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Baron von Steuben's Liquor Case: The Technical Study and Treatment of a Campaign Item from the American Revolution

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ABSTRACT

An 18th century travelling liquor case from the Buffalo History Museum, proclaimed to be once owned by General Baron von Steuben of the American War for Independence, was delivered to the Buffalo State College Graduate Art Conservation Department for technical analysis and conservation treatment. The little background information known about the case was augmented by the completion of a materials analysis performed on the wood, glass and metal components, which suggested manufacturing techniques appropriate within the context of the 18th century American glass industry. Historical research conducted also supported an American origin of production, as opposed to a European one. The conservation and restoration treatments conducted were wide ranging given the variety of materials, all showing their own forms of wear and inherent degradation, such as glass crizzling, iron oxide corrosion and wood shrinkage. Each material was addressed separately, with ethical questions regarding the removal of original materials arising several times. Ultimately, the treatment successfully stabilized the object and improved the aesthetic appearance of its previous damages.

1 INTRODUCTION

In November of 2015, an 18th century liquor case, complete with stoppered glass bottles (see Fig. 1), was delivered to the SUNY Buffalo State Art Conservation Department for conservation treatment and technical analysis. The liquor case was donated to the museum in 1936, with claims that it belonged to Friedrich Wilheln Ludolf Gerhard Augustine Steuben, who served with Washington's Continental Army from 1778-1784, during which period he carried this chest.

Fig. 1. Baron von Steuben's liquor case and glassware from the Buffalo History Museum

2 PROJECT OBJECTIVES

For a history museum that looks at objects as instruments to illustrate the past, this 18th century liquor chest could very well be a perfect embodiment of the war-torn American colonies and the struggles that led the way to U.S. independence in 1783.

As a liquor chest, it stands as part of the historical record that chronicles colonial drinking habits and the spirits trade, both of which were directly connected to the success of the American glass industry. Its fine glassware is evidence of the history of commerce and craft in the colonies -- the great struggle merchants and manufacturers faced under British rule to make and sell their products and achieve the independence they needed to grow and prosper. Finally, having been owned by a Revolutionary General and carried from one battlefield to the next, this case not only holds historical remnants, but also a vivid story of battle campaigns and the lifestyle of soldiers in the camps.

As is usually the case with objects that have such a long and rich history of use, the chest has suffered physical damage. The people and the records that explain its origin and production are lost. This project aims to illuminate that lost portion of its history by using scientific analysis of its materials to place it in the context of 18th century glass production, shedding light on its origin and manufacturing techniques. In addition to clarifying its past, a full conservation treatment of the liquor chest will also be performed in order to repair some of its damage and bring it to a safer and longer-lasting condition, so that it can continue to be used as a tool to teach history, as well as be displayed as a museum piece and art object.

3 HISTORICAL BACKGROUND

3.1 Baron von Steuben

According to the donor of the chest to the Buffalo History Museum, its original owner was Baron Friedrich Wilhelm Ludolf Gerhard Augustin von Steuben (see Fig. 2), a famous inspector and major general in the Continental Army during the American War for Independence.

Fig.2. Portrait of von Steuben by Ralph Earle c. 1786 (49.5 x 41.5in)

General von Steuben was born in 1730 in Magdeburg, Prussia. He eventually developed his military career, becoming a Prussian officer, serving in the Seven Years War (1756-63), and then as a volunteer under Frederick the Great, the King of Prussia, during the Siege of Prague (Powers 2006:811). He quit the army in 1763 to become chamberlain to the prince of Hohenzollern-Hechingen, where he remained for a decade and received his title of Baron. By 1775, von Steuben became interested in joining the army again and put out inquiries for employment, which led him to his position fighting in the American colonies.

In 1777, at a meeting in Paris for those interested in aiding the American cause, Steuben was introduced to Benjamin Franklin. Franklin immediately wrote to Washington about Steuben, exclaiming that his military expertise would be of use to the inexperienced American armies. The Baron was offered employment and the French funded his trip in December 1777. He reported for duty first at Valley Forge, PA, where he was met with thousands of inexperienced soldiers and unorganized, inefficient camps. He set to work fashioning order and training them. He taught soldiers how to march in formation, clean their weapons, and made improvements to camp life by reorganizing tent layouts, food usage, and sanitation. Baron von Steuben was a tremendous help to the American troops. He led campaigns and organized

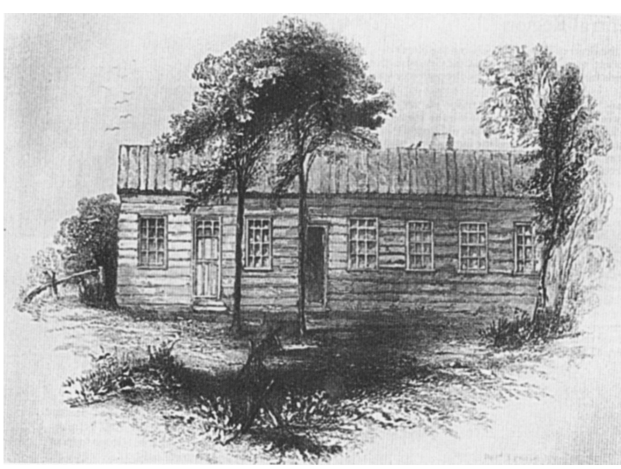

Fig. 3. Drawing of von Steuben's residence, 1802

regiments in the north and the south, and was in Yorktown during the last decisive battle at the wars conclusion in December 1781 (Hughes 2006; Powers 2006).

The liquor case was probably brought with Steuben to upstate New York after the war's conclusion. As a gratitude for his service, New York State deeded Steuben 16,000 acres of land of his choosing. He built a small cabin in the woods of Utica, then known as Fort Schuyler, where he spent the summers in isolation with his dog. He died suddenly in November of 1794 at the age of 64, after becoming ill while building a mansion in northern New York (Hughes 2006). Although his wish was to be buried in an unmarked grave in the woods, his body was discovered in 1804 and moved to his present day resting place at the Steuben Memorial State Historic Site in Remsen, NY, where there is a large stone monument dedicated to him, as well as a reproduction of his cabin.

3.2 Liquor Chests and Case Bottles in the Colonies

The history of boxes made to transport alcohol dates back millennia. However, the style of General Steuben's box began in Germany, where its tall, square type of bottle is generally thought to have originated during the 16th century. The style soon spread to the Netherlands, where they began to be referred to as "case bottles," or *kelderfles* in Dutch, because they were transported in cases, or *kelders*, lined with straw for padding (Hoogsteder & Hoogsteder 2016). Evidence of this early use of case bottles can be seen in Dutch and German paintings like Arie de Vois' Utrecht painting from 1690, "Woman Drinking" (see Fig. 4.) By the 17th century, they were being produced in France, England and elsewhere in Europe. The style then came to America by the late 17th or early 18th century (McKearin 1978:224).

Fig. 4. "Woman Drinking" by Arie de Vois Utrecht c. 1690

Advertisements from American glass companies write of cases with 6, 7, 9, 12, 15, 16 or 24 bottles, many glass-stoppered, with square or rectangular bodies made of flint or white glass, and finely polished. The most common sizes were pints and two-quarts, and cases holding six or seven bottles (like Steuben's) predominated. The glass in this liquor case – colorless and finely finished with glass stoppers -- would have been a style reserved for aristocrats and the well-to-do merchant class, as opposed to the more common olive green or amber glassware. Other high-end bottles may have been clear, but made with lead (referred to as flint glass), and may have had metal mountings for screw caps (McKearin 1978:225-226).

There is no way of knowing precisely what each one of the bottles in Baron von Steuben's chest contained, but in addition to cider and beer, applejack and peach brandy, rum and whiskey (the patriotic choice) were the most common alcohols consumed in 18th century America (Crews 2007). Similar imported rectangular bottles would typically have been filled with rum (also called "kill-devil"), or gin ("Geneva" or "Holland"); and the slender square bottles, like the two in this liquor chest, may have carried port wine or brandy (there are records of that style of bottle being used for port in England as early as 1700) (McKearin 1978:210, 226).

Liquor chests show up with some frequency within the backdrop of 18th century letters and stories about American notables. For example, in 1728, Colonel William Byrd, the founder of Richmond, Virginia, writes of his dismay that a case bottle of cherry brandy broke on a trip to Roanoke, and "not one precious Drop was saved (Bassett 1901)." Or in the story of the Siege of Fort Vincennes, the British Governor Henry Hamilton was having an apple toddy around a fire with his prisoner, Captain Helm, when they were attacked and their drinks were spilled to the dismay of them both. Indiana State University claims to own the only surviving liquor bottle from the liquor case they were using, which happens to be the apple toddy bottle (Indiana Quarterly 1905).

Notably, liquor cases find their way into the stories of George Washington's fight over overpriced goods from England, and in particular against Carey & Company, the business at the heart of his indignation over trade with England. In 1761, Washington complained of the cost of a case he wanted to buy from Carey & Company in London. He remarked: "Surely there must be some mistake, or as great an Imposition as ever was offered by a Tradesman. The case is a plain one and such as I could get in this Country (Where work of all kinds is very dear) of the same stuff and equally as neat for less than 4 Guineas. Is it possible that 16 gallon Bottles with ground stoppers can be cost 13 Guinneas?" (McKearin 1978:226).

A liquor case was also recorded as a campaign item of George Washington's by the Mount Vernon Ladies Association in the 1940s (see Fig. 5). This case happens to be an identical model to von Steuben's and is assumed to have accompanied Washington during his campaigns, as he rarely spent time in Mount Vernon during the war. Washington is known to have had a propensity for Madeira wine, which he ordered continuously during the war. He may have filled his matching decanters with Madeira,

Fig. 5. George Washington's liquor case (on the left), owned by the Mount Vernon Estate, and Baron von Steuben's liquor case (on the right). The case and bottles are extremely similar and were most likely made by the same manufacturer.

and with a matching stem glass to Steuben's, made his famous toast on April 15th, 1783, three days before the cessation of hostilities, to the soldiers "to drink Perpetual Peace, Independence and Happiness to the United States of America (MVLA 1948, 5)."

In addition to Washington's liquor case, many other matching cases are known, that have only very minor adjustments (in size, paper lining and gilt glassware decoration), leading one to believe that they were a fairly common item. They can be found across the United States, some with known provenances connecting them to other Revolutionary War figures like Steuben. Some of the other matching cases known to exist today are: a case owned by William Blount, a signer of the US Constitution, located in the Blount Mansion Museum in Knoxville, TN; and a slightly larger version owned by the Tavern Museum in New York, which purportedly also belonged to Baron von Steuben. Others are found at various U.S. auction houses, often also claiming to have been owned by Revolutionary War figures. They include: "Captain's Wood Liquor Chest" (ebay.com); "Liquor Chest" (bidsquare.com); "Liquor Chest" (pricesforantiques.com); "Liquor Chest owned by Jacob Wendell," a Revolutionary Colonel in New York (invaluable.com); "Revolutionary War General's Liquor Chest" (treasurenet.com); "Liquor Chest belonging to General Abraham Rose of Long Island" (khanfineantiques); and so on. All of the liquor cases and glassware mentioned above match General Steuben's case in style with only slight differences, and were most likely made by the same manufacturer.

3.3 Drinking Habits During the Revolution: Setting the Stage for Rebellion

Alcohol was an integral part of life in 18th century America, which made liquor cases like this one an important accessory for any person needing to travel long distances. In 1790, Americans over fifteen years old drank an average of thirty-four gallons of beer and cider, five gallons of distilled spirits, and one gallon of wine per year, compared to today's average of 2.3 gallons of alcohol (of all types combined) today. The popularity of alcohol then was due in part to necessity, since 18th century water often made people ill (Crews 2007). Thus, if one had a profession that required them to move from place to place like Baron von Steuben did, having a liquor chest like his would have been critical.

Indeed, it is easy to imagine General Steuben sitting around the campfire with other soldiers or officers, drinking whiskey and recounting stories from the battlefield.

Alcohol also took on a central position within politics during the American Revolution because of the high import taxes that were put on rum from the Caribbean. Rum had been the most popular drink in the colonies, with Americans drinking an estimated three pints of it every week by 1770 (Regelski 2016:13). However, when high tariffs were imposed by England on imported goods, rum was ousted, along with the glassware it arrived in. Thus, Americans turned to homegrown whiskey and homemade glassware in order to meet their needs (and support their and habits), rejecting their dependence on England. These kinds of changes, fueled by political conflict during the American Revolution, led to a consumer revolution that, in turn, drove the development of the glass industry. Material goods like this liquor case played a key role in paving the path towards independence and a new colonial identity.

4 DECIPHERING AN ORIGIN OF PRODUCTION

4.1 American Glass Industry and Uprising

During the colonial period, glass was imported from Europe as well as produced in the American colonies. Discovering the origin of this liquor case is thus complicated because the style and composition of the glass could have technically been produced on either side of the Atlantic. The identification of the wood used to build the chest, White Oak, doesn't offer clarification either, since White Oaks are common on both continents (see Section 8.2 on the material analysis of the wood). However, the political conditions of the time, the number of matching cases that have been found in the U.S., the high price of 18th century foreign goods, and the imperfections in the case and glassware construction, points to a greater likelihood of it was made in the colonies at one of several glasshouses.

Before the American Revolution began in the 1760s, there was a high demand for glass to be made at home, especially common glassware such as decanters, drinking glasses, and medicine bottles, which were needed to hold everyday items (such as rum and whiskey). Importing these goods from England had become a costly enterprise due to a series of high tariffs put on goods from England, and the colonies were furthermore restricted from trading with other countries due to the Navigation Acts (although some trade did occur illegally) (Dickerson 1951). In 1767, the Townshend Acts put a tax on imported glass, as well as other items like tea, artist's paint, flint and paper. This was the third blow to colonists after the Sugar Act of 1764 and the Stamp Act of 1765, and it led to the Non-Importation Agreements in which many citizens and merchants agreed not to buy certain foreign items, including glass (McKearin 1978:30, Palmer 1978:98).

Considering the array of existing matching cases owned by other officers in the Revolution, it's likely that this liquor case was made around the same time that Baron von Steuben arrived in America in 1777., It seems much less likely that the glassware would have been bought from England, given the heightened political situation. Buying British glass would have appeared unpatriotic. In fact, glassmakers advertised exactly that in the newspapers. On July 31, 1769, Richard Wistar advertised in the Pennsylvania Chronicle as follows, *"…where also may be had most sorts of bottles, gallon, half gallon, and quart, full measure, half gallon case bottles, snuff and mustard bottles, … As the above-mentioned glass is of American manufacture, it is consequently clear of the duties the Americans so justly complain of; and at present is seems peculiarly the interest of Americans to encourage her own manufacturers, more especially those upon which duties have been imposed for the sole purpose of raising a revenue…. –Richard Wistar" (McKearin 1941: 81)*

Additionally, as noted, this particular liquor chest does not appear to have been a unique item in the colonies. The fact that so many cases and bottles of this type still exist today in the United States could be another indicator that they were manufactured here. Similarly, because other Revolutionary War figures seem to have owned them, there may be a possibility that they were made and distributed to War leaders as campaign items.

Although an argument has been made for the liquor case being a product of the American colonies, it is still nearly impossible to identify the origin of the glassware, mostly because the glassmakers in America were mainly from Europe and were using the same styles and recipes they used in their homelands to produce it. British glassmakers were forbidden to come to America at this time, and so most of them were from Germany (McKearin 1978:31). Baron von Steuben's glassware has definite German stylistic origins. Not only did the square bottle type originate in Germany and remain more common there than in England, where it tended to be unpopular, but the half-post method used to make the glassware (see Section 5.1 on manufacturing techniques) was also considered characteristically German, and is appropriately referred to as the "German half post method" (Ibid:21). The German influence on 18th and 19th century American-made glass is well known and believed to be first attributed to the glassblowers of the Wistarburgh Glass Factory, which began production in 1739 (Palmer 1976:78). Thus, if the glassware were not made in America by German glassmakers, the next likely option would be that it was made in and imported from Germany or the Netherlands. There is evidence showing that there was a mass importation of gin in liquor cases during the Gin Craze in Europe during the first half of the 18th century and that liquor chests were imported from Holland in the early 19th century by the thousands (McKearin 1978: page), thus making importation a possibility. However, during the mid-18th century, while the navigation acts were being enforced, this trade would have been illegal, and thus less likely to have occurred that homemade production.

A final argument can be made for the American origin of Baron von Steuben's liquor case, which is that the construction of the case and the bottles was somewhat hastily completed. Some of the various wood and metal elements do not line up correctly, as seen by viewing the interior of the lid (see Fig. 6.); the decanters have unintentional glass inclusions, which disrupt their

Fig. 7. The decanter on the left leans fairly far to one side.

smooth surface; and some decanters lean fairly far to one side (see Fig. 7.). Furthermore, although a paper or fabric lining would have obscured the sawn wood edges, the wood was noticeably crudely cut. One would assume that if constructed in England, within a well-established industry, that the product would have been more finished and refined.

Fig. 6. The unfinished quality of the wood and misalignment of some of the case's components suggest a somewhat hasty construction.

Adding complications to discovering the origin of the glassware is that no American glass house during the 18th century has ever been known to mark their glassware with an identifiable name or symbol. In addition, glassblowers often moved between glasshouses, spreading the same techniques and styles, as was the case with the workers of Wistar and Stiegel (Palmer 1978:78). Thus, if General Steuben's glassware were made in the colonies, there would have been several glasshouses that could very well have done the job. The following section will discuss these houses as the possible producers of the glassware. Although it cannot be proven, it will at least place Steuben's glassware in the context of the period in which it was made.

4.2 Glasshouses that May have Produced von Steuben's Glassware

During the 18th century, a glass house like the one that would have been responsible for making the bottles and cups in von Steuben's liquor chest was a costly and complex production that involved infrastructure, materials, fuel, transportation and marketing. Skilled workers were required to carry out daily tasks such as melting, blowing, annealing, cutting and drying firewood, preparing clay for molds, making the melting pots, repairing the furnaces, making and mending irons and other tools, caring for the horses and oxen, housing workmen, making boxes, and packing the glass for shipping (McKearin 1978:31). Glassmaking may have been one of the most expensive industries to maintain in the American colonies, which explains why so few of them were successful.

Nonetheless, there were several glasshouses in colonial America where this object's glassware *could* have been made during the mid-to-late 18th century. Although more than several glasshouses existed, many were unable to stay in business for more than a few years, and only seven are known to have advertised case bottles in the 18th and early 19th centuries. The seven glasshouses were: Germantown Glassworks in Massachusetts, who advertised case bottles in 1755 and 1760; Wisterburgh in New Jersey, who advertised them in 1769; Stiegel in Manheim PA, with manufacturing records documenting their production in 1767 and subsequent years; Bakewell, Page & Bakewell in Pittsburgh, who advertised green glass case bottles in 1813; Schuylkill Glass Works, also advertising in 1813; Philadelphia Glass Works, Stiegel's sole American competitor for the domestic market, who advertised making "white flint" case bottles in 1773; and the New England Glass Co., advertising in 1818 (Ibid:227). Of those listed, only Stiegel and Philadelphia Glass Works were active during the right time frame from the mid-to-late 18th century, although it is important to note that while advertisements and logbooks only show evidence of the abovementioned producers, others could have existed.

Stiegel (Elizabeth Furnace and Manheim) in Pennsylvania was the glasshouse of Henry William Stiegel. During his main period of operation from 1763-1769, his primary products were ordinary bottles, flasks, and window glass. Evidence of the manufacture of case bottles, and other clear glass products, are seen in his ledgers between 1765-1767 in which he lists glassware such as "pocket bottles, pocket pints, case bottles, snuff bottles, bottles from half pint to three gallons..." Stiegel was the first glass company to make non-lead, clear flint glass, and from the 1770s onwards he concentrated on that effort by opening his American Flint Glass Manufactory. Nonetheless, the majority of his products consisted of soda-lime glass, like most other glassworks in America at the time. His production ran until 1774, when he shut down due to debt (McKearin 1978:38-39, Tassel 1950:16-18). The American War for Independence lasted from 1775-1783, so if Stueben's case and bottles were a campaign item during the war and made by Stiegel, they would have had to be made at the war's onset before the glass company closed. Although Steuben did not arrive in the U.S. until 1777, this possibility should not be discounted, as Stiegel was one of the most prominent producers of glass in the country and thus would have been a manufacturing option for someone seeking to mass-produce a product.

The Philadelphia Glass Works in Kensington, Philadelphia is another possible manufacturer of the glassware in von Steuben's case. It opened in 1771 along the Delaware River with the intent of making flint glassware, as noted in several advertisements in 1772 asking for "broken Flint glass" and "good alkaline salts" (McKearin 1978:38). As the glass company grew, they became Stiegel's sole competitor in terms of size and influence. By 1773, they had merged with a shop owner named Isaac Gray, who sold cider and beer for foreign and domestic consumption and thus was a huge customer of the Philadelphia Glassworks, purchasing bottles on a regular basis. By 1773, the company announced that they could produce any kind of white or green glass, and that it would be as good and as cheap as British imports. Case bottles of the "home made White flint glass" variety were offered, by at least 1775 (Ibid: 38-39).

As previously mentioned, no glassware from Stiegel in Manheim, or the Philadelphia Glass Works was ever known to have been marked (Tassel 1950:16). Certainly more glasshouses existed than the ones mentioned above that could have produced case bottles. But the work of the glasshouses cited and their production capabilities do offer at least evidence that the glassware could have been produced in the American colonies.

5 MANUFACTURING TECHNIQUES

5.1 Production of Glassware

Colorless glassware was mainly reserved for the aristocratic population in 18th century America. This is because colorless glass was much harder to make than colored glass, requiring pure silica without impurities. Venetian glassmakers spearheaded its production in the 15th century, and the English began producing it by the 18th, using flint rock, which is virtually pure quartz (Lindsey 2016). Thus, von Steuben would have shown his status as a war general in part by using this clear glassware, which due the higher level of skill and additives required to make it would have been much more expensive than common colored glass. The manufacturing techniques used to form and make the glassware, discussed below, were safeguarded techniques. Today, with technical analysis and historical research, we can shed light on the intricacies of their manufacturing process.

Glass is composed primarily of silica (60-80%) obtained from sand. However, because pure silica requires such a high temperature to melt, and because sand is rarely composed of pure silica (quartz), fluxes, stabilizers, and colorants are also needed to form various glass recipes. Ionic salts from alkali metals, like soda-ash (sodium carbonate), potash (salts containing potassium), or lime (calcium oxide) are the other main components of glass. Von Steuben's glassware is composed mainly of silica, potash, and calcium (see Section 8.4 on material analysis). Calcium is added as a stabilizer, since the glass would be water-soluble if it contained silica and alkali salts alone (Lindsey 2016). In the American colonies, potassium was obtained from the ashes of burnt wood or other vegetation, which could have included plants such as bracken and saltwort. As Dossie wrote in an 18th century letter about the Philadelphia Glass Works, "It [bottle glass] is formed of sand of any kind, fluxed by ashes of burnt wood or any part vegetable" (McKearin 1978:8-9). And Benjamin Franklin wrote in 1747 about the Wistar glasshouse that, "[wood] furnishes at the same Time [a] great Part of the Ashes that are wanted," to act as the alkali for the glass mix. For this reason, glass houses had to be built near a ready source of wood. The calcium, or lime, could be obtained from a number of sources, including from the potash or sand, however, in the colonies it was most likely obtained from oyster shells, chalk, or limestone (Palmer 1978:79).

In addition to fluxes and stabilizers, colorants, or de-colorants were also added. This is because a simple sand-potash-calcium mix would usually yield a green glass due to iron inclusions in the sand. Thus, 18th century recipes for making clear glass like von Steuben's often included compounds such as arsenic oxide and manganese dioxide, which acted as decolorizing agents. In fact, oxide of manganese was known as "Glassmakers Soap" because it took away the greenness of the glass (McKearin 1978:10, Lindsey 2016) by cancelling it out with the purple of the manganese (a complimentary color of green). In fact, a faint purple tint can be seen at certain angles in the thickest portions of von Steuben's glass decanters.

The glassware contained in this liquor case was analyzed using XRF spectroscopy, which is discussed further in Section 8.4. General results from analysis of the base colorless glass showed that its composition has a potassium-calcium base, with elements of arsenic, manganese, and iron. This is almost identical to Robert Dossie's 1764 account of a recipe for white/colorless glass used in the American colonies to make fine quality ware:

"Take of white sand one hundred and twenty pounds, of unpurified pearl-ashes fifty pounds, of common salt ten pounds, of arsenic five pounds and of magnesia five ounces." This recipe could make glass, "very near to the crystal glass" (Ibid:10). With this object, magnesium oxide is used in the place of manganese to counter the effects of the iron.

Once the ingredients were combined, the next important element was the furnace. Many of the furnaces used for glassmaking during this time no longer exist, but various accounts from correspondences and archaeological excavations have revealed the technology. For instance, we know from Benjamin Franklin's writings in 1747, that Wistar's furnace was "about 12 foot long, 8 wide, 6 high, has no Grate, the Fire being made on its floor…On each Side in the Furnace is a Bench or Bank of the same Materials with the Furnace, on which Pots of Metal stand, 3 or 4 of a side" and that the bricks for the kiln were made with fresh white clay mixed with used ground kiln bricks. The styles of kilns described during the mid-18th century closely resemble furnaces in Germany and northern Europe (Palmer 1978:80), where many of the glassblowers had come from.

As previously mentioned, the case bottles were most likely formed using the "German half-post method." The process is as follows: a warmed blowpipe is dipped into the pot with the melted glass and turned until a sufficient amount of glass, called the gather, is collected on its tip. The gather is then blown slightly and dipped into the glass pot again to obtain a second layer of glass that forms a ridge, usually at the shoulder. The thick ridge at the bottom of the neck on Steuben's glassware is the indication of the height to which the bottle was dipped the second time (see Fig. 8.). The glass is then blown fully into the clay (or sometimes wooden) mold to create the straight sides, arched at the top, with spandrel-like curves at the shoulder corners (McKearin 1978:31, 225). The type of mold used was most likely a two-piece dip mold, into which the glass was blown from the top and cut, cracked or burst (with a bubble) off at the top of the neck. After being taken out of the mold, the sides and edges were then ground down using sandpaper made of ebony or another material. The evidence of grinding is clearly seen on the flat sides of the bottle. Grinding was done to remove the textured surface of the mold and to return the brilliance to the glass. The body would have then been held in place with a glass tipped or blowpipe pontil rod at the base (leaving the pontil marks clearly seen on von Steuben's bottles) (see Fig. 9.), so that the bottle could be fire polished to eliminate seam lines, or for application of the lip and gilding. No seam lines are visible on von Steiben's glassware which suggests they were either ground away or that it was fire polished. The bottles have laid-on lips, consisting of a ring of glass applied in a spiral-like manner. The extra glass around the lip gives support to the mouth, which was especially helpful for corked or stoppered bottles (Lindsey 2016).

Fig. 8. The ridge of glass at the top of the shoulder indicates to where the bottle was dipped into the glass melt.

Fig. 9. Pontil mark left at the bottom of one of the large decanters.

The smaller stem glass and flip glasses were made in a similar manner, most likely being blown into a mold as well. The base of the foot of the stem glass was also dipped into the hot glass like the decanters and shows a pontil mark at its base. The flip cups were ground at the bottom and on the flat sides, so they do not show a pontil mark or seam lines.

The glass stoppers would most likely have been blown and shaped without the use of a mold. In fact, their size and shape are specific to the decanter they fit into, which suggests they may have been blown directly into the decanters to ensure an exact fit.

After the glassware was shaped and annealed, the gilded decorations were applied. There are various methods, cold and hot, to apply gilding to glass, however XRF analysis suggest that these were done by applying a lead based solution mixed with gold powder onto the glass (see section 8.4 on material analysis), which were then fused to the glass with heat. This is a very old method, even mentioned on the Leiden papyrus from the 3rd century AD and in the early Medieval Mappae Clavicula, in which it is recommended to mix finely powdered lead with gold powder in order to heat it onto a base metal. The general procedure would consist of mixing the lead and gold powder into a paste (using a gum, honey, or water as a binder for instance), painting it onto the glass surface, and then heating it in the furnace. The lead holds the gold, while an inter-diffusion occurs between the gold and the glass, and the lead either oxidizes, or is partially absorbed by the glass (Oddy 2000:8). In UVA illumination, the lead fluoresces a blue color and can be seen around the perimeter of all of the gilding (see UVC image in Section 8.4). This infers that the design was painted on with the lead-gold mixture, rather than the gold being etched away after firing to create the design. This method would have also saved gold and medium from being wasted.

5.2 Production of Wood and Iron Case

The wood used to construct the case is a combination of oak on the exterior and a soft wood, such as pine, for the interior components, including the removable shelf. Oak would have been readily available in both Europe and the American Colonies and would have been cut using small saws and sanded with sandpaper. Sandpaper in 18th century America was either emery ordered from England, shark skins, or constructed by gluing sand to paper (Carter 1775).

Under UVA illumination, the exterior surface of the wood fluoresces a faint orange color, which indicates that is was once coated in shellac. Although the coating was not analyzed, shellac would have been a common material used as a varnish for wood at the time because it gave a somewhat glossy finish and offered a degree of water resistance. Shellac during the 18th century was also dark in color (Flexner 2010), which may explain the dark coloration of the exterior wood. A dark stain could have also been achieved using pigment washes or dyes.

Fig. 10. Elegant bail handle twist forged by a blacksmith.

The wrought iron strapping, lock mechanism, nails and handles were hand forged from bar iron by a blacksmith, who would have used a charcoal fire forge with a hand-operated bellows. After heating the iron, it was hammered on an anvil for shaping, or manipulated using vices and tongs, as was done with the elegant twist at the center of this case's handles (see Fig. 10.). The subtle hammered texture left behind from hand-forging can still be seen on the metal strapping (see Fig. 11.). By the 18th century, iron stock would have been available from local forges and domestic furnaces for creating the metal (Mulholland 1981, 79). Remnants of tin on the metal strapping and lock components suggest that the iron pieces were tin-dipped (see Section 8.3 for further explanation). Tin has a very low melting temperature, which makes it easy to cast, or coat with. Tin and pewter (an alloy of tin, containing either

Fig. 11. Notice the subtle texture of the metal strapping caused by hammering while it was being shaped by a blacksmith.

copper, antimony, lead, bismuth, or a combination of them) were common in colonial America, especially as dining ware among the wealthier families. Although tin was purchased from England, and thus its production interrupted during the American Revolution, tinsmithing continued throughout the period by recycling pewter and tin items for new production (Mulholland 1981, 95).

5.3 Production of Paste Paper Lining and Textile Components

The little that remains of the interior paper lining inside of the case appears to be a paste paper, commonly used during the late 17th to late 18th centuries to line book covers, boxes, and eventually wooden furniture objects. The style of von Steuben's paper is referred to as Herrnhut, named after Herrnhut, Saxony, where two brothers produced some of the finest designs by developing new tools, like combs, blocks and rolls to make their patterns.

Paste paper is made by painting two sheets of paper with dyed paste (such as wheat, potato, or corn), followed by pressing them together to combine the designs, and then pulling them apart. The base paper is usually primed first with water paints. Various effects can be achieved by pulling the papers horizontally or vertically when pressed, or by applying paste and pressure to varying degrees. Additionally, paste paper designs can be made by spreading the dyed paste over the surface with a brush or other tool (Krause 2002:8-16, 22), as is most likely the case for the paper in this liquor case. The paper in von Steuben's case is mainly pink on a white background, although small remnants of a blue and white paste paper are seen underneath some of the fabric lining.

On the left side of the base and lid on the interior is the remains of a piece of white fabric, once nailed to each side to keep the chest lid at a 90° angle when open, to relieve stress on the hinges. The nails used to attach the fabric match the exterior nails, which implies that this fabric may be original. In addition to this fabric there are also strips of white cotton lining the top of the compartment dividers, nailed to the wood. There are also two small remnants of a piece of leather, nailed to the right side of the base and lid.

Because the nails used to attach the strips of cotton and leather do not match the exterior nails, and because paste paper can be found underneath the fabric, it suggests that the fabric and leather may have been added at a later date, in order to obscure potential loss of the paste paper, and to replace the original fabric support, which had perhaps broken by then.

6 RESEARCH AND TREATMENT OBJECTIVES

Considering the potential stories and rich history that Baron von Steuben's liquor case has the capacity to provide the Buffalo History Museum to use for teaching the public, several research and treatment objectives were aimed for that will hopefully help this object achieve its purpose in its museum context.

The primary goal of the project was to stabilize any fragile components, making it safer to handle, exhibit and store long-term. Second, in addition to researching the historical context of the object, certain aspects of its history regarding its materials and construction techniques were sought by means of technical analysis. Finally, the last goal of the project was to make aesthetic repairs, so that when visitors view this old and worn object, they can be free to let their imaginations delve into the past without being distracted by its damages.

Baron von Steuben's liquor case is composed of many different materials, which make it a wonderful tool for learning about a variety of conservation treatment techniques. In the following sections, the description, condition and treatment of the object will be addressed, based on the various components and materials involved.

7 EXAMINATION AND DOCUMENTATION

7.1 Description

7.1.1 Case

Fig. 12. Small dowels were used in conjunction with the metal strapping and mitered joins to connect the wood.

The case base and lid are composed of wooden slats, mitered and glued. As previously mentioned, the wood was identified as White Oak under microscopic observation. The joints on all sides are reinforced with forged iron strapping, with two extra straps across the top. Wooden dowels are also used to connect the top and bottom slats to the walls (see Fig. 12.). The lid is detached from the base because its two strap hinges are damaged on the backside. Originally, the case would have opened to a 90° angle, being held in position by a piece of fabric, but only the ends of this fabric remain nailed to the left side of the base and lid, so they are no longer functional. There are also remnants of a leather strip on the right side of the base and lid. This may have been a replacement for the original fabric once it broke, since its nails do not match the originals (see Fig. 13).

There are two iron angle brackets on the bottom front and one on both the right and left sides, which secure the walls to the base. An iron, circular-spring-chest-lock is mounted inside the front center of the base, with an arrow shaped lock receiver on the lid (Borg 2016). All iron components are held with small hand crafted, iron nails, which appear to

Fig. 13. The fabric remnants (on the left) of the strap which was connected to the base and the lid to keep the case open at 90 degrees. Its nail match the exterior nails. The remnants of a strip of leather (on the right), serving the same purpose as the fabric, but attached with a different type of nail.

be original. The two elegant wrought iron twisted bail handles on the right and left sides are attached with iron brads, or split-pin fasteners.

The interior of the chest probably had nine compartments originally and one removable shelf. The back right divider has been lost, leaving eight compartments presently. The left and right compartment dividers are slotted and glued. Below the shelf is a removable slat of wood with four holes crudely cut out to house the four flip glasses. The wood could be so hastily cut because it was once lined with fabric, as is seen in a matching liquor case owned by George Washington in the collection at Mount Vernon. Above the flip cup holder sits a shelf with a central divider, also crudely cut, to house the two small ovoid shaped stem glasses, of which only one remains. Most likely, the entire interior of the case was lined with an 18th century, Herrnhut-style patterned, white and red paste paper (although small remnants of a green paste paper can also be found underneath the divider fabric). The paper may be an old restoration that replaced lost fabric. Either way, a fabric or paper lining would explain the unfinished quality of the woodwork, since it would have hidden it. Covering the top of the compartment dividers are strips of white cotton fabric attached with nails. There is paste paper beneath the cotton.

There were originally three rectangular wooden slats (now two) adhered to the underside of the lid for the purpose of holding down the stem glass shelf unit when the box was closed. The shelf and wooden elements on the lid interior were identified as a softwood using polarized light microscopy and is most likely a pine species (from visual examination).

7.1.2 Glassware

The case originally contained six large rectangular bottles with stoppers, two narrow square bottles with stoppers, four flip glasses, and two stem glasses. One of the flip and port glasses, and two of the large rectangular bottles have been lost, leaving eleven glass pieces total. Only four of the glass stoppers remain. All of the glassware is colorless, and is of a potassium based ("potash") composition with gold decorations.

The square rectangular bottles have flat sides that arch at the top with spandrel-like curves at the shoulder corners. They have a trail string lip and flat base with a pontil mark. Gracing the shoulders of the two short sides are foliate designs in gold with a solid gold line on the long sides that follow the spandrel shaped shoulder. The lips are also decorated with a solid gold line around their circumference (see Fig. 14.).

The two more narrow bottles share the same description as the large bottles, but have a square shaped belly instead of rectangular. They also have gold lines that follow the spandrel and cover the finials of the stoppers, but have flower and foliage designs on each shoulder corner instead of on the flat side (see Fig. 15.).

The stoppers are also made of colorless glass, and have round finials connected to a tapering ground shank. The finials are decorated with solid gold (see Fig. 16.).

The three flip glasses have a dodecahedral shape, having twelve equal sides. Their rims are decorated in solid gold, and a festoon of foliage and flowers, draped between three suspended ribbon bows decorates the circumference of the belly. There are no pontil marks on the bottom.

The stem glass has a simple and short extruded stem with a slightly ovoid shaped bowl, although the rim does not curve inwards. The glass has a thick foot, which is slightly off round. There is a pontil mark at the base. The rim is decorated with solid gold, and the bowl with the same festoon design as the flip glasses (see Fig. 17.).

Fig. 14. Baron von Steuben's large decanters.

Fig. 15. Baron von Steuben's narrow decanters.

Fig. 16. Baron von Steuben's narrow bottle stoppers.

Fig. 17. Baron von Steuben's stem glass and three flip cups.

7.2 Condition

7.2.1 Case Exterior

The wood and metal components of the case exterior were in a fair condition overall when they arrived to the Conservation Department for treatment. In summary, the main issues with the wood were that the lid was disconnected due to its badly damaged hinges; it has suffered extensive wear from use, including aqueous damage that distressed the wood surface coating; and there was tape adhesive residue on all sides. The metal hardware is in good structural condition, however it has also suffered damage, loss, and considerable ferric corrosion throughout. The lock was so badly distorted that it could not be inserted in to the receiver and therefore, the case couldn't lose properly.

General wear: dirt and scratches

The surface of the case shows its age and wear from use. It is covered in aged scratches, various accretions, and had a layer of surface dirt, which was most substantial on the topside where it was most likely to accumulate do to exposure from the elements. The top is therefore a shade darker and more matte than the other sides. Dirt had also accumulated under and around the metal strapping, becoming grimy in some of the interstices.

Fig. 18. The crack in the base of the chest was probably created due to shrinkage across the grain of the wood.

Structural damage

The wood used for the exterior had also suffered structural damages from cracking and loosening joints. There are several cracks along the grain, including one along the entire length of the bottom, where the panel had seemingly shrunk across the grain, creating a ¼" separation down the center (see Fig. 18). Other cracks throughout are small and extend along the grain from the nails.

Accretions

The case also had a variety of accretions on the surface, including a white-creamy material, black waxy material and newsprint stuck to the bottom. The most obvious and harmful accretion however was a thick tape adhesive residue, located on all sides except for the bottom. The tape encouraged dirt build-up, especially on the top, so those areas appeared darker in color than the rest of the wood (see Fig. 19). Although the adhesive was not easily

Fig. 19. The tape adhesive appears as dark strips on the top of the case because it had attracted dirt.

noticeable on all sides, its texture and presence could be seen clearly using UVA illumination, which caused it to fluoresce bright green.

Staining and discoloration

The color of the wood was uneven and damaged on all of its sides due to the tape adhesive, aqueous damage and migration of metal corrosion into the wood. There were spotted areas where tape was previously applied, where the wood was lighter in color than the rest, presumably because the tape either removed some of the darker wood finish or because it protected those areas from darkening from dirt and light exposure. Most of the staining and discoloration was from aqueous damage, often in combination with dirt buildup. The damage was located on all sides, but most dramatically on the front, back and top, where there were visible drip lines on which the wood finish had been compromised (and is lighter in color), and where liquid had carried the buildup of corrosion from the metal strapping into the wood grain, causing dark stains that stem from the metal. On the bottom side, aqueous damage had led to substantial staining and possible mold growth (now presumably inactive), concentrated in the top left corner. The newspaper fragments attached to the bottom may have become adhered at the same time the water damage occurred.

Identifying marks

There are a number of different marks throughout the case's exterior and interior surfaces that could have been made by the manufacturer of the case to help organize its assembly. The marks are written in red and are concentrated on the interior walls and shelf units, with dashes and symbols that correspond to the adjacent walls. In addition to these markings, there is a peculiar burn mark composed of two triangles on the bottom side of the case exterior. It would be interesting to investigate the other matching liquor cases mentioned previously to see if they have this marking as well, as it may have been made by the manufacturer or distributor as a type of branding.

7.2.2 Hardware

Corrosion

The iron strapping, lock, hinges, handles, and nails all showed significant red iron oxide corrosion throughout. Corrosion on the top side was much thicker and darker in color than on the other sides because, like the dirt, it was undoubtedly subjected to the greatest amount of exposure to the elements (see Fig. 20).

Fig. 20. There is heavy red iron oxide corrosion on much of the metal.

Structural damage and loss

The most pressing condition issue regarding the metal components was their extensive amount of loss and structural damage. Both the right and left hinges were broken, missing their central knuckle piece, so that the lid could be fully lifted off of the base. The left hinge was also missing 2” of its strapping as well as the nail that held it in place. Another two 1” pieces of strapping were also missing from the top, bottom and back sides of the case.

Fig. 21. The green outlines the scattered areas of a thin, degraded surface layer less than 1mm thick.

In areas across the surface of the metal components were the remnants of a thin layer of what at first appeared to be a paint layer, less than 1mm thick (see Fig. 21). The layer was stable, but had obviously suffered major loss (see section 8.3 on materials analysis).

Fig. 22. The lock had been bent upwards so that it could not be inserted into the receiver. The nails attaching it are also lost.

The metal components had also suffered significant distortions. The top portion of the lock on the lid had been bent upwards (see Fig. 22), and thus lost the nails that were once used to keep it down. The top of the lock receiver was also bent inwards, so that even if the lock were straight, it would not be able to be inserted into the receiver. The metal strapping is also significantly distorted on the top and back sides, where it bends up and down like small humps in the areas between its nails.

7.2.3 Case Interior

The components of the case interior could be considered to be in fair to poor condition overall before treatment. In summary, all of the components were badly stained from dirt and grime throughout; the flip cup and stem glass shelf units were cracked and unstable, as well as two of the compartment dividers and a flip cup shelf post, which were not secured in place; the paper had suffered extreme loss, aqueous and pest damage, and was extensively uplifting; the fabric was badly stained from dirt and ferric corrosion from its nails; and the strap that held the lid in place when open has been lost.

Dirt and staining

All of the interior wood surfaces were extremely dirty, with grime build-up especially on the base and at the corners and edges. There was also evidence of insect habitation with casings found in many of the interstices where the wood components connect. The interior surfaces were also covered in dark stains and blotches throughout, especially on the right and left sides, which were probably mostly caused by aqueous damage.

Structural damage and loss

Various components of the interior wood were damaged and unstable, including the flip cup holder, which had several cracks and a disconnected post; the stem glass shelf, which had several cracks, was distorted from its base shrinking across the grain, and had its central divider disconnected; and the large compartment dividers, which were able to shift and swing, in danger of becoming disconnected.

The most distracting loss to the interior wooden components was the one missing piece of wood of the three pieces used to hold down the stem glass shelf when the chest was closed.

Finally, throughout the interior of the case, extensive insect grazing patterns gave evidence of multiple previous infestations. The grazing along the grain of the wood on the stem glass shelf suggested a wasp infestation (Mussen 2010), while other grazing patterns may have belonged to wood boring beetles, responsible for the singular exit holes on the exterior of the case, and cockroaches, who may have fed on the paste paper, which also showed extensive grazing.

7.2.4 Interior Paper and Cloth

The paste paper lining the interior of the case may have been the most unstable material of the entire object. The majority of it had been lost, but the little that remained was significantly uplifting throughout due to a failed paste adhesive and insect infestation. The largest portion of the existing paper, measuring less than 4 x 9”, was left in only a mere section of left side of the lid and was widely detaching (see Fig. 23). The other

Fig. 23. The largest piece of paste paper remaining is located on the left side of the lid interior. It is almost completely detached.

small piece scattered throughout, were fraying and uplifting around their edges. In addition to its loss and instability, the existing paste paper was markedly dirty, stained, yellowed, embrittled, and significantly damaged by insect grazing.

The cotton strips of fabric attached to the tops of the compartment dividers with nails, were also slightly darkened and browned from age and dirt accumulation. They were stained due to the migration of ferric corrosion into the fabric from the nails that attached it to the wood.

7.2.5 Glassware

The majority of the glassware was considered in good structural condition before treatment, with its main issues concerning loss and surface accretions.

Structural damage and loss

The most distracting condition concern was the broken glassware with lost pieces. Two of the large and one of the narrow decanters were broken at their necks, although one of the large rectangular bottles still had a piece of the broken portion in tact. The rest of the broken portions were lost. And although four bottle stoppers were retained with the object, one of both the large rectangular decanters and narrow decanters were missing their stoppers.

Crizzling

Small networks of hairline fractures known as crizzling were also seen within all of the decanters, and especially the large rectangular ones (see Fig. 24). The crizzling is best seen using microscopic observation. The phenomenon is due to alkali salts leaching out of the glass and depositing on the surface, an inherent degradation property of glass

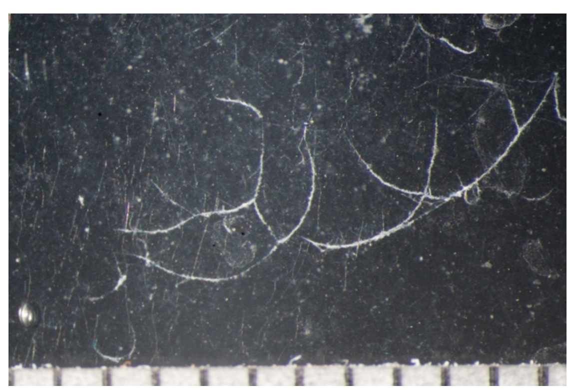

Fig. 24. Detail of crizzling on large decanter. Field size: 7.3 x 10.9mm

(the process of crizzling is further explained in Section 11.1).

Accretions

All of the bottles had light surface dirt on their interior and exterior surfaces. Most also had a thin, cloudy, white accretion on their interior walls, which was most likely from the liquid which once filled the bottles, since drip marks and layering lines could be seen where the accretions were thickest. The contents may have also increased the leaching of alkali onto the surface, which was also the cause of the cloudy and sometimes opalescent, surface effect. A brown-red dust was found at the bottom of some of the decanters as well.

In addition to unintentional accretions, one of the broken, large rectangular bottles had a red wax on the interior of its neck and along its break edges (see Fig. 25). Historically, in addition to glass and cork being used as stoppers, wax was used, often in combination with parchment or another material (McKearin 1978) to keep liquid secure while in use. It is possible that the stopper was lost and the neck of the glass broken during use, and that the wax was used to maintain the functionality of the bottle. The wax may also be the remnants of a previous restoration, not done while in use.

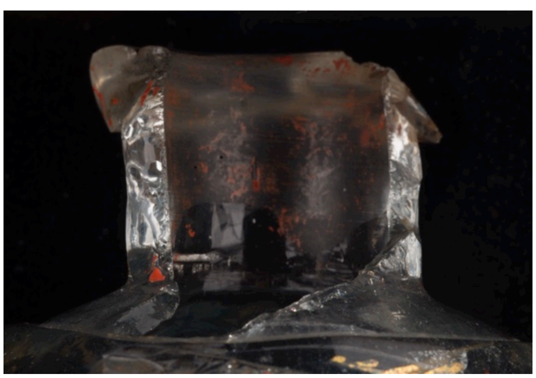

Fig. 25. The red wax is adhered to the interior of the neck and also on the break edges.

Wear

All of the glassware has small scratches throughout their exterior surfaces. These were probably caused by wear during use, perhaps even from the act of taking them in and out of the case. The gilded designs are also worn and lost in many areas, most significantly along the bottle rims and the bottle stopper finials. Remains of the fixative used to adhere the gold is still visible in the lost portions (it is fused to the glass), so the complete design is still decipherable.

7.3 Previous Restorations

The liquor case may have had several past restorations, all now very aged.

A small block of wood, about 1 ½ x 1 ½" was glued into the bottom of the left narrow decanter compartment. This was most likely done for aesthetic reasons in order to lift the bottle with a missing stopper to the same height as the ones with their stoppers, creating the illusion that the set is complete.

As mentioned previously, the white fabric lining the top of the compartment dividers, as well as the remnants of a leather strap along the right side of the lid and base may have also been restorations, as the nails used to attach them are both different than the original nails used on the exterior and also for the fabric strap on the left side of the case interior. They may have been attached in order to replace the fabric or paper lining and the right strap after they were lost or damaged.

Finally, the red wax on the large broken decanter was most likely a very early repair made to the bottle while still in use in order to continue to use the bottle after its neck had broken.

8 MATERIALS ANALYSIS

8.1 Purpose of a Technical Study

The material analysis of artwork can reveal many lost stories about an object's history. In the case of Baron von Steuben's liquor case, many questions regarding its manufacturing techniques were answered upon examination, but other information has become lost with time with the records of the glassmakers and blacksmiths who constructed the case. In this study, analysis was performed on the wood, metal and glassware in order to characterize the materials in more detail, and better situate the object in the context of 18th century industry in Europe and the American colonies.

There are several main questions that were attempted to be answered during the technical analysis of the case's materials. They are: Can identifying the wood help to establish an origin of production? What in the composition of the iron causes its uncharacteristic greenish hue? What is the thin degraded surface layer on areas of the metal? Was it an original coating, now lost? What ingredients were used to make the glass? And how was the object gilded?

Various methods were used to carry out this analysis, including ultraviolet (UV) and infrared (IR) imaging, optical microscopy, and X-ray fluorescence spectroscopy (XRF).

8.2 Analysis of Wood

Analysis of the wood was carried out in order to see if its identification could help to establish an origin of production. Although upon visual examination, a person versed in woodworking may be able to guess that it is an Oak variety, the type of Oak is harder to decipher without the aid of a microscope. Quercus rubra, commonly known as Northern Red Oak, is native to North America. Although it was introduced into Europe as an ornamental tree as early as the 17th century, it was not successfully introduced into forest ecosystems until the end of the 18th century (Woziwoda 2014:39-40). Thus, if the case's wood can be identified as Red Oak, the possibility of it having an American origin would be much more convincing, since Red Oak was common in the colonies and readily used. Quercus alba, commonly known as White Oak, on the other hand was a very common species in both Europe and North America during the 18th century (Abrams 2003) and would lead to more uncertain conclusions about the case's origin. Identifying the wood species, however, can have other beneficial purposes besides establishing an origin of production. Wood reacts to stress and strain from humidity in varied ways, some being more sensitive to change than others depending on species (Erhardt 2011:342). Thus, identifying the wood and knowing its properties can be beneficial in case the object were to ever travel to locations with varied environmental conditions. Additionally, if the case were to ever be damaged and need a replacement piece, the conservator would know what wood to choose for carving their fill.

Fortunately, the identification of the wood in von Steuben's liquor case was achieved without having to remove a sample. A small area on the left side, on the base panel, was chosen due to its discrete location and the accessibility of the end grain for analysis. Using a single edge razor blade, an extremely thin layer of the surface, less than 1mm thick, was removed in order to reveal a clean surface, free of grime and surface coatings that might complicate analysis. The end grain was then observed using a Wild 650 microscope at 800x magnification, with a field size of 7.3 x 10.9mm.

The wood revealed the identifying characteristics of Oak: the end grain was very ring-porous, with large earlywood pores arranged radially, followed by smaller latewood pores within each growth ring; and it had large multiseriate rays and narrow uniseriate rays, which is especially characteristic for Oak. Other wood elements were visible as well, such and lighter masses of mixed parenchyma cells and tracheids surrounding the early and latewood pores, and dark masses of fibers running parallel to the rays (see Fig. 26). Red and White Oak are distinguished by a number of elements, including ray height, the presence of tylosis and the size and arrangement of latewood pores. Because my sample size was no larger than ½ x ½", ray size could not be used for characterization since White Oaks usually have rays taller than 1 ¼", much larger than the sample area. Upon close examination, tylosis was indeed present. Tylosis, bubble-like structures that form in the vessels, although sometimes seen in Red Wood, is generally considered a marker for White Oak, in which it is abundant, especially in the heartwood (Hoadley 1990:29, 34, 100-103). The latewood pores seen within the sample were very small and plentiful. They seemed to gather around the earlywood pores and continue to the outer edge of the growth ring in smaller numbers. Their abundance, small size and distribution are more characteristic of White Oak, since Red Oak latewood pores are much larger, easily counted and align in a more radial pattern. Thus, the examination of the wood using microscopic observation suggests that the wood is Quercus alba, or White Oak.

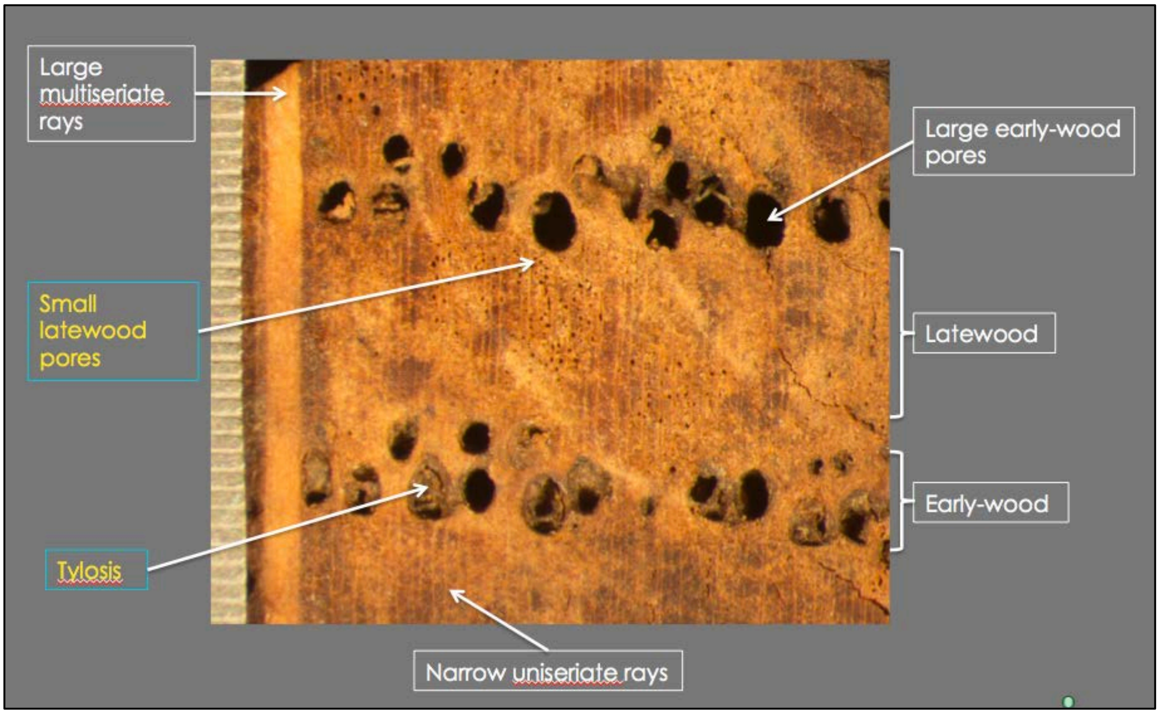

Fig. 26. End grain under magnification with different wood elements. Field size: 7.3 x 10.9mm

8.3 Analysis of Metal

Analysis of the metal was carried out in order to determine the cause of the greenish hue of the iron, and to characterize what seemed to be a degraded coating on portions of the metal strapping and lock mechanism. XRF was chosen to investigate these questions because it is a non-destructive technique and can be extremely successful at characterizing inorganic materials. The technique generally works by emitting X-rays onto the sample, which interact with each of the elements on its surface. The interaction causes energy transitions to occur within the elements' atoms and ultimately produces secondary X-rays that leave the sample at the same angle at which the primary X-rays were fired. They hit a detector and are ultimately converted into electron pulses, analyzed, and displayed in a spectrum of X-ray energies (Henderson 2000:15). There are many factors affecting the quantitative results of XRF spectra that will not be discussed in this report, but the analysis does provide valuable insight that can lead to confident suggestions about the elements present.

To analyze the metal using XRF, spectra were collected using a Bruker Artax 400 energy dispersive X-ray spectrometer system. The excitation source was a Rhodium (Rh) target X-ray tube with a 0.2 mm thick beryllium (Be) window, operated at 45 kV and 800 uA current. The X-ray beam was directed at the artifact through a masked aperture 3 mm in diameter. X-ray signals were detected using a Peltier cooled XFlash silicon drift detector (SDD) with a resolution of 146.4eV. Spectral interpretation was performed using the Artax Control software. Spectra was collected over 60 seconds (live time *or* real time). No filter was used.

Analysis of the metal on the back, left strapping and the bottom right of the lock receiver showed a large peak for iron, with trace element peaks for copper, arsenic and tin (see Fig. 27). The back of the lock receiver was also analyzed after it was removed from the case during treatment. Upon removal, it was evident that a large amount of silvery metal was present on the surface. This was analyzed using XRF, which showed peaks for tin, with trace amounts of copper and arsenic (see Fig. 28).

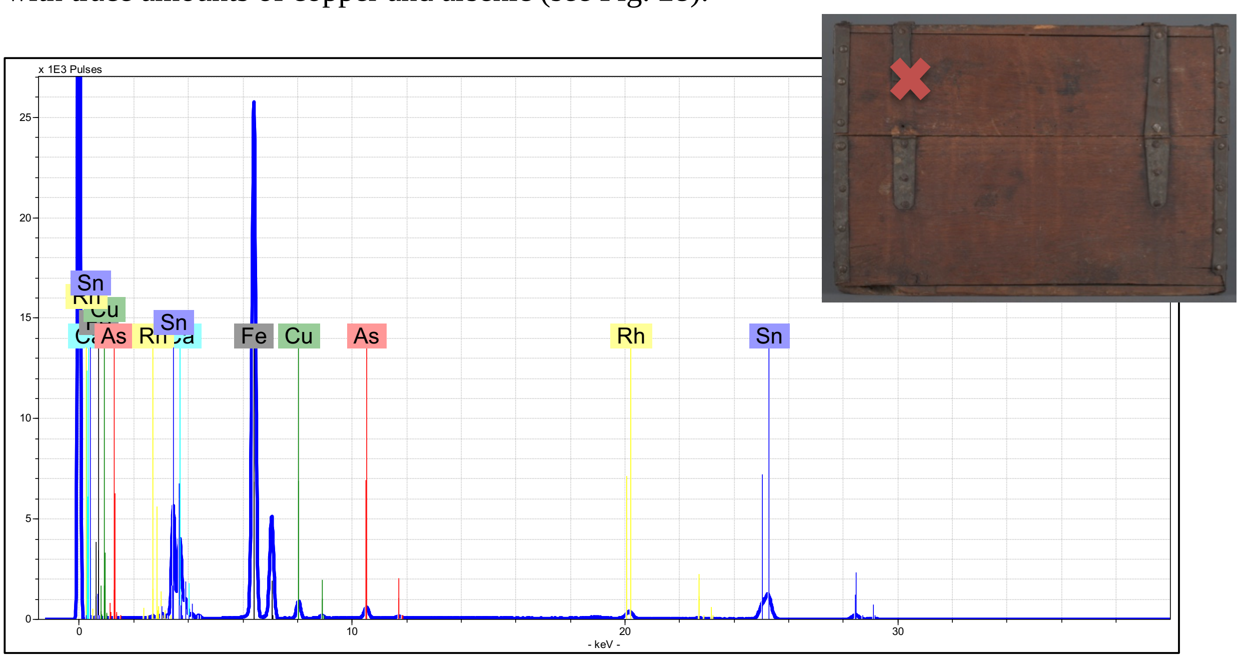

Fig. 27. XRF spectra of metal strapping on the case lid. taken at 45kV voltage, 800uA current, 3mm collimator, Air, no filter, 60 seconds. Note the same main elements of iron, copper, arsenic and tin, that the lock shares (Fig 28).

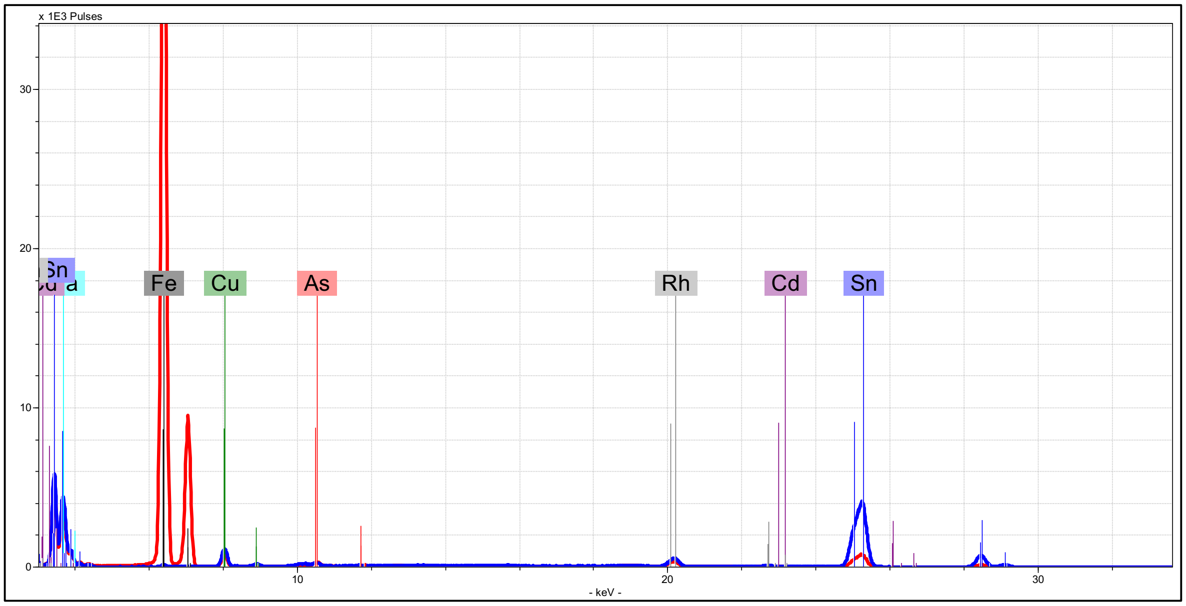

Fig. 28. Lock: Spectra taken at 45kV voltage, 800uA current, 3mm collimator, Air, no filter, 60 seconds.
Red spectrum: Exterior metal of lock receiver mechanism. Note the large peak for iron.
Blue spectrum: Interior metal of lock receiver mechanism. Note the large peak for tin, and absence of iron.

Although conclusions can only be inferred and not proven, the analysis suggests that the metal components were originally "tin-dipped," as was discussed in Section 5.2 describing the manufacturing techniques. Tin is commonly found with copper, as with "hard tin" which has a 0.4% Cu content, or in Pewter, which is typically tin with 2% Cu and other elements such as antimony (Avner 1974: 522). These metals, and especially pewter, would have been readily available materials, recycled to serve the purpose of tinning, and would explain the trace presence of copper on both the exterior iron and interior tin sample areas. This would also explain the thin degraded layer that appears in areas throughout the metal strapping and lock. Tin coatings were an attractive technique, since they made the iron more appealing as well as rust resistant. In practice, tin does prevent the corrosion of iron as long as the coating is complete. Unfortunately, if the iron is exposed to moisture at any point, corrosion can be initiated. The electrons from the iron move into the tin, making the iron more anodic (Lower 2016). A galvanic reaction thus ensues, in which the tin is actively promoting the corrosion of the iron, which can pop off the tin layer as it spreads, leaving only remnants behind, as seen in von Steuben's case metal.

Although neither iron or tin is known to create a greenish hue upon corrosion, the copper within the tin surface layer may have deposited on the iron surface and created the green patina. Additionally, the peak for arsenic is very small and could thus be an inclusion in either the tin or iron components.

8.4 Analysis of Glassware and Gilding

Analysis of the glassware and gilding was carried out in order to gain insight about its elemental composition and the gilding process. Discovering this information can be beneficial for dating glassware based on historic recipes, for adding evidence to the manufacturing techniques, and also to inform the conservation treatment (for instance, discovering how the bottles were gilded can inform whether or not the gold is safe to wash). UVA (longwave ultraviolet radiation) and UVC (shortwave ultraviolet radiation) were used in conjunction with XRF analysis to form conclusions.

Ultraviolet imaging uses radiation of wavelengths from 100nm to 400nm on the electromagnetic scale. When bombarded with this radiation, the electrons within certain materials will become excited and may fluoresce as a result. Von Steuben's glassware was subjected to UVC radiation, from 185-280nm, and UVA radiation, from 320-400nm. These methods are used in conjunction to identify or locate differences between materials that are not visible in normal illumination. In order to see only the ultraviolet induced fluorescence of the object, UV absorbing filters were placed on the camera to limit violet coloration and record the true fluorescence of the object.

Under UVA irradiation, von Steuben's glassware fluoresces a bright yellowish-green color (see Fig. 29). This is a very typical fluorescence for "potash" or potassium-based glassware. If the glassware were a lead-based variety, such as flint glass for example, it would have fluoresced an icy-blue (Grant 2000). Under UVC irradiation, the glassware fluoresces a deep orange. What was seen in UVC that was not apparent in normal or UVA irradiation is that a bright blue fluorescence occurred in the areas surrounding the gilding, indicating that there is either a separate material in the glass composition in those areas, or that there is a different material on the surface (see Fig. 30).

Fig 29. Glassware under UVA induced visible fluorescence. The yellowish-green hue is indicative of "potash" glass.

Fig 30. Decanter in UVC-irradiation. Note the blue fluorescence surrounding the gilding.

The potassium based composition of the glassware, the blue fluorescent areas, and the gilding, were further investigated using XRF. In order to check the potassium based glass composition, XRF was performed using the same methodology used to examine the metal, with a few alterations. Because elements respond to the X-rays based on their atomic weight (Henderson 2000:16), the primary X-ray energy was adjusted to 15kV, instead of 45kV, to gain a response from elements such as potassium and calcium with relatively low atomic weights, below that of iron. Additionally, a helium purge was used to enhance the sensitivity to light elements. The results at 15kV showed major peaks for silicon (Si), potassium (K) and calcium (Ca), which in combination with UVA analysis, further suggests a "potash" glass. There were also trace element peaks for aluminum (Al), titanium (Ti), manganese (Mn), and iron (Fe) (see Fig. 31).

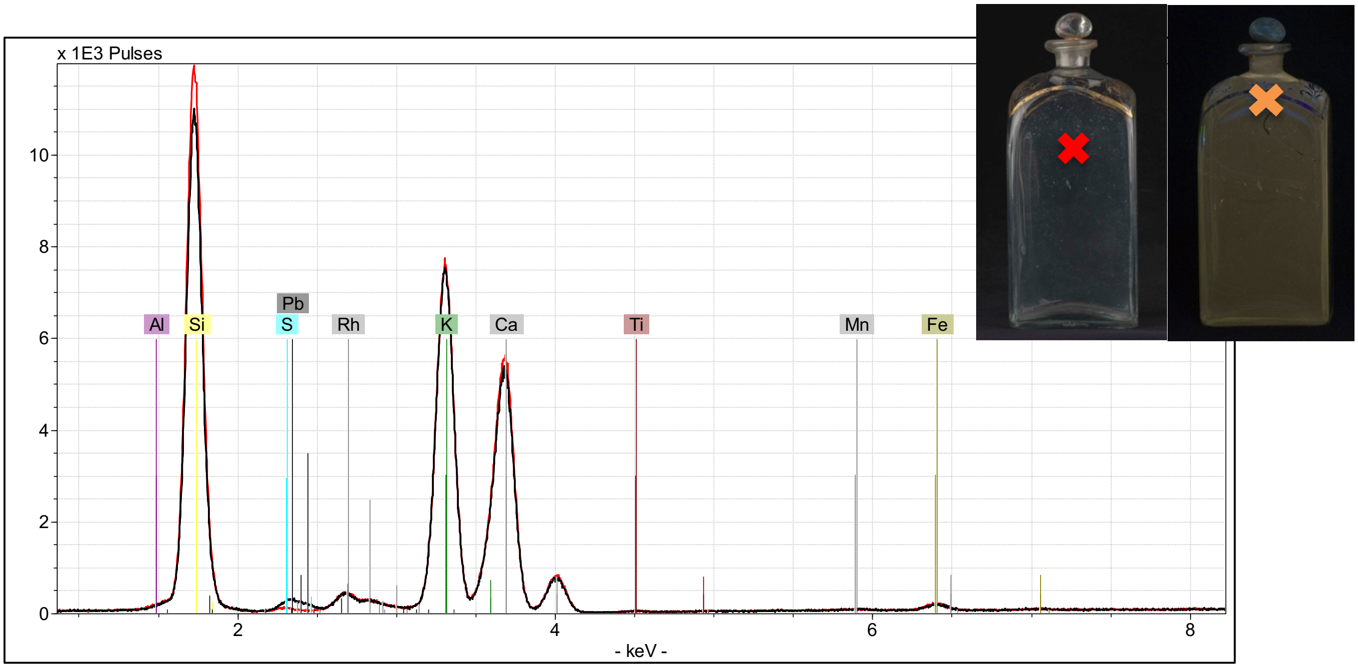

Fig. 31. Base glass, 15kV: Spectra taken at 15kV voltage, 1500uA current, 3mm collimator, He flush, no filter, 120 seconds. The photographs show where the samples were taken at both 15kV and 45Kv (Fig.32)
Red spectrum: Base glass, non- fluorescent area. Note the Si-K-Ca composition, indicating a "potash" glass.
Black spectrum: Base glass, fluorescent area. Note the small peak for lead.

An energy of 45kV, without a helium purge was used to detect higher atomic weight elements (Fe and higher), that may have been used as colorants and additives in the glass. The XRF spectra showed a large peak for arsenic (As), and trace element peaks for copper (Cu), rubidium (Rb), strontium (Sr), and zirconium (Zr) (see Fig. 32).

The elements found to be contributing to the composition of von Steuben's glassware are not surprising. The potassium-calcium-silicon combination is a common base glass composition, with the potassium added as a flux and the calcium as a stabilizer (as discussed in Section 5.1). The large peak for arsenic is also not surprising, as arsenic was an important oxidizing agent that contributed to decolorizing the iron (Weyl 1999:118). Manganese, sometimes substituted with Magnesium, is added to the glass mixture as a decolorant. Due to its purple coloration, it offsets the natural green coloration from iron found in the sand (McKearin 1978:10, Lindsey 2016), essentially using laws of contrasting colors to cancel each other out. The peak for titanium is so small that it is hard to draw any conclusion from it, however, Ti is sometimes associated with

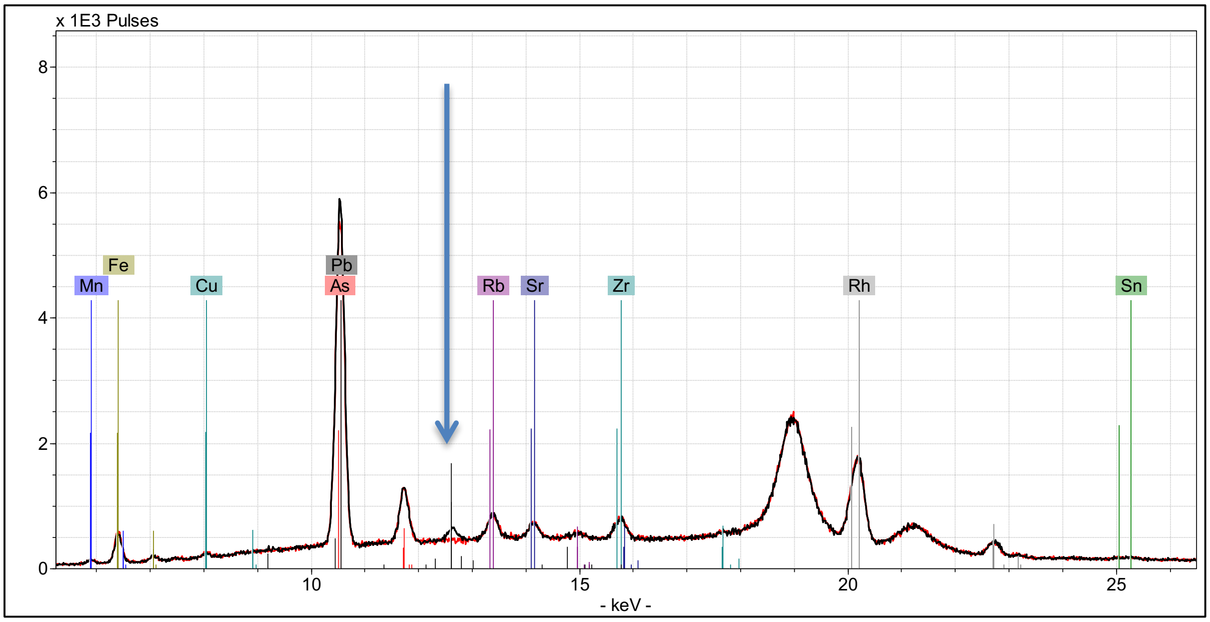

Fig. 32. Base glass, 45kV: Spectra taken at 45kV voltage, 800uA current, 3mm collimator, Air, no filter, 60 seconds.
Red spectrum: Base glass, non- fluorescent area. Note the large primary and secondary peaks for arsenic, and the absence of a secondary peak for lead (indicated with the green arrow), showing that lead is not in the glass composition
Black spectrum: Base glass, fluorescent area. Note the small secondary peak for lead.

manganese to alter the color of glass (Weyl 1999:213). Rb, Sr, and Zr are all linked to the glass silicate matrix.

XRF was also used to gain insight about the blue fluorescent areas under UVC irradiation that surround the gilding. A fluorescent area of the base glass was chosen for analysis at both 15kV with a helium purge, and at 45kV without the helium. By comparing the results against the spectra run on areas of the non-fluorescent glass, it is clear that the only difference between the two, at both energies, are small peaks for lead (see Figures 31 and 32). If lead were part of the glass composition, it would have undoubtedly shown up as a peak in the 45kV spectra for the non-fluorescent areas, given its large atomic weight. Thus, the results indicate that the lead is on the surface of the glass, and is therefore probably related to the gilding medium.

This is further suggested with XRF analysis of the gilding, also conducted at 45kV, no helium flush. The spectra for the gilding show large peaks for gold and lead, with a trace element peak for iron. On an area where the gilding was worn away, but were the transparent medium was still visible, the spectra showed a large peak for lead, and trace peak for iron (see Fig. 33). These results support the gilding mechanism already discussed in the manufacturing techniques section, which is that a lead based medium was used to apply the gold onto the surface. This is a known technique, used in combination with heat, to fuse the gold to the surface. The areas of blue fluorescence that seem to flow down the shoulders of glass away from the gold, were probably lead medium that escaped the brush of the artist. The small trace peak for iron is possibly insignificant and could be present due to a small inclusion in the material, or from dirt on the surface.

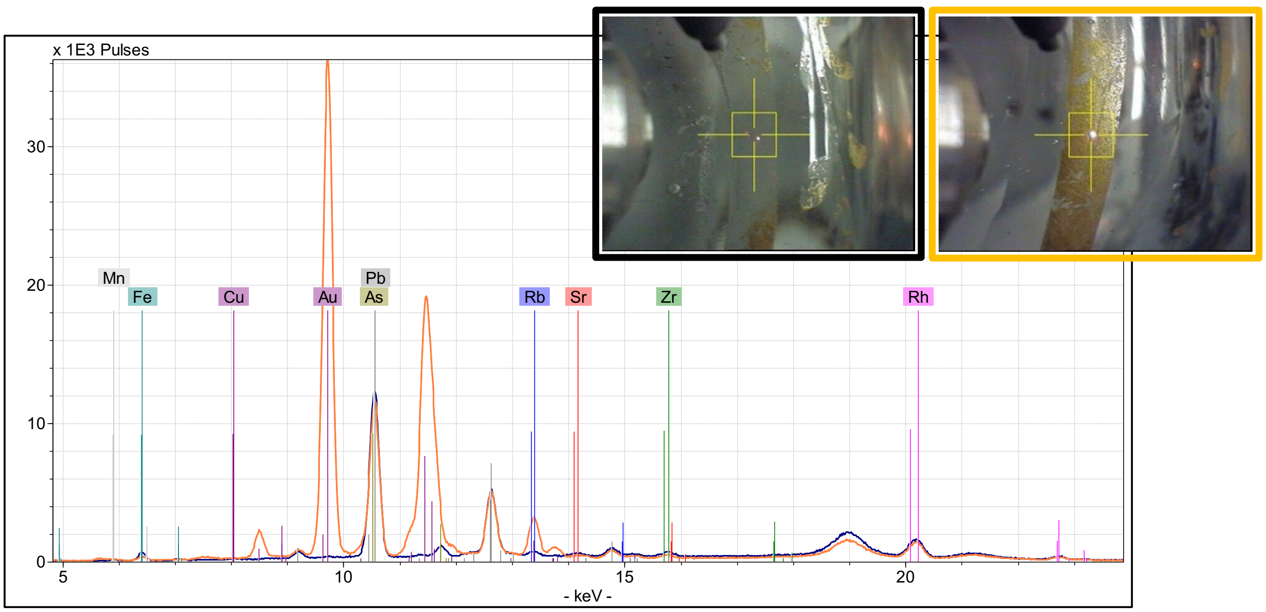

Fig. 33. Gilding: Spectra taken at 45kV voltage, 800uA current, 3mm collimator, Air, no filter, 60 seconds.
Orange spectrum: Gilding on decanter shoulder (bottle ----). Note the high concentration of gold, and the smaller peak for lead.
Blue spectrum: Gilded area on the same decanter where gold has worn off. Note the slightly higher peak for lead and the absence of gold.

8.4 Analysis of Newsprint

On the base of the chest there can be found remnants of a yellowed and stained newspaper. Although the paper is definitely not original to the case, it was not removed during the conservation treatment because of its appearance of being very old. In an effort to confirm this assumption and find out more about the origin of the paper, infrared imaging was used to decipher the text in the paper, which is unreadable in normal illumination due to soiling. By using various filters on the camera lens that only permit radiation in the infrared region of the electromagnetic spectrum, from 700-1000nm, to be recorded, the text in the paper could be seen below the brown surface dirt and grime.

The IR images (see Figures 34-35) revealed a number of words and phrases that could then be researched as keywords for matches on the Internet. The results of the research seemed to suggest that the main article was about the replacement of a Judge David Sanford by Judge Charles Sedgewick in Litchfield County, CT, circa 1870 (Kilbourn 1909; CSCE 1864).

Fig 34-35. The newsprint on the base of the chest photographed in normal illumination (on the left) and in reflected near-infrared (IR) (on the right), in which the text is much more legible.

9 TREATMENT

As noted in the research objectives and goals of treatment, the main priority for conserving von Steuben's case and glassware was to stabilize its components and make aesthetic repairs to damages that distracted from the overall comprehensiveness of the object. Because it is not a decorative arts object, its aged and worn quality was preserved during treatment instead of attempting to perform involved cleaning in order to restore it to its original appearance. It is believed that this approach helps to preserve the integrity of the object by preserving its history of use and can more easily spark the imagination of visitors who want to visualize its past.

The treatment was approached in sections due to its many different materials and component parts. The exterior wood of the chest was treated first, followed by the interior wooden components and paper. The metal was addressed afterwards as a final step before reattaching the lid. The glassware was then conserved to complete the treatment.

9.1 Exterior Wood

The main issue needing to be addressed on the exterior of the case was the buildup of dirt and the thick adhesive residue left behind by a pressure sensitive tape. Surface dirt was easily removed by vacuuming and the dirt build-up underneath the metal strapping could be reduced with small tightly wrapped swabs with acetone. The adhesive was best solubilized in acetone and ethanol, however, in order to lessen the amount of time the solvent made contact with the wood, to avoid absorption and harming a possible shellac coating, it was decided to use acetone, which evaporates more quickly. The adhesive swelled upon contact with acetone and could be lifted off with swabs. More stubborn areas required longer contact, which was made for about 30 seconds using a blotter with acetone, covered in Mylar to prevent evaporation. After swelling, obstinate adhesive residue could then be gently scraped off with a metal spatula. Throughout the process of removing the adhesive, the case was periodically viewed in the dark under UVA radiation in order to see the progress of the adhesive removal and find areas where the residue was not obvious in normal light.

The results of the cleaning were very successful. Although under UVA irradiation, remnants of the adhesive can still be seen embedded in the grain of the wood (see Fig 36), it was removed for the most part and will no longer be visually distracting or a threat for attracting dirt.

Fig. 36. The top of the case before treatment in normal and UVA irradiation (on the right) and after treatment (on the left). Note that the adhesive is no longer visible in normal light, but that under UVA, the damage it caused and small remnants still caught in the grain are visible.

9.2 Paper Components

Perhaps the most fragile and damaged component of the entire object needing conservation was the paste paper interior lining. Methods that would allow the paper to be removed from the case and washed were sought out due to its dramatic staining and grime on the surface. Because the red pigment was very water soluble, ideas such as coating the coloring with cyclododecane before washing were discussed. Ultimately, safely washing and removing the paper from the case would have been very time consuming, and also put the paper at more risk than was appropriate for the treatment. The dirt was able to be reduced very slightly using dry eraser crumbs after consolidation using wheat starch paste with deionized water. This method of stabilization was also performed on the newsprint on the base of the chest. Paste had to additionally be painted onto a thin strip of Mylar and inserted under the largest piece of paper on the right side of

Fig 37. The yellow lines indicate one of the areas where almost invisible Japanese paper bridges were made between the paper and the wood. Note the weights on the left where the paper had just been re-adhered using wheat starch paste.

the lid in order to attach the uplifted areas that were unreachable with a brush. After inserting the Mylar, the paste and paper were held in place and the Mylar strip pulled out. This proved to be a successful method for laying down the majority of uplifting areas, and because the paste was used very dry, it did not create new tide lines. To complete the stabilization of the paper, small, essentially invisible Japanese paper fiber bridges were made along some of the borders between the paper and wood, in order to add additional security to avoid future uplifting (see Fig. 37).

9.3 Interior Wood

The severe staining and soiling of the interior wooden components were not addressed beyond a simple surface cleaning using a vacuum to remove embedded dirt and insect frass, and dry erasers for more ingrained dirt. Like the exterior surface, more involved cleaning methods were avoided in order to preserve the aged and worn quality of the case.

The damaged and unstable interior components, such as the cracked stem glass shelf and its divider, and the flip cup holder and its post, were repaired using fish glue and clamped for drying. In the case of the post and shelf divider, the original adhesive had to be swelled and removed to provide a clean surface for contact with the new adhesive. The compartment dividers that could shake and swing within their slots were immobilized by painting Japanese Paper with wheat starch paste, twisting it, and inserting it into the slot to fill the gaps. The paper was colored beforehand with acrylic paints and matched the color of the wood, so that it would not be distracting after application.

An ethical question emerged upon correcting the distortions in the stem glass shelf, whose base had shrunk across the grain and thus detached from its walls. In order to correct the distortions and reattach the base to the walls, a small dowel originally used for the connection would have been compromised (see Fig 38). Although it is never desirable to remove portions of an original material, in this case it was decided to remove a small piece of wood, so that the shelf could be corrected without breaking the delicate dowel, which is an important indicator of the woodworking techniques used for the shelf's construction. The distortions were then corrected using fish glue and clamped in place to dry (see Fig 39).

Fig. 38. The arrow points towards the small dowel compromised by the distortions to the base.

Fig. 39. A small piece of wood was removed to the left of the dowel before the base was re-adhered using fish glue.

In addition to stabilization and cleaning, the missing wooden component of the lid mechanism meant to hold down the stem glass shelf was deemed aesthetically distracting since it is such a large loss. A decision was made to replace the piece and make the lid component complete again. A similar piece of soft wood, White Pine, was chosen, as its grain is very similar to the interior wood, which is also most likely of a Pine variety. The piece was cut, planed, shaped, colored to match the wood using watercolors, and then glued in place along the original glue lines using fish glue (see Fig 40-41). The addition was successful in creating a more harmonious aesthetic for the lid interior.

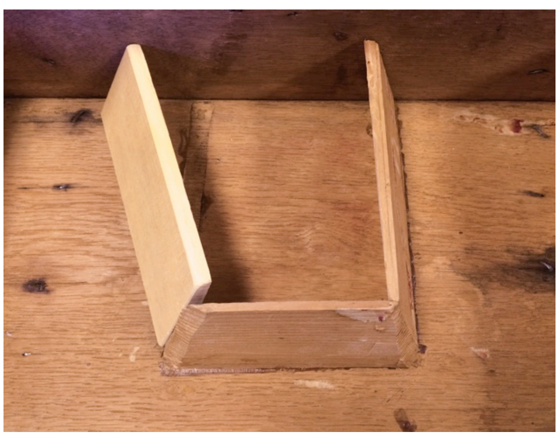

Fig 40. A similar soft wood was chosen and shaped to match the original missing lid component.

Fig 41. The replacement piece was colored to match using watercolors and glued in place.

9.4 Metal

Corrosion

The heavy red iron oxide corrosion was addressed initially by using fine steel wool (grade 0000) dipped in petroleum benzine to gently reduce the level of the corrosion to be planar with the un-corroded metal components. This initial reduction greatly improved the appearance of the metal. Following mechanical corrosion reduction, a tannic acid solution was used to passivate the remaining ferrous corrosion by converting it to a stable black iron-tannate layer. This is a common tactic used for the conservation of ferric metals because it halts corrosion and increases the lifespan of the metal. The newly converted iron tannate layer is darker in color, which was noted in areas, such as the lock mechanism (see Fig. 42). Overall the dark coloration is in harmony with the original dark hue of the forged steel. Many of the corroded areas did not convert however with the tannic acid, which could be a positive signifier that the metal is already relatively stable and resists organic solvents.

Fig 42. The lock mechanism darkened slightly after treatment with tannic acid.

Lock and Receiver

After the surfaces of the metal had been treated, the distortions and losses to the lock and hinge components were addressed. In order to correct the distortions in the lock that prevented the case from being closed properly, the mechanism had to be removed. This required that the remaining nails be pulled out. Another ethical question was thus presented: Because two of the nails had

Fig 43. The tips of the nails bent on the interior were cut off using an electric rotary tool.

been bent-in on the interior and were embedded in the wood, they could not be straightened and removed

Fig 44. Distortions were corrected by hammering the metal between pieces of wood (on the left) and by using a number of other wooden tools with rounded tips (on the right)

without damaging the wood. A decision therefore had to be made about whether or not to cut off the bent tip of the nail, or damage the wood to get to the tip for straightening. Removing the nail tip was the better decision based on aesthetic reasons, since scratching the wood would cause very noticeable damage to the texture and color of the surface. The nails were cut using an electric rotary tool with a small burr attachment, and the nails were safely removed (see Fig 43). The nails were then also treated with tannic acid.

The distortions in the lock and receiver were reduced by carefully hammering the bent areas using a rawhide and plastic hammer with a variety of soft wooden tools with rounded tips (see Fig 44). Correcting the distortions between pieces of wood ensured that the original texture and hammering marks from the blacksmith would be

Fig 45 (left). The lock receiver stuck in its *locked* position, preventing the arrow from being inserted. Fig 46 (right). Two mild steel wedges are used to keep the lock in its *unlocked* position, allowing the lid to be closed.

preserved without imparting new marks.

After the lock and receiver were straightened, it was discovered that the lock receiver was in the locked position, and unable to be unlocked. This made it impossible to insert the lock into the receiver and thus close the lid properly; and is most likely why the lock and receiver were bent in the first place (see Fig 45). To allow the straightened lock to be inserted easily into the receiver so that the case could be closed, the teeth were carefully pried open into their unlocked position, and two mild steel wedges were cut and shaped, and inserted at the sides of the circular spring mechanism to prevent it from closing again. The wedges are held securely in place by pressure from the lock, and the receiver is now secure in its unlocked position (see Fig 46).

In order to re-attach the lock and receiver, several of the original nail holes needed to be re-drilled so that the nail head could lay flush on the surface of the metal. Prior to removal, several of the nails were in diagonal positions, possibly becoming distorted when the lock mechanism was pulled, or due the shrinking and expansion of the wood. The minimal changes to the nail holes allowed them to be inserted straight and to better secure the metal in place. A small amount of 25% Paraloid B-72 in acetone was applied to the nail for added security before securing the lock and receiver back onto the chest. Once the nails were inserted, the tips were re-bent into their original positions by hammering them against a rounded iron tool, which gently bent them into place.

Hinges

The lost portion of the left metal strapping on the back of the chest, as well as the right hinge knuckle pieces (see Fig 47), were recreated using a piece of mild steel (low carbon steel), forged to match the thickness of the original strapping. The iron was forged by repeatedly heating it to a glowing orange color followed by hammering on an anvil. Once it was flattened sufficiently, it was reheated again and drawn through a rolling press until the correct thickness and flatness was achieved to match the original strapping components (see Fig 48). It was annealed slowly, being allowed to cool at room temperature over several hours. An iron replacement was chosen because it was available and is possibly the most appropriate choice for aesthetic and technical reasons. By choosing a metal with the same composition, it limits the potential of a galvanic reaction occurring in which one metal can promote the corrosion of the other.

Fig 47. The highlighted areas (in light gray) show the pieces of iron strapping that were reproduced.

Fig 48. Piece of mild steel forged and shaped before being cut and rusticated for the replacement hinge pieces.

The right and left replacement hinge pieces and left strapping were then cut out of the forged metal using a jeweler's saw. The left strapping and left hinge piece were incorporated into one piece (see Fig 47) (originally the hinge knuckle was made separately and nailed behind the strapping) and the original bro ken hinge knuckle on the

Fig 49 (left) and 50 (right). Back left hinge before and after treatment. The new , forged iron, replacement part (on the right) attaches the lid to the base and allows the case to be opened. closed.

right was removed and replaced by the new one. The nail securing the hinge was also bent on the interior and thus had to be drilled off before being pulled out as was described previously.

The curled central knuckles for the right and left hinges were shaped using jeweler's tools and rounded pliers. The worked texture of the original strapping was recreated by hammering the replacements and their color was adjusted to match the greenish hue of the original metal by applying hot pigmented wax resin (see Fig 50).

Nails

Nails were made in order to reattach the left hinge and replace the lost nails on the lock mechanism. The nails were made from larger rounded nails, and made to match the originals by grinding down the heads to be flat, imparting texture by hammering (mimicking blacksmith work), and then filing the shafts to be square with a tapered end (see Fig 51). The length and width of each nail was individually adjusted to fit into its corresponding hole. A dark fire scale patina was achieved using a torch.

Fig 51. Filing rounded nails square to match the shape, length and width of the originals.

The hinges were then secured in place, first using a small amount of 25% B-72 in acetone to adhere the metal to the wood, and then with nails - the original nail for the right hinge and the replacement nail for the left hinge. The left hinge nail had previously been secured through the thin rabbet of the case lid (instead of the thicker, lid wall, used for the right hinge nail), so in order to make sure the nail would be held securely in place, the tip was split using a jeweler's saw before being inserted, so that it could be butterflied on the interior, making a very secure connection. The original broken right and left hinge pieces were placed in a polyethylene bag and will be retained with the object, but remain unattached.

Once attached, the replacement hinge knuckles and nail were painted with Golden acrylics on the case interior to add a patina. Acrylics were used instead of wax resin (used on the exterior) because acrylic paint will be able to better withstand the wear from opening and closing the lid.

Fig 52. Sophie Hunter completing the treatment of the case by bending the replacement knuckles around the original pins.

As a final step, the replacement knuckles were bent around the original pins (see Fig 52), which successfully re-attached the lid, making it functional again, and completed the treatment of the case. The case can now be open and closed safely.

9.5 Glassware

The glassware was washed to remove dirt and alkali on the surface by first using a very dilute solution of tap water mixed with Triton XL-80N. A large piece of cotton attached to the end of a wire was used to reach the interstices of the narrow bottles and avoid scratching their surface. The glassware was then rinsed with tap water, followed by a thorough final rinse with deionized water. All washing was done over a soft plastic bin to avoid breakage in case the glass slipped. The glassware was then placed on a clean dish rack to drain and air dry. A small amount of acetone was introduced to the interior of the bottles to help with the drying process, since their narrow necks prevent the water from draining efficiently and drying.

The detached piece of the neck from the large broken decanter was cleaned along all of its break edges using deionized water and ethanol, followed by acetone to ensure complete dryness. It was then adhered in place using HXTAL epoxy. Application was done by placing small beads of the epoxy along the break edges, which spread throughout the break via capillary action when the piece was placed down. It was then left to dry for approximately 48 hours. A small sample of the HXTAL was kept on a piece of Mylar next to the object to be able to see when the adhesive had dried completely.

As mentioned in the description of the glassware, one of the broken decanters had what may be an historical wax repair on the interior and break edges of its neck (see Fig. 53). After discussing the wax with the Buffalo History Museum (see correspondence in Appendix 1), it was decided to leave the bottle broken, as the repair could have been made during use and is thus part of the object's story.

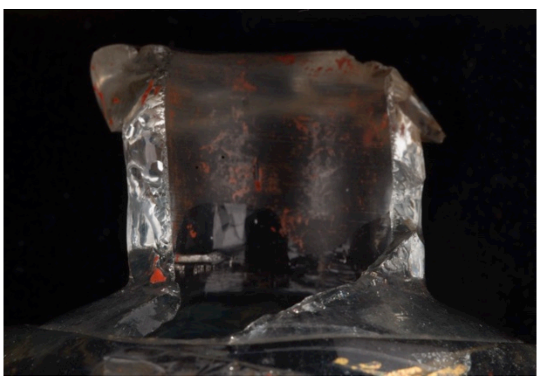

Fig 53. Detail of red wax on the mouth of one of the large broken decanters, possibly the remains of a repair made while the bottle was in use.

The lost portions of the glassware (on the narrow bottle and second large broken decanter) were re-sculpted directly onto the break edges using dental plaster (mixed with deionized water). Dental wax was shaped using the large decanters matching bottle stopper and placed inside of the bottleneck to back the plaster fill and ensure that the interior shape would be a correct fit for the stopper once completed (see Fig. 54). Sculpting tools and fine grit sandpapers were used to shape the fills and smooth them (see Fig. 55).

Once the plaster fills were complete, they were pulled off and placed in a bath of 5% B-72 in xylenes until they stopped bubbling, and then set on blotters to dry. The infusion of B-72 made them stronger to withstand handling and stress from pouring the mold.

Fig 54. The plaster fill was backed with dental wax, shaped using the bottle stopper to ensure a correct fit.

Fig 55. The plaster was shaped directly onto the glass over the wax and smoothed using various grit sandpaper.

Frames for pouring the mold were made using Plexiglass, sealed at the edges with non-sulfur-containing plasticine (sulfer inhibits the silicone from drying, so the type of plasticine used is important).

The fill pieces and original stopper (the stopper was also recreated for the narrow decanter missing its own) were secured inside of the mold frames using small wooden dowels and/or plasticine, attached with a small bead of B-72 in acetone. The dowel is used to keep the fill in place and the space serves as the pour and air-escape hole after the mold is dry.

Clear silicone rubber was mixed and placed in a vacuum chamber to de-aerate, which rids the silicone of bubbles that can interfere with the final pour. The silicone was then poured into the Plexi mold frames and allowed to dry (see Fig 56). Once dried, the molds were strategically cut open using a scalpel so that they could be easily re-connected and used

Fig 56. Clear silicone rubber mold made of the small glass decanter's stopper, ready to be poured with HXTAL epoxy.

again for pouring. Small channels were cut out of the mold in a few areas for epoxy and air escape holes, which prevent bubbles from getting trapped. After the plaster fills were removed, the silicone molds were reconnected using Plexi and rubber bands, and then poured with HXTAL epoxy, the final glass fill material. The HXTAL was allowed to dry inside of the molds for 4-5 days.

The cast pieces were sanded down using 1,200 grit wet dry sandpaper attached to small bamboo skewer tips, followed by 32,000 and 36,000 micro-mesh. Once the surface was smooth, a very thin layer of HXTAL epoxy was painted over the surface using a bamboo skewer cut like a quill pen, to bring back the translucency of the material. The epoxy was left to dry for 48 hours (see Fig 57). The bottle stopper base was sanded flat using a belt sander and its body slight cut down using scalpels so that it could fit into the narrow bottle.

Fig 57. The fills were attached to the bottle using HXTAL before being "frosted" on the interior and the lip gilded.

The decanters have a frosted appearance on the interior of their necks from being ground during production. This frosted appearance was recreated by mixing floated silica with HXTAL epoxy and painting it onto the interior surface of the restoration piece in the same pattern as the original.

The final step to complete the restoration of the glassware was the application of the gilding. Quick epoxy was thinly applied to the areas to be gilded and quickly wiped off. Pure gold powder was then pounced onto the surface to recreate the worn appearance of the original gold (see Fig 58-59).

Fig 58 (left). Large decanter with completed fill (top half of mouth) – attached and gilded.
Fig 59 (right). Small decanter fill (bottom right of lip) and replica stopper completed.

10 DISCUSSION OF TREATMENT

The main goals of the project - to stabilize, analyze and restore the object to a safer, more longer lasting and aesthetically cohesive state, were accomplished, thus making the conservation treatment of von Steuben's liquor chest a successful one. However, as is most always the case with the conservation of materials, there are often several ways to approach a treatment, and this object was no different. Throughout the project, various methods and ethical questions were debated, their pros and cons argued, with final decisions made carefully, but not without hesitation.

One of these questions was regarding the use of HXTAL epoxy for the repair and restoration of the glass decanters. HXTAL, although produced for the field of conservation, is believed to have a lifespan of no more than one hundred years (Koob 2006: 48) before beginning to yellow, as most epoxies do. This makes it a less desirable adhesive and consolidant than Acryloid B-72, which is another common resin used for the conservation of glass. Given the high refractive index of the clear glass, however, and the thickness of the fills, HXTAL was chosen over B-72 for its more similar refractive index, its strength, and its ability to be shaped and made glossy after setting. Overall, it was an aesthetic decision. Because of the potential HXTAL has to yellow and the degree of difficulty required to reverse a repair made with it though, it was decided to make the fill separately from the decanter, as was discussed in section 9.5 about sculpting a plaster fill first that was then turned into a removable HXTAL fill using silicone molds. Because the fill was created separately as opposed to directly onto the glass, it will ultimately be easier to remove in the future if its ever required to do so.

Other questions arose during the treatment regarding the ethics of altering and destroying original material in order to carry out aesthetic and stabilization steps. For instance, in order to remove the distortion in the base of the stem glass shelf, a very small fragment of wood had to be removed so that a small dowel would be left undamaged. In another instance, the small tips of original nails were cut in order to leave the wood undamaged while the lock mechanism was removed for its repair. The tannic acid treatment of the iron components also altered the original appearance of the metal by slightly darkening it. And finally, original nail holes, which had warped with the expansion and contraction of the wood over time, were re-drilled in order to straighten the path of the nails and allow them to be inserted completely into the wood (the nails could not be inserted completely prior to this step and would have stuck out of the holes at various angles had they not been re-drilled). In all of the above-mentioned instances, non-destructive solutions did not seem to be an option after prioritizing the results of these treatment steps, which in the above cases, were the dowel and stability of the shelf; the appearance of the wood; the passivation of harmful corrosion; and the stability and appearance of the lock mechanism.

Although conservators aim for all of their treatments to be irreversible and non-destructive, this is often an impossible goal to achieve. The most one can do is weigh their options against the goals of the treatment and make the most informed and respectful decisions possible. Despite the minor adjustments made to the original material of the case, those sacrifices brought the object into an improved condition overall.

11 RECOMMENDATIONS FOR STORAGE AND EXHIBITION

In addition to the treatment carried out, preventive conservation measures will be important to secure the long-term stability of Baron von Steuben's liquor case. There is a plethora of concerns in regards to this object's preservation due to the variety of materials it is composed of. For instance, the wood, metal and glass are all sensitive to humidity, but only the wood and paper elements need to be monitored for pest infestations; where light exposure may influence the glass, they may not have any effect on the metal components; or where normal handling may be suitable for the case, special precautions may be necessary for handling the delicate glassware. Most of the materials in Steuben's case should remain stable in a standard museum storage environment, thus, the following storage and exhibition recommendations concentrate on the glassware, since glass degradation is so complex and requires more informed management.

11.1 Relative Humidity

Perhaps the most pressing element to consider in order to ensure the long-term stability of glass, is its contact with water. As previously mentioned, the analysis of the glassware shows that it has a base composition of silica, potassium (K_2O) and calcium (CaO). When glass has extensive contact with water, either as a liquid or via humidity in the air, potassium within the composition can be leached out onto the surface, being replaced by smaller hydrogen protons from the water (Newton 1996: 136). Potash glass (KCO_3) like Stueben's is at an even higher risk than other types of glassware (like soda-lime glass) because K_2O is so soluble (Koob 2007: 13-14) and the potassium ions are larger (which leaves more space empty within the composition after they are leached out). The leaching of these alkali salts is what caused the crizzling noticeable under magnification, and is also what caused the opalescent streaking and cloudiness seen in some areas on the interior walls of the decanters. Luckily, von Steuben's glassware has not progressed beyond the initial stages of crizzling, even after over two hundred years of being exposed to very harsh climates (as evidenced by the shrinkage and aqueous damage of the wood). If kept in the right conditions, the glass should be able to remain stable for many years to come.

The first preventive measure to inhibit the continuation of leaching potassium salts, is to wash the glassware and remove alkali already on the surface. This was performed during the treatment, and the glassware should not have to be washed again, unless an increased crizzling or cloudiness is noticed. In that case, another washing should be carried out as directed on the treatment report (see Appendix section 16.6).

Monitoring humidity levels is the next most important preventive measure. Glassware must be kept in an environment with moderate humidity levels. Levels of 60% RH and higher can lead to more leaching, and low humidity levels of 30% and lower can cause the glass to crack, thus, it is important that RH levels between 40-50% be aimed for during storage and exhibition.

11.2 Light Exposure

Light does not commonly pose a great threat to the stability of glass, however von Steuben's glassware has trace amounts of manganese within its composition, which makes it a notable exception to the norm. Manganese dioxide, originally used to decolorize the glass, will become photo-oxidized with prolonged exposure to ultraviolet radiation and become pink or violet in color (Koob 2007: 139). Thus, UV filters on the lights or display cases are critical when displaying this item. Lighting should also be designed so that the buildup of heat on the glass is also prevented, since heat can increase the crizzling phenomenon and speed up degradation.

11.3 Handling

Although gloves are often used when handling museum objects, if glassware is to be handled for an extended period of time, then it is considered safer not to wear gloves. Gloved decrease one's ability to grip the smooth glassware and detect areas of fragility. Considering this, it is extremely important that bare hands be washed and dried completely and continuously while handling so as not to impart lotions, hand oils, or dirt on the surface of the object.

11.4 Storage

In order to further lessen the chances of water exposure, the glassware should no longer be stored inside of the wooden liquor case. Wood absorbs humidity readily, being a cellulosic material, and thus can create a microenvironment within the case, where humidity, heat (which speeds up the crizzling process), and acidity, can build up and lead to faster degradation.

Furthermore, the glassware should ideally be stored within an archival box that allows for air circulation so that a humid microenvironment is prevented. Storing the glass within a box can also act as a buffer against extreme fluctuations in temperature and humidity and lessen the amount of dirt build-up on the surface. The materials that make direct contact with glass in the storage mount should not be able to hold moisture, which might subject the glass to prolonged water exposure if the materials were to ever become absorbed (Koob, 133).

The same requirements apply during exhibition. If the object is displayed in an enclosed vitrine, a small fan or dehumidification systems would be helpful to regulate humidity levels and circulate air within the case. If that is not possible, desiccants like silica gel can be used if appropriately monitored (for replacement). If the glassware is displayed within its case, the case should remain open, and a material, such as Tyvek (spun-bonded polyethylene) be placed in-between the glassware and wooden compartments. This will create a separation between the absorbent wood and glass surfaces and prevent abrasion.

11.5 Wood Preservation

There are also many factors to consider regarding the preventive care of wood. Because this wood is old and more stable than the glassware in typical museum collection environments, it will only be discussed briefly. Like the glass, humidity is an important factor to monitor, since the wood can expand if it absorbs water, and shrink when it dries out. The wood in Steuben's chest has experienced huge fluctuations of this type as noted in the base panel, which has a ½" wide crack because of shrinking across the grain. If maintained in a controlled environment, further distortions than the ones that already exist should not be a possibility.

Off-gassing is often a concern with wood in regards to the items that are stored around it. This oak was cut over 200 years ago and has probably off-gassed as much as it is going to, and thus should not pose a large threat to surrounding materials (Erhardt 2011:242).

The following steps are suggestions regarding the most pressing issues regarding the glass and wood components of the object. They may help to limit the damages caused by agents of deterioration and inherent degradation.

12 CONCLUSION

Overall, the conservation and restoration of von Stueben's liquor case was successful. The unstable structural elements of the case, such as the damaged interior wooden components, the delicate paper, and the metal hinges were stabilized, which will help to prevent further damage and loss caused by handling and temperature and humidity fluctuations. The surface treatment of the object was also successful. The reduction and passivation of corrosion, alkali on the glassware, and grime and tape adhesive on the wooden surfaces will prolong the life of the materials and slow the process of deterioration. Furthermore, the restoration of the glassware, and various components of the wooden case accomplished the final goal of the treatment, to create a more unified appearance by making the damages less distracting.

Baron von Steuben's liquor case proved to invaluable to me as a student of objects conservation. The many materials composing the object – metal, glass, and wood, as well as the nature of the various components – the case acting as a more utilitarian object, while the gilded glassware fell more easily into the category of decorative arts, made the treatment, analysis, and goals of the project broad and diverse. Not only was it an educational tool to learn about conservation treatment, but through research and analysis it also became a tool to learn about the history of glassmaking, paste paper production and metalworking in 18th century America. The rich history of the liquor case led to lessons in the history of commerce and craft in the colonies, especially regarding the spirits trade and glass industry, both of which played a central role in the struggles that led to the fight for U.S. Independence. Finally, it taught me about Baron von Steuben, who helped shape the future of the country, carrying the liquor case with him from one battle campaign to the next, stopping for the occasional brandy to cope with and celebrate battles along the way.

After withstanding over 200 years of life, surviving wars, economic depression, rain and sunlight, travel on horse and in automobile, and many late nights with cocktails, there is a hope that the conservation of this object will help the effort to preserve it as an item of cultural and historical importance for generations to come.

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15 AUTOBIOGRAPHICAL STATEMENT

Sophie Hunter received a Bachelor of Fine Arts degree in History from the University of Chicago in 2007. Before starting her graduate education in art conservation at Buffalo State College, she completed conservation internships at the Southwest Museum of the American Indian - Autry National Center, in Los Angeles, CA, the Smithsonian National Museum of African American History and Culture, in Washington, D.C., and for Fine Arts Conservation and The Conservator's Easel, both private studios in Hollywood, CA. She has also worked extensively in the Education Department of the Natural History Museum of Los Angeles County and in the Collections Management Department at the Autry and the Academy of Motion Pictures Arts and Sciences Museum in Los Angeles. The experiences Sophie accrued throughout her internships and employment positions influenced her desire to work with a diverse range of historical objects and artifacts.

During her graduate education at Buffalo State College, Sophie has completed conservation treatments of both ethnographic, historical and decorative art works, as well as a research project investigating copper corrosion using Pourbaix diagrams. During the summer of 2015, she completed treatments and technical analysis of an eighteenth century chapel in a historic church in Guadalajara, Mexico and two murals with the Escuela de Restoracíon y Conservacíon de Occidente. Sophie will spend the summer of 2016 at George Washington's Mount Vernon Estate in Virginia and the following year at the Museums of New Mexico Museum Resource Division conservation labs in Santa Fe, NM, where she will receive mentorship from Maureen Russell and Mina Thompson, while assisting in the treatment of objects from the history, folk art, and American Indian collections.

Sophie will receive a Master of Arts and Certificate of Advanced Study in Art Conservation with a focus in objects conservation from Buffalo State College in September 2017.

16 APPENDICES

1 Correspondences with the Buffalo History Museum

2 Examination Report

3 Examination Report Images

4 Treatment Proposal

5 Treatment Report

6 Treatment Report Images