Cu
BMFA 2	Upper case, bottom long drawer, in "roof" to the left of the drawer pull on the proper right side (raised).	leaf	94% Au 5.5% Ag trace Cu
BMFA 3	Upper case, bottom long drawer , to the left of BMFA 2 (raised).	leaf	96% Au 4% Ag trace Cu
BMFA 4	Upper case, third long drawer from top, banding around edges, at bottom edge of drawer front at center (flat).	particles	--------
BMFA 5	Lower case, front face of proper left leg stile (flat).	leaf	95% Au 4.5% Ag trace Cu
BMFA 6	Waist molding, front face of proper left front corner (flat).	paint (restoration)	94% Cu 7% Zn
BMFA 7	Upper case, bottom long drawer, proper right side, reclining figure in pagoda (flat).	leaf	--------
	Virginia Museum of Fine Arts		

91.8.1	Lower case, proper right side, bottom edge of skirt towards the front (flat).	plates	91% Cu 9% Zn trace Pb, Sn
91.8.2	Same as 91.8.1.	plates	91% Cu 9% Zn
91.8.5	Proper left front leg at corner, gilded collar at top of facets on leg (flat).	leaf	95% Au 3% Ag 2% Cu
91.8.7	Proper left front leg, gilded collar at top of facets on leg (flat).	leaf	87.5% Cu 14% Zn
91.8.8	Upper case, proper left side, cornice molding at the back edge, second molding from the top (flat).	paint	96% Cu 5.5% Zn
91.8.11	Upper case, just below cornice molding, above proper right drawer (flat).	paint	92% Cu 8% Zn
91.8.12	Upper case, top long drawer, proper right side, raised decoration above architecture (raised).	leaf	93% Au 7% Ag trace Cu
	Winterthur Museum - Cecil Bedroom		
52.255 .14	Upper case, top long drawer, proper left side, in the "fence", (raised).	leaf	94% Au 5% Ag trace Cu
52.255 .15	Upper case, center long drawer, flower group on left side of lockplate (raised).	leaf	93% Au 7% Ag trace Cu
52.255 .16	Same as 52.255.15.	leaf	97% Au 3% Ag trace Cu
52.255 .21	Upper case, proper right side, inner border line at top, towards back (flat).		92% Cu 8% Zn trace Pb
52.255 .23	Upper case, proper right side, border at top (flat).	leaf (restoration)	100% Al
52.255 .24	Upper case, proper right side, central design, tree limb (raised).	leaf	92.5% Cu 5% Zn 2.5% Pb
52.255 .25	Upper case, proper right side, central design (raised).	leaf	88% Cu 9% Zn 3% Pb
	Colonial Williamsburg Foundation		
CWF 1	Upper case, shell drawer, bottom of shell, just above drawer pull (raised).	leaf	97% Au 3% Cu
CWF 2	Upper case, shell drawer, bottom edge on drawer molding (flat).	leaf	91% Cu 9%Zn
CWF 3	Lower case, bottom edge of front, to the proper left side of the central drops on the skirt (flat).	plates	92% Cu 8% Zn
CWF 6	Lower case, proper left corner of the front face of the skirt, near the leg (raised).	leaf	97% Au 2.5% Ag trace Cu
	Shelburne Museum		

HC 2	Upper case, cornice drawer, center (flat).	unclear	96% Au 2.5% Ag 1.5% Cu
HC 5	Upper case, top drawer on the proper right side, bottom left corner in flower petal (raised).	leaf	95% Au 5% Ag trace Cu
HC A	Upper case, second drawer from the bottom, proper right side, in leg of animal.	leaf	95.5% Au 3% Ag trace Cu
HC B	Same as HC A.	leaf	96% Au 4% Ag trace Cu
	Museum of Fine Arts, Houston - Bayou Bend		
BB 1	Upper case, proper right side, in "flowers" at the bottom corner towards the front (flat).	leaf	
BB 2	Upper case, proper right side, cornice molding in cove (flat).	leaf	100% Ag trace Cu, Pb
BB 3	Upper case, bottom long drawer, proper right side from the face of the "bird" to the left of the drawer pull (raised).	leaf	96% Au 3% Ag trace Cu
BB 4	Upper case, bottom long drawer, dark banding along bottom edge (flat).	particles	100% Ag
BB 5	Upper case, bottom long drawer, proper left side above the back of the "deer" (flat).	leaf	98% Au trace Ag, Cu
BB 7	Waist molding, front, center (flat).	leaf (restoration)	93% Au 5% Ag 2% Cu
	Winterthur Museum - Pimm Highboy		
HP 1	Pediment on upper case,proper left side in cove near the center (flat).	leaf	95% Au 3% Ag 2% Cu
HP 1A	same as HP 1.	leaf	97% Au 2.5% Ag trace Cu
HP 2	Upper case, shell drawer, carved garland to the proper right of center, bottom flower, (raised).	particles	96% Au 2.5% Ag 1.5% Cu
HP 3	Upper case, bottom long drawer, proper right side of center in "fence".	particles (lower) leaf (upper)	100% Sn trace Cu 95% Au 2.5% Ag trace Cu
HP 4	Upper case, bottom long drawer at proper left side, leaf under the drawer pull (flat).	leaf?	96% Au 2.5% Ag 1.5% Cu
HP 5	Pediment, proper left side in cove near corner (flat).	leaf?	96% Au 3% Ag trace Cu
	Baltimore Museum of Art		
B4	Upper case, center long drawer, from "dog."	leaf	98% Au 2% Cu
B5	Upper case, cornice drawer, proper left side towards the front (flat).	particles	97.5% Au trace Ag, Cu

* A trace is defined as 1% or less concentration.

found in the cross-sections. Semi-quantitative information was not always possible because of the contamination from neighboring layers. The results from the semi-quantitative program were adjusted based on the calibration graphs from the analysis of the standards from the National Bureau of Standards. The amount of each element found in the metals is reported in Table I.

The results are reported only to the nearest percent because of the amount of error that is inherent in dispersive x-ray analysis based on the type of sample analyzed. In addition, the composition of metal particles can vary considerably even though they were made from the same piece of metal. This is because the composition of an alloy may vary significantly throughout and only small areas can be sampled. Analysis of a one micron square area would not be a fair representation of the composition of all of the metal in the decorative layers unless it were possible to take many samples. This is not appropriate in most cases for the object.

Discussion

A. Analytical Methods

Light Microscopy

Light microscopy can often be used to identify the metal as a leaf, powder or paint. Light microscopy also provides critical information as to the context of the metal in the layer structure of the decorative surface. The position of the metal in the finish layers is as important as knowing the composition of the metal if the intent is to identify the technique used in the decoration. A reflected light source is normally all that is needed to find the metal layer. Manipulation of a fiber optic source produces the reflection of the metal which distinguishes it from a pigmented paint or a resin layer. The non-fluorescent property of metals in ultraviolet light can be used to clarify the position and physical configuration of the metal if it is surrounded by darkened resin layers. These resin layers will normally auto-fluoresce in contrast to the black of the metal.

Light microscopy alone cannot be used to identify the elemental content of the metal. Even the color of the metal in normal light under magnification can be deceptive. Often, most metals, including tin and silver, have a tendency to appear gold-colored in reflected light under the microscope. An indication of elemental composition can be obtained using light microscopy in conjunction with wet chemical spot testing. For example, 8-hydroxyquinoline, although not used in this study, has been used in the past to identify the presence of zinc in a metal layer. The presence of zinc indicates the use of a brass leaf, powder or paint.

The major limitation in the use of microscopy is the quality of the grinding. A flat, finely polished surface is critical for obtaining the optimum amount of information. A curved or scratched surface will produce deceptive results.

X-*ray Fluorescence*

As a non-destructive analytical technique, information about the composition of the metal can be obtained using XRF, however, the limitations of XRF are significant. The resin coatings that are frequently found on top of metallic designs, such as toners and protective varnishes, create a significant amount of background “noise” in the spectrum by scattering x-rays. In most cases, the background can obscure the identification of elements that are found in low percentages or render quantitative analysis difficult. For example, a 23K leaf alloyed with both copper and silver may be identified only as gold. The copper may be identified as a trace, but the silver may be obscured. The analysis is also restricted by the size of the beam from the energy source. The beam is approximately 0.5 to 1.0 cm in diameter. A site to be analyzed that is smaller than this will contain a significant amount of “contamination” and background making analysis difficult. Another limitation is the thinness and porosity of the metal layers and the orientation of the particles in the medium in the case of powders or paints.

XRF can be used if all that is needed is a general idea about the content of the metal. XRF will identify the major components of the metal, if it is gold or a copper alloy. It may not be able to distinguish between individual brasses and bronzes.

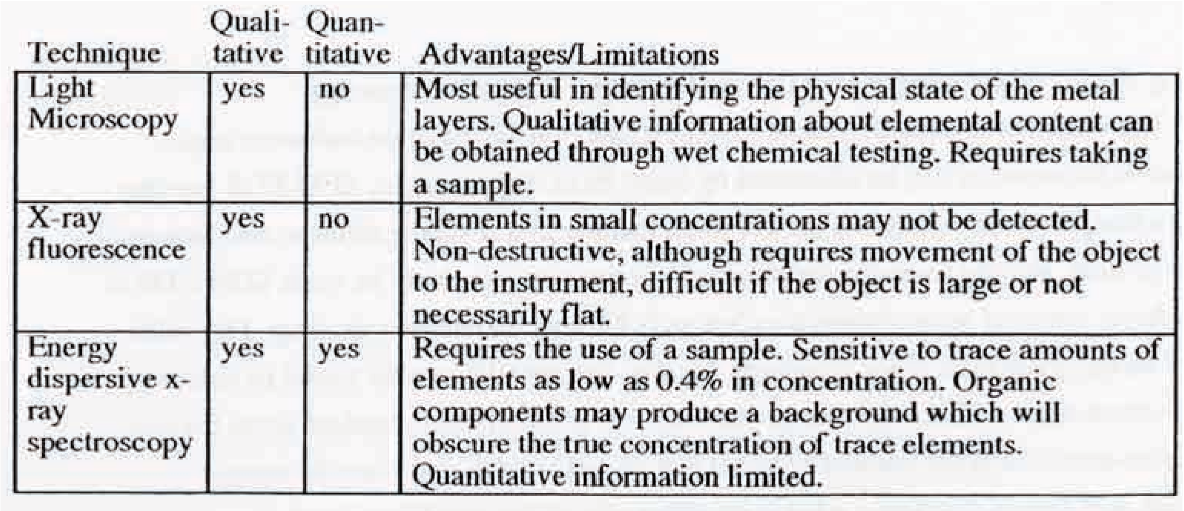
In general, large pieces of furniture are difficult to move around. Movement can cause significant damage, especially to fragile japanned surfaces. Although XRF is a non-destructive technique in terms of sample taking, it requires that the object be moved to the instrument. This may be unacceptable if the instrument is located far away. Taking a small sample, on the scale of a cross-section, may be a more logical analytical option and safer than transporting the object to the instrument. Portable XRF units are available, although there are limitations in their use as well. In this case, SEM-EDS becomes a more appropriate analytical procedure. Samples can be taken by one conservator, mounted in polyester, and sent to another conservator, or institution, with the instrumentation. This is much safer than sending a small drawer or another piece of the object to the facility which has XRF capabilities.

Scanning Electron Microscopy with Energy Dispersive X-*ray Spectroscopy*

The next step in obtaining more specific qualitative information and some semi-quantitative information can be addressed by SEM-EDS. By its nature, SEM-EDS requires placing a sample of the material in the vacuum chamber of a scanning electron microscope. A cross-section, already mounted for standard microscopy can easily be used. SEM-EDS is able to detect traces of some elements as low as 0.4% concentration in an alloy. This value is based on the calibration of the standards. Ideally, the metallic sample would be extracted from the cross-section. Although this is possible, it is generally not practical given the size of the cross-section and the amount of metal that would be obtained from the sample. Therefore, it is essential to know what is on either side of the metal layer in the cross-section prior to analysis. Light microscopy will often provide this kind of information and should be used prior to SEM-EDS when examining cross-sections. For example, a leaf may have been applied to a surface using oil size. The oil size appears as a resinous layer with red pigment particles in it. The red pigment could be either a red lead or a vermilion. In this case, the presence of mercury, lead or iron in the spectrum could be from the oil size as well as possibly a component of the metal. The amount of these components in the spectrum can often identify them as contaminants or actual constituents in the metal alloy.

A major limitation in the use of SEM-EDS is the size of the metal fragment analyzed. Leafs are, on average, less than one micron thick. Powders vary in size from less than a micron thick to about 4 microns thick. The detector can analyze an area as small as 2 or 3 microns in diameter. It is also important that the sample is polished flat for analysis and free of any surface contamination such as dust. If the material surrounding the metal layer in the sample is composed of elements that are unlikely to be part of the metal, this is not a major concern. In this case, semi-quantitative information can be obtained by using the standardless semi-quantitative program to look for only a certain group of elements. However, large amounts of organic material can create a significant background in the spectrum obscuring the true percentage of the trace metals in the material. A significant background makes it impossible to distinguish between different karats of gold leaf, although, it was possible to identify the major alloying metal in a leaf; for example, the leaf can be identified as primarily a gold-silver alloy or a gold-copper alloy.

TABLE II - A COMPARISON OF THE USEFULNESS OF MICROSCOPY, XRF AND EDS



Technique	Qualitative	Quantitative	Advantages/Limitations
Light Microscopy	yes	no	Most useful in identifying the physical state of the metal layers. Qualitative information about elemental content can be obtained through wet chemical testing. Requires taking a sample.
X-ray fluorescence	yes	no	Elements in small concentrations may not be detected. Non-destructive, although requires movement of the object to the instrument, difficult if the object is large or not necessarily flat.
Energy dispersive x-ray spectroscopy	yes	yes	Requires the use of a sample. Sensitive to trace amounts of elements as low as 0.4% in concentration. Organic components may produce a background which will obscure the true concentration of trace elements. Quantitative information limited.

B. Analysis of samples from the high chests

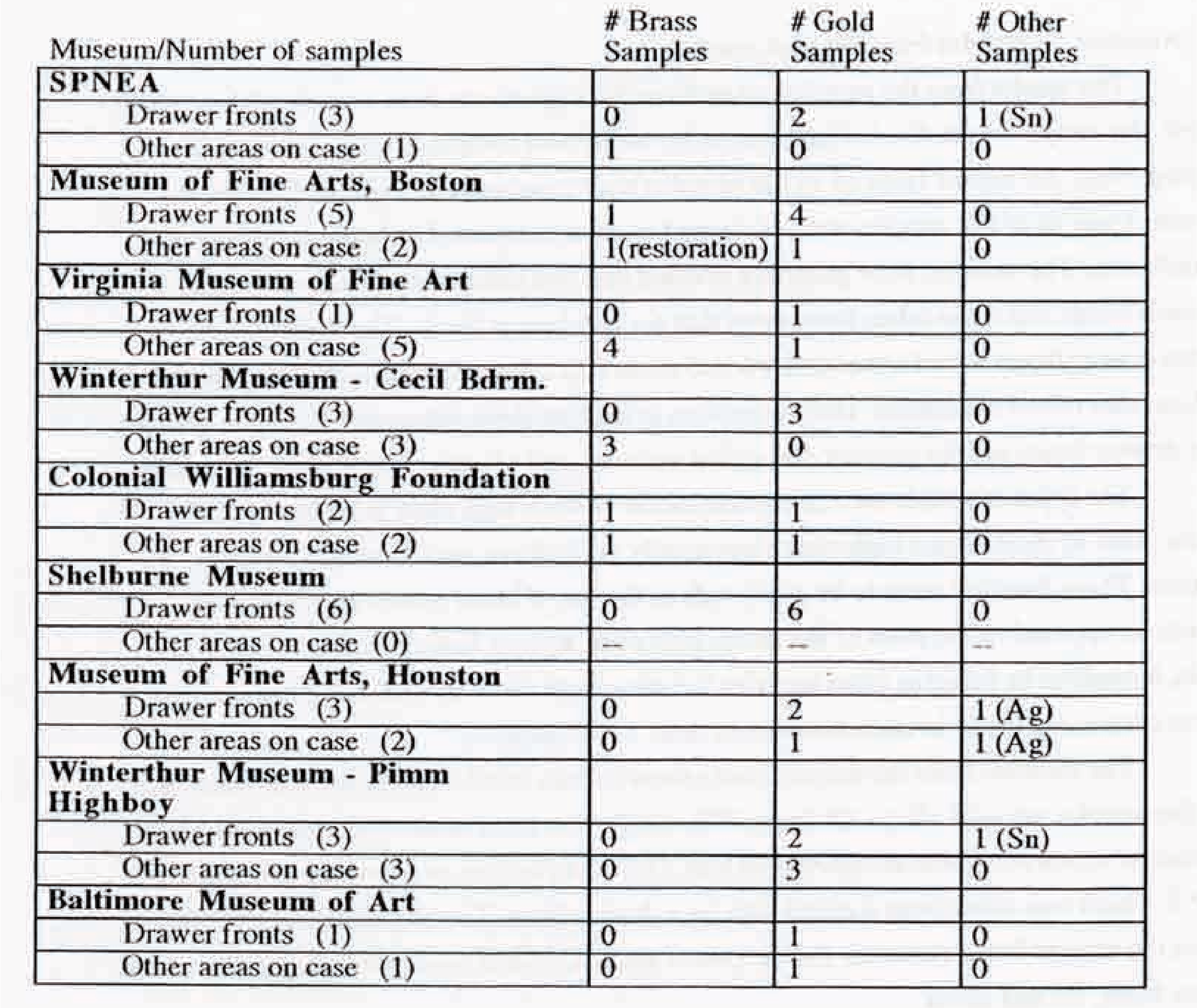
The results from the samples taken from the high chests were examined three ways. First, the samples were divided into groups by object and compared only within each group. Next, the results from all of the samples were compared as a group. Finally, the results from all of the samples were compared to what is reported as being used in period handbooks. The samples were generally divided into two categories: those taken from drawer fronts and those taken from areas that are not drawer fronts. The samples taken from drawer fronts were further divided into those taken from flat decoration and those taken from raised decoration. The assumption in making these categories is that, in general, the drawer fronts are the primary decorative surfaces, and all other surfaces are secondary.

The types of metals used in the decoration on each high chest is highly variable from chest to chest. Some high chests use mostly gold alloys, and some use a variety of metals. There does not seem to be any trends in the use of baser metals on the drawer fronts as opposed to the sides of the cases. However, when a baser metal is found in one area, it tends to be found in other areas on the same high chest as well. Lead and mercury were commonly found in trace amounts in most of the samples.

The samples from the drawer fronts show certain trends: on the drawer fronts, 81% of the samples are gold alloys. Of these, 77% were taken from raised decoration; the metal found on raised areas was always a gold leaf. Gold only occurs as a powder in one sample, HP 2, which was taken from a raised area on a drawer front. The remaining samples taken from the drawer fronts represent flat decorated areas. One half were gold alloys. The others were brass, tin and silver.

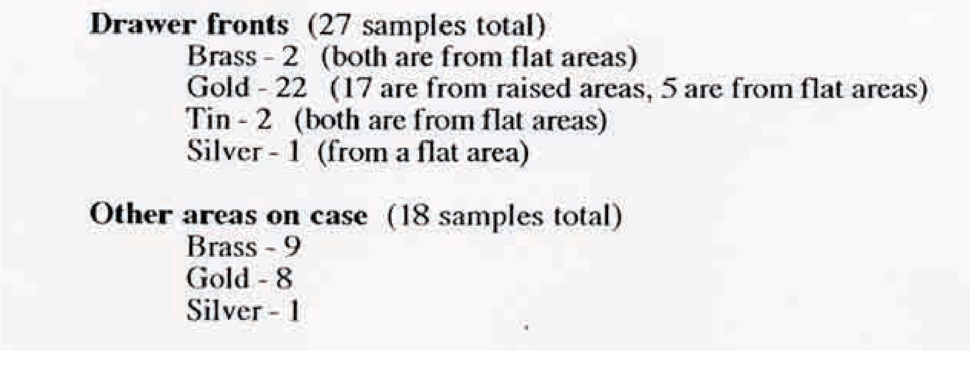
Of the samples taken from areas on the high chests other than drawer fronts, one half are gold, the other half are brass. One sample contained silver. In general, more brass was found on areas other than the drawer fronts, but there is also less raised decoration on non-drawer front areas.

TABLE III - TYPES OF METAL: DRAWER FRONTS VERSUS OTHER AREAS ON THE CASE



Museum/Number of samples	# Brass Samples	# Gold Samples	# Other Samples
SPNEA			
Drawer fronts (3)	0	2	1 (Sn)
Other areas on case (1)	1	0	0
Museum of Fine Arts, Boston			
Drawer fronts (5)	1	4	0
Other areas on case (2)	1(restoration)	1	0
Virginia Museum of Fine Art			
Drawer fronts (1)	0	1	0
Other areas on case (5)	4	1	0
Winterthur Museum - Cecil Bdrm.			
Drawer fronts (3)	0	3	0
Other areas on case (3)	3	0	0
Colonial Williamsburg Foundation			
Drawer fronts (2)	1	1	0
Other areas on case (2)	1	1	0
Shelburne Museum			
Drawer fronts (6)	0	6	0
Other areas on case (0)	--	--	--
Museum of Fine Arts, Houston			
Drawer fronts (3)	0	2	1 (Ag)
Other areas on case (2)	0	1	1 (Ag)
Winterthur Museum - Pimm Highboy			
Drawer fronts (3)	0	2	1 (Sn)
Other areas on case (3)	0	3	0
Baltimore Museum of Art			
Drawer fronts (1)	0	1	0
Other areas on case (1)	0	1	0

TABLE IV - METALS USED ON DRAWER FRONTS AND OTHER AREAS ON THE CASE



Drawer fronts (27 samples total)
- Brass - 2 (both are from flat areas)
- Gold - 22 (17 are from raised areas, 5 are from flat areas)
- Tin - 2 (both are from flat areas)
- Silver - 1 (from a flat area)

Other areas on case (18 samples total)
- Brass - 9
- Gold - 8
- Silver - 1

The variety of metals found is rather narrow considering the number of metals listed in the period handbooks. The samples are predominantly gold leaf or brass powder. Not one sample contained true bronze, a copper-tin alloy. Other metals were also found, two samples with tin powder and two with silver powder. In the case of tin and silver, it appears that the gray color of the metal was intended to be shown, and in one case, it was used as a background color. This confirms the importance of the color of the metal as opposed to its composition. These metals were not intended to be substitutes for gold.

In most cases, the handbooks list only the name of the metal and not its content. For instance, in Stalker and Parker's *Treatise,* "dirty gold" and "green-gold" are listed, apparently referring to the color of the metal rather than its composition. In this case, the value of the metal is in its color, not necessarily in its content or cost. This is a clue to the aesthetic and, perhaps, the proper appearance of the japanned decoration. Not all of the handbooks are this elusive. William Sanderson's *Graphice,* published in London in 1658 by Robert Crofts, describes the process for making gold powder. The gold leaf skewings are mulled in a shell with gum water. When the particles are rinsed and mixed with gum arabic, a small amount of "mercury sublimate," a form of mercuric chloride, is added. The purpose of this addition is a "temper," although what Sanderson means by this is unclear. Sanderson also mentions that vermilion is a pigment frequently employed by "painter-stainer's," presumably, someone who decorates furniture. Vermilion is a mercury containing compound as well, and is often added to the oil size applied to the surface before gilding. Therefore, mercury found in the analysis of a gold powder may be both a component of the vermilion in the oil size and a trace element in the gold powder. In sample HP 2, a gold powder, mercury was found in trace amount.

Another example which confirms the techniques that are described in the period hanbooks is the use of a brass powder in a green-colored medium as a paint (refer to the samples 91.8.8 and 91.8.11). Sanderson also describes how to make "emerald." "Liquid silver," or silver paint, is applied, and "verdigreece," mixed in a varnish is added on top of it. The green-colored medium that appears in the samples taken from the high chest is likely to be verdigris. Verdigris is a copper-based material, as is brass. A quantitative analysis of the brass particles would be very difficult considering the size of the particles and the contamination of the verdigris paint.

Although these two examples show different uses of metals by American japanners, in general, the variety of different metals appears to be more conservative than those used by European craftsmen.

Conclusions

This investigation indicates that SEM-EDS may be a more appropriate technique than XRF for obtaining compositional analysis of small metal fragments used to decorate large, japanned furniture. In fact, this procedure can be applied to any object decorated with metallic paints, powders, or leafs. Although SEM-EDS requires taking a sample, the procedure is more straightforward and a more practical analytical option for the object than XRF. Semi-quantitative analysis is possible but limited by the size of the finish sample, the thinness of the metal particles or leaf, and their orientation in the cross-section.

The results of this study have provided several observations about eighteenth century American japanning. Brass powders and gold leaf predominate as the most popular metals used in the decoration. Gold leaf is always used to decorate raised areas. Flat areas of design were made with gold leaf, gold powder, brass leaf, brass powder, tin powder and silver. These observations are general, however, they are good indications of what will probably be found on other American japanned objects, although exceptions are common.

All of the handbooks examined were published in England. Based on the results of this study, the composition of the metals from the American high chests generally reflect a more restricted style than the English. Whether this is a function of the availability of other metals or a matter of style remains unclear. Nevertheless, the use of the metals does differ slightly from the techniques described by the English handbooks, even though the intent of the japanner appears to be the same: to use the variety of metals for their color.

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