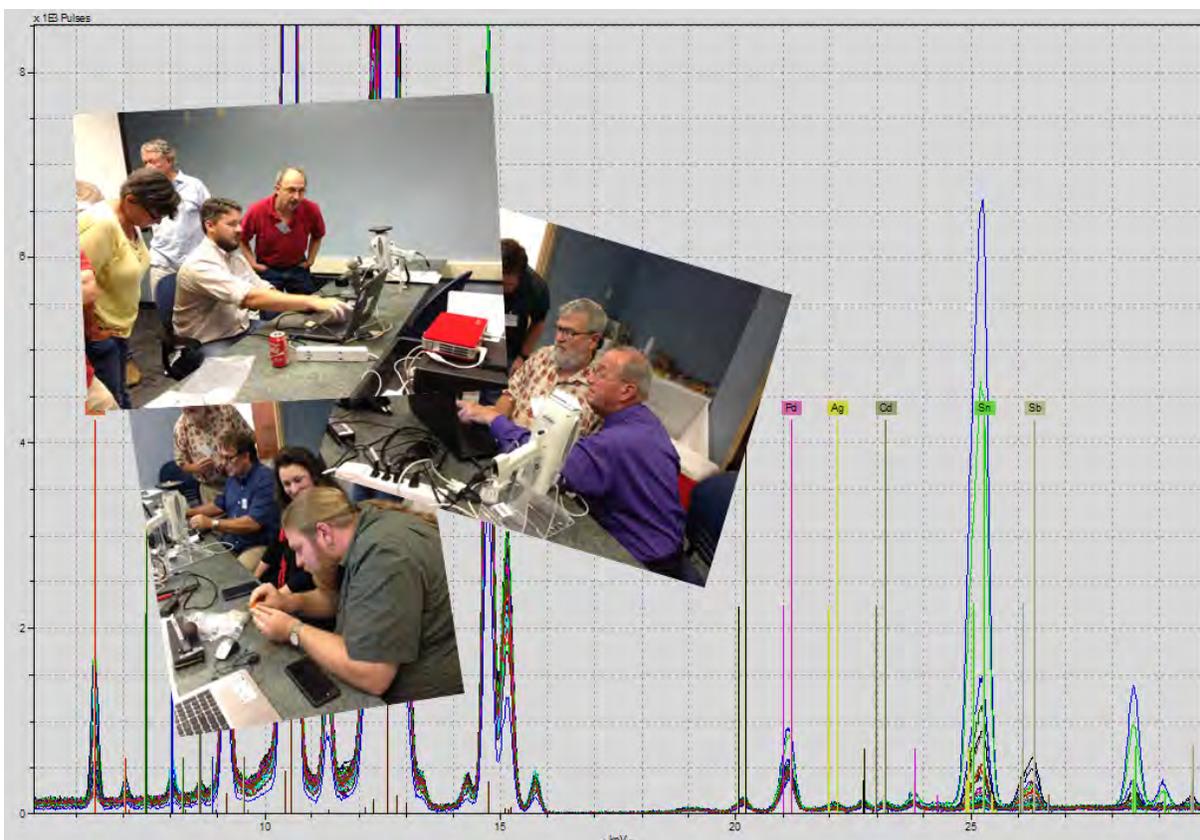


## ***Get the Lead Out:***

# **Towards Identifying Ammunition on Eighteenth- and Early Nineteenth-Century Battlefields and Settlements**



## **LAMAR Institute Publication Series, Report Number 205**

**The LAMAR Institute, Inc.  
Savannah, Georgia**

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**The LAMAR Institute, Inc.**

**Savannah, Georgia**

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## Executive Summary

This report details the results of the 2017 Get the Lead Out! Workshop that was conducted by the LAMAR Institute and National Park Service in June, 2017. It also incorporates data from an earlier 2015 workshop, as well as elemental data collected by researchers since 2012. Small arms ammunition in America, throughout the eighteenth- and early nineteenth-centuries, consisted of round soft-metal balls. These were mostly lead, although archaeologists have documented other metals such as pewter and silver as additives. Available small arms and related ammunition varied by military unit, and included pistols, rifles, trade guns, carbines, fowlers, and large caliber wall guns, as well as American, French, Spanish and English weapons. Macroscopic identification of associated bullets alone limits battlefield interpretations. Seibert and Elliott present a formalized regimen of lead ball analyses that combines elemental characterization (portable X-Ray Fluorescence, or pXRF) along with traditional descriptions and quantitative measurements. Traditional analysis documents diameter, weight, firing condition (impact evidence, rifling, worming, ramrod impact, casting evidence), alterations (chewing, cutting, carving), other post-depositional damage (rodent gnawing), and archaeological context. The elemental information collected by pXRF shows promise in identifying ore sources, contaminants introduced, firing condition, age, and military association. If combined with other data from lead ore sources, including isotope studies, baseline information can be developed for comparison among battlefield assemblages and incorporated into a global dataset with the purpose of better understanding the geographic distribution of military supplies and military strategy at macro global and regional levels, as well as at micro-battlefield levels.



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## I. Introduction

This monograph presents the findings from early work and two Portable X-Ray Fluorescence (pXRF) workshops that addressed the elemental composition of round ball ammunition from early sites in North America.

Previous study of Eighteenth-century lead (round ball) artifacts from archaeological sites have explored various physical aspects of these objects (Sivilich 1996, 2004, 2016; Branstner 2008).

A December 2015 pXRF Workshop explored the elemental composition of round ball ammunition from several archaeological contexts in the southeastern United States (Elliott 2016a). Preliminary investigations on this topic by researchers with the National Park Service, Southeast Archeological Center and the LAMAR Institute demonstrated the potential for pXRF to distinguish bullets within battlefields and between different archaeological sites. Using a Bruker Tracer III handheld unit in 2015, archaeologist Daniel Elliott (LAMAR Institute) sampled several hundred round balls gathered from Revolutionary War battlefields in Georgia and South Carolina, from Colonial and Early Federal fortifications in Georgia and from Native American village sites in Georgia. This preliminary work also has shown that pXRF technology works well when applied to older museum collections. Bruce Kaiser processed Elliott's data and determined that significant elemental differences were manifest in the various assemblages. The cultural meaning of these differences remains an active discussion and the proposed workshop will build on this early work. For example, was the addition of tin and antimony intentional to improve the ballistic performance, or was it simply done of necessity in the absence of reliable and abundant lead sources? Are non-lead additives linked to specific military groups or armies, or to specific weapon types? Larger samples from a variety of sites were required to assess the full utility of this technology, however, and participants recognized that another workshop was a logical step in pursuing this research.

The LAMAR Institute organized a larger workshop that was funded by a 2016 PTT Grant (Grant Number P16AP00371) from the National Center for Preservation Technology and Training (NCPTT), which was entitled, "Get the Lead Out: Elemental analysis of 18th and early 19th century ammunition in eastern North America." This workshop was held on June 29 and 30, 2017.

The NCPTT workshop, which was held at the Coastal Georgia Center in Savannah, Georgia brought together archaeologists, museum curators, and physicists to explore the elemental composition of small arms ammunition of the eighteenth and early nineteenth centuries in North America. Workshop attendees employed portable X-Ray fluorescence (pXRF) technology on small samples from their respective archaeological study sites or museum collections. Attendees were guided by physicists who are highly trained in the theory and expectations, methods and data processing of these pXRF datasets in the analysis of their collections. The results from the workshop form the basis of a continuing elemental database on early ammunition. This database is intended to distinguish between the elemental composition of ballistic artifacts. As the dataset grows in its variety and sophistication, other topics, such as sourcing, may be approached using this information.

## **The Problem**

Small arms ammunition from the eighteenth and early nineteenth centuries is difficult to identify since it consists of round metal balls of varying sizes. Unlike later ballistics from the Civil War, few attributes serve as clues to the people who possessed the ammunition. While attributes such as bullet diameter (caliber) and weight offer some indication of the weapon types from which the bullets were fired, many gaps remain in defining these enigmatic metal artifacts. Furthermore, bullets that have been fired and heavily impacted are often rendered unrecognizable for traditional analysis. With pXRF researchers are offered a significant advance in artifact identification which, when combined with other artifact attributes, can greatly enhance the understanding of a bullet assemblage and its historical context on the battlefields and military encampments.

Archaeologists' expectations for pXRF in the study of round ball ammunition were great, albeit naïve. We had hopes of using this technology as a sourcing tool. That task is better served by isotope analysis, which is not covered by pXRF. Elemental analysis with Bruker technology does provide useful information, however, about the composition of lead ball assemblages from various sites that eventually may provide important insights into human behavior not available by other means.

## II. Background

### History of Lead Mining in Europe

Lead occurs at many locations throughout Europe. Lead mining has ancient roots with the Romans, Egyptians and other former civilizations. The Romans explored many lead deposits throughout Europe. Lead isotope analysis of Roman lead objects from several archaeological sites in Germany revealed that these objects came from ores in Germany and Britain (Durali-Mueller et al. 2007).

#### Great Britain

Great Britain abounds in major lead deposits, which have been mined since at least Roman times. Great Britain led the world in lead production from the seventeenth through nineteenth centuries. Many mines were active in Great Britain in the eighteenth century. England contained several areas where lead was extensively mined in the 1700s. In his 1774 study on lead poisoning physician Thomas Percival noted, "The river Derwent flows through a large tract of Derbyshire, which abounds with Lead mines" (Percival 1774:33). In his 1789 history of Derbyshire, James Pilkington (2007:95-130) described the lead mines of Derbyshire in greater detail. Percival (1774:36) also mentioned the white and red lead works in Sheffield, England. In a 1778 treatise on mining William Pryce refers to lead mining practices in Cornwall, England (Pryce 2010:243). Shropshire, England was another area where lead was extensively mined and smelted in the eighteenth and nineteenth centuries (Shropshirehistory.com 2017). Lead was mined at Tyndrum, Stirling District, Scotland beginning about 1741 (Moreton 2015). Lead was mined in Strontian, Scotland in the early nineteenth century (Good et al. 1813). Ireland also had lead mines in the 1700s. Sir William Petty (2007:vi) discussed the lead mines in Kerry, Ireland in 1769, which were first opened in 1667. Lead was also mined at Knocaderry, County Tipperary from ancient times until at least 1803 (O'Halloran 1803:205). Lead was mined at numerous locations in Wales in the early nineteenth century. These include mines at Holywell, Llanrwst in North Wales, Llangynnog, and Anglesea, Wales (Kauffman 1803:200).

#### France

Lead was mined at several localities in France in the eighteenth and nineteenth centuries. Lead was mined in Brittany [Bretagne], northwestern France in the early eighteenth century (Baker and Warner 1732:24; Duhamel 1780). Lead was mined in the Limosin region of central France in the late eighteenth century (Robinson and Robinson 1793). Lead was mined in Le Pesay, eastern France in the early nineteenth century (Williams 1807:73; Taylor and Peuchet 1815:186).

## Spain

Lead mining in Spain dates to Roman times. Early mining districts in southern Spain are known (Heriot 1914:358-361). Lead isotopes from these mines have been identified in Greenland Ice dating from 600 B.C. to A.D. 300 (Rosman et al. 1997:3413-3416). As late as 1914, Spain was the second largest lead-producer in the world. Lead production in Spain in the 1860s was second only to Great Britain among European countries (Fletcher 1991:200). Spain also obtain quantities of lead from mines from its colonies in Central and South America.

## History of Lead Mining in North America

Lead mining in North America in the colonial and Revolutionary War eras was extremely limited. Mines in eastern North America that operated in the eighteenth century have been documented in Connecticut, New York, Pennsylvania, Virginia and West Virginia. Production statistics for these eighteenth century mines are lacking. Suffice it to say that geological knowledge of North America was quite limited in that period and the mining activity was dwarfed in comparison to that of Europe. A boom in lead mining in the Mississippi River valley followed the Louisiana Purchase. By 1830 miners in the United States of America produced approximately 7,260 metric tons of lead. By the following decade that amount had increased to 15,420 metric tons, and by 1850, it produced 19,960 metric tons. By 1860, on the eve of the American Civil War, the U.S. produced 14,150 metric tons of lead (U.S. Geological Survey 1990:Table 1). By 1900, approximately 343,000 metric tons of lead were produced in the U.S., which was approximately 45 percent of the world's lead supply (U.S. Geological Survey 2017). The United States led the world in lead production for most of the twentieth century. Today, China is the world's leading producer of lead, followed by Australia and the United States.

## Connecticut

A Revolutionary War-era lead mine operated on Butler Creek near Middletown, Connecticut (Morse 1794:359; Ingalls 1908:87-88). Geologist J. Z. De Boer noted that, "the Middletown mine was originally opened to mine lead - one of only two sites in New England that produced the metal for the Continental Army during the early stages of the Revolutionary War. The operation began in earnest in 1775 when smelting works were built along the river to provide lead for ammunition, including cannonballs. Records show that the mine produced 15,563 pounds of lead and even helped defeat British Gen. John Burgoyne - and 6,000 British troops - during the Saratoga Campaign in 1777. The mine was opened periodically over the years after the Revolution, including a stint as a silver mine in the mid-1800s when huge stampers crushed tons of rock laden with silver" (Marteka 2009).

## Georgia

Our research has been unable to locate any references to lead mines in Georgia dating prior to the nineteenth century. By the nineteenth century miners had identified lead deposits in Georgia and several mines were opened. Pre-Civil War mining of lead is documented by the Canton Mining Company in Cherokee County (Shepard 1856). Additional lead mines in Georgia that developed in the later nineteenth and early twentieth centuries include: Rich mine and Evalee Richards prospect, Cherokee County; Magruder mine and Seminole/Magruder/Wardlaw/Jackson veins, Lincoln County; Landers, Tatham and Woodall mines, McDuffie County; Earnest Galena prospect, Murray County; McGarrity Prospect, Paulding County; Shiloh Church prospect, Polk County; McKenzie Mine, Quitman County; Habersham County occurrences[?], Rabun County; H. Amason prospect, Troup County and Chambers mine, Wilkes County.

## Massachusetts

Lead mining began at Southampton, Massachusetts in 1765. These operations were suspended by the Revolutionary War (Ingalls 1908:88). Lead was mined in Hampshire County in the early nineteenth century (Nash 1827:238-270). Lead also was reportedly mined at Worcester (Ingalls 1907:980).

## New Jersey

We were unable to locate any record of lead mining in New Jersey from the eighteenth century. Bristed (1818:62) notes that there were lead mines in New Jersey about 1818, although no specific locations were identified. The Sussex Lead Mine in Sussex County, New Jersey is the only identified lead mine. This mine was active in the mid-nineteenth century prior to 1893 (New Jersey Geological Survey 1893:426).

## New York

Lead was mined at Northeast in Dutchess County, New York as early as 1740. The Board of War wrote to Elias Boudinot in 1777 regarding Congress' desire to have New York Governor Clinton procure workmen to "work the Lead Mines in that Sate for Continental Use", and, "if Workmen cannot otherwise be procured your are to furnish him on request with such Numbers of Prisoners as he shall require" (Board of War 1777). Ingalls (1908:88) notes that, "attempts to obtain lead here were also made during the Revolutionary War, but the quantity available was too small to admit of profitable development".

## North Carolina

Our research has been unable to locate any references to lead mines in North Carolina dating prior to the nineteenth century. By 1838 lead was mined in four

counties in North Carolina, which were: Lead mine, Alexander County; Morganton, Burke County; Rocky River mine, Cabarrus County; and Silver Hill, Davidson County (1838),

### **Pennsylvania**

Fort Roberdeau was constructed by the patriots in 1778 near Birmingham in present-day Blair County, Pennsylvania to protect a lead mine and an associated smelting operation. The lead mine only operated for a few years (FortRoberdeau.org 2014; Ingalls 1908:88; Stapleton 1971:361-371). Daniel Roberdeau wrote to General George Washington on June 4, 1778 describing the fort at the lead mine, "To prevent the Evacuation of the frontier of Bedford County and, for the general defence against Indian incursions I have built with Logs at the Mine in Sinking Spring Valley at the foot of Fisher Mountain, a Fort, Cabbin fashion, 50 yds square with a Bastion at each Corner. The Fort consists of 48 Cabbins about twelve feet square exclusive of the Bastions." (Roberdeau 1778). The Continental Congress recorded in its journal for October 10, 1778 concerning a letter from General Armstrong, which stressed the "Importance of the Lead Mines upon the Frontiers of Pennsylvania", and Congress discussed the option to recommend to the State of Pennsylvania call out 100 militia, "to be stationed at or near the said Lead Mines" (Continental Congress 1778).

By the nineteenth century lead sources in eastern Pennsylvania were being exploited. Lead was mined at the Perkiomen Lead Mine in the early nineteenth century (Wetherill et al. 1826). Lead also was mined in Lancaster County about 1855 (Mitchell 1855).

### **South Carolina**

Our research has been unable to locate any references to lead mines in South Carolina dating prior to the nineteenth century. Tuomey (1848:127) debunks legends of lead mines in York County, which were secretly used in the American Revolution by concluding, "I invariably examined all such localities...I found no indications of lead at any of these places". Bristed (1818:63) notes the existence of lead mines in South Carolina about 1818, but no specific locations were identified. Lead was mined at the Cameron and Morgan lead mines in Pickens and Spartanburg counties prior to 1865 (Leiber 1860:69, 86; South Carolina General Assembly 1866:27). Lead deposits are reported more recently for three South Carolina counties, which include: an unnamed barite mine, Cameron, Kings Creek, Lavender Place, Silver Mine Ridge, The Big Incline, Wallace Gold Mine and West Hill mines and Northeast Barite Pit and Kings Creek Barite Southwest Area, Cherokee County; Barite Hill mine, McCormick County; and the Wright mines and Castles and McKnight prospects, York County.

## Virginia

Virginia served as the major source of lead in eastern North America in the eighteenth century. Whisonant (1996) summarized the early lead mining industry in southwestern Virginia: “The Wythe County lead mines that later came to be known variously as the mines on Cripple Creek, the Austinville mines, or the Wytheville mines ...were opened in 1756 by Colonel John Chiswell, a British officer who was a native of Wales and an early adventurer in southwestern Virginia...During the Revolutionary War, the lead mines produced significant amounts of ammunition for George Washington's Colonial Army” (Austin, 1977).

Wood (2014) notes that the lead mining operations near the New River in Montgomery County (now Wythe County), Virginia were started by William Herbert. The operation was shut down prior to the war but then reactivated during the war, again by William Herbert. Other modern sources note that Colonel Charles Lynch was in charge of the mines from 1777-1787 and that the, “lead was mined by slaves and guarded by the militia because this resource was an attractive target to the British” (avocamuseum.org 2014). These mines were near Fort Chiswell, Virginia and records pertaining to the mines are contained in the special collections at William & Mary College (McGavock Papers 1760-1888).

## Kentucky and West Virginia

Lead was mined in the Kanawha River valley in the American Revolution (Morse 1794:534). In 16780 Tories from North Carolina and Virginia attempted to capture these mines but were repulsed by the Americans. Leadmine run is a stream in Tucker County, West Virginia. Filson (2017:16) noted in 1784, “South of Green River, in the lands reserved for the continental and state troops of Virginia, an exceedingly valuable lead mine has lately been discovered”. Imlay (2013:21, 53) noted in 1793, “A lead mine has been worked many years with considerable profit, which lies in the county of Montgomery, upon the waters of Great Kanhaway. There is another between the Cumberland and Tenasee rivers which is said to be very valuable, and its ore is more pure than any other which has been discovered in America”, and, “The country between Green and Cumberland rivers is in general rich, and finely watered. There is in it a most valuable lead mine...”

## Illinois, Iowa, Missouri and Wisconsin

Lead mines were established by the French and Indians in the upper Mississippi River watershed as early as the 1680s. By the early nineteenth century lead mines were established at many locations in Illinois, Iowa and Wisconsin (Chandler 1829). The Fever River was one area where quantities of lead were mined as early as 1690.

Lead was mined in French Louisiana, now known as the Old Lead Belt of southeast Missouri, as early as 1721, when French explorer Phillipe Francois Renault began mining near present-day Potosi, Missouri. Early mining operations also were established at Mine La Motte, near present-day Frederickstown, Missouri. Lead ore was taken from the mines down the Mississippi River to Ste. Genevieve and eventually to France. Seeger notes that the French mining activity in the Old Lead Belt had tapered off by the 1750s (Seeger 2008:5, 10). No records have been found to indicate that the Old Lead Belt deposits in Missouri contributed significantly to the ammunition used in the American Revolution, although little or no primary research has been done on the topic.

The lead mining operations at Mine La Motte ceased in 1769, when it was destroyed by Chickasaw Indians. Mining there did not resume until 1780 or 1782 (Ingalls 1907:981). Imlay (2013:121) noted in 1792, “the lead mine on the Mississippi must prove inexhaustible. It extends from the mouth of Rock river more than 100 miles upwards. Besides these there are several others, some of which lie on the Spanish side of the Mississippi, and have been used for years past.”

With the signing of the Louisiana Purchase in 1803, the U.S. government took a heightened interest in the lead mines of the Mississippi River region. Moses Austin provided a description of the lead mines in Upper Louisiana that was read before Congress in 1804. It included descriptions of ten mining areas (Austin 1804).

By 1810 the lead deposits in the Fever River region were used by local U.S. Army troops (Thwaites 1895:271-292). By the 1830s, lead production in the Fever River region had outstripped that of Missouri. Production estimates for the period from 1823-1829 list more than 31 million pounds of lead produced from the Fever River mines, versus slightly more than 5 million pounds from the Missouri mines (Hinton et al. 1852, Volume 2:172). By 1844 an estimated 30 million pounds of lead were produced annually in this region (Murray 1844:209-210). It is not presently known if lead from this region made it to market in the Eastern Seaboard prior to 1810 or in the following few decades.

By the late nineteenth century Missouri was a global leader in lead production. It remains a major producer of lead in the twenty-first century (Missouri Department of Natural Resources 2017).

### **Lead Ball Production**

Lead (Pb) is a chemical element with the atomic number 82. It has several properties that make useful to mankind. It is a dense, heavy metal that is soft and malleable (Mohs hardness of 1.5) and it melts at a relatively low temperature (621.43 degrees F) (Thornton et al. 2001).

The production of lead begins with the mining and smelting process. Lead rarely occurs as pure lead ore so it must be extracted through smelting. Smelting involves heating the ore in a furnace to separate the lead from other minerals. The molten lead solidified into blocks, called "pigs". Lead occurs in many forms in the earth's crust. Galena, or lead sulphide (PbS), is the principal lead-bearing ore but lead carbonates, lead oxides and various other lead sulphates also were exploited for their lead content. Arsenic, antimony, bismuth, gold, silver and tin are common impurities in lead minerals.

Lead has been mined for many thousands of years. Early archaeological evidence for lead use is found in China, Egypt, Tunisia and throughout the Roman Empire. Techniques from the Middle Ages are documented by Agricola (1556) and his treatise served as a guidebook for miners and smelters for several centuries after it was published (Figure 1). Lead mining in Great Britain dates to Roman times but it flourished in the eighteenth and nineteenth centuries (Figure 2).



Figure 1. Woodcut Showing Smelting of Ores (Agricola 1556).



**Figure 2. Bower Yard Smelter, Ironbridge, Shropshire, England (Chesam 1788).**

With the invention of firearms in the Middle Ages lead soon became the preferred ammunition. Its softness was less damaging to iron gun barrels, its high density allowed for better velocities and its low melting point facilitated bullet production using wood fires.

Lead round ball munitions were produced by three different methods. The most familiar method is casting. Balls were cast individually or in gang molds. Many lead balls were cast at a munitions laboratory, while others were cast in the field by the troops. Bullet molds were made from stone or metal.

Rupert shot were produced by pouring molten lead through graduated screens from a high shot tower. The size of the ball was determined by the gauge of the screen. The balls cooled as they fell through the air before landing in a pool of water at the base. The resulting impact left a tell-tale dimple on many of these Rupert shot. Rupert shot were first produced in the 1600s and their invention is attributed to Prince Rupert. This shot tower technology was improved following the erection of the Bristol tower in England and the 1782 patent issued to its builder William Watts (Pssatrap.org 2017). One of the earliest documented shot towers in America was the Sparks Shot Tower, which was built in 1808 in Philadelphia, Pennsylvania (Spivak 2007). J. Macklot erected a shot tower in St. Louis, Missouri and was producing shot by 1809 (Thwaites 1895:284-285).

A third and uncommon method is lead balls produced by hammering. Small chunks of lead were beaten with harder objects until they were roughly spherical.

Bullet molds for field use took a variety of forms and were made from several types of material. Figures 3-5 show three types of early round ball molds. Figure 3 is made from soapstone and it produced a series of balls all the same caliber. Figure 4 is a brass bullet gang mold that produced balls of four sizes, approximately .68, .58, .55 and .47 caliber. Figure 5 is an early brass gang mold that produced 10 balls, all approximately the same diameter (24.5 mm) (Trömner 2017). Other bullet molds were made of iron. Many molds produced a single ball, while others produced ten or more.



Figure 3. Soapstone Bullet Mold (Omanisilver.com 2017).



Figure 4. Brass Gang Bullet Mold (Gunsinternational.com 2017).



Figure 5. Brass Gang Bullet Mold, Circa A.D. 1500 (Trömner 2017).

### **III. Chemical Characterization and Sourcing of Lead**

X-Ray Fluorescence (XRF) and Portable X-Ray Fluorescence (pXRF) are modern techniques for examining the chemical composition of material objects (Beckhoff et al. 2007; Shackley 2011). This technology has attracted archaeologists, who seek its useful application for various materials. Previous studies that involved the use of XRF, pXRF and other scientific methods in characterizing lead isotopes in archaeological specimens (Farquhar et al. 1995; Lockman 2006; Wilson et al. 2006; Huntley et al. 2007; Craig et al. 2007; Hall et al. 2011).

The application of XRF and pXRF technology in characterizing weapons-related lead (bullets, lead balls, etc., production sprue, etc.) is in the early stage of research. Seibert and his colleagues at the Southeast Archaeological Center conducted pXRF analysis on ammunition recovered by NPS in their archaeological study of the Palo Alto, battlefield in Texas (Seibert et al. 2015). The battle took place on May 8, 1846 and was a United States victory. Battlefield evidence consisted of artillery and small arms ammunition. In that study Seibert was able to differentiate between some of the Mexican and United States small arms round balls based on the presence/absence of copper. The Mexican ammunition contained copper, while the United States examples did not.

#### **Data Collection Methods**

One of the goals of the Elemental workshop was to develop a standardized research method for collecting data on round ball ammunition. Ten different methods for collecting data have been used from 2014-2017. These are described below.

##### **Method 1**

Method 1 was used by Seibert on data collected from the Cowpens battlefield in 2012. Data were collected for each specimen with a Bruker Tracer for 500 seconds, green filter (Ti/Al), 40 kV (kilovolts) voltage, and 14  $\mu$ A (microamps) of current.

##### **Method 2**

Method 2 was used by Elliott, Seibert and Watters in 2015 prior to December. Data were collected for each specimen with a Bruker Tracer for 180 seconds, green filter, 45 kV voltage, and 20  $\mu$ A of current. This method was used for collections from Brier Creek (2015), Carrs Fort, Estatoe, Fahm Street, Fort Hawkins, Guilford Courthouse, Kings Mountain, Madison Square, Minuteman Park, Moores Creek, Mount Pleasant, Ninety-Six, Okfuskenena, Purysburg and Spring Hill Redoubt.

### **Method 3**

Method 3 was used by Elliott in December 2015. Data were collected for each specimen with a Bruker Tracer for 180 seconds, black filter (Ti/Al), 48 kV voltage, and 29  $\mu\text{A}$  of current. This method was used for collections from Mount Pleasant.

### **Method 4**

Method 4 was used by Elliott beginning in December 2015. Data were collected for each specimen with a Bruker Tracer for 180 seconds, black filter (Ti/Al), 45 kV voltage, and 20  $\mu\text{A}$  of current. This method was used for collections from the Battle of Beaufort (2016), Kettle Creek and a small portion of the Cowpens sample.

### **Method 5**

Method 5 was used in the 2017 workshop for the 22OK1172 sample. Data were collected for each specimen with a Bruker device for 180 seconds, black filter, 45 kV and 30  $\mu\text{A}$  of current.

### **Method 6**

Method 6 was used for some samples in the 2017 workshop. Data were collected for each specimen with a Bruker Tracer for 60 seconds, black filter, 45 kV voltage, and 30  $\mu\text{A}$  microamps of current. This method was used for collections from Fort Daniel, Fort Necessity, Charlesfort/Santa Elena, Savannah River Carved ball, Stark Farm, most of the New York Historical Society samples and a portion of the Battle of Beaufort samples.

### **Method 7**

Method 7 was used in the 2017 workshop for the Brier Creek Battlefield samples provided by Brockington & Associates, and portions of the Battle of Beaufort sample. Data were collected for each specimen with a Bruker Tracer for 60 seconds, black filter 48 kV voltage and 15  $\mu\text{A}$  of current.

### **Method 8**

Method 8 was used in the 2017 workshop for the En Bas Saline site, Fort Frederica, Spanish Florida sites, Galphin, Hanging Rock, New Jersey sites, Tar Bluff and portions of the Camden and Fort King samples. Data were collected for each specimen with a Bruker Tracer for 60 seconds, black filter, 48 kV voltage and 29  $\mu\text{A}$  of current.

### **Method 9**

Method 9 was used in the 2017 workshop for Fort Motte, Fort Watson, British Arsenal Nepal, Shubrick plantation and a portion of the Camden samples. Data

were collected for each specimen with a Bruker Tracer for 180 seconds, black filter, 48 kV and 30  $\mu$ A of current.

### **Method 10**

Method 10 was used in the 2017 workshop for the Fort Moore sample. Data were collected for each specimen with a Bruker device for 50 seconds, black filter, 50 kV and 25  $\mu$ A of current.

### **Potentially Important Elements for Study**

The Bruker Tracer series is unable to identify elements with Atomic Numbers of 12 (Magnesium, Mg) or lower. Seven elements have been identified thus far, which may have relevance for cultural meaning in early round ball ammunition. These include Antimony (Sb), Cadmium (Cd), Copper (Cu), Hafnium (Hf), Nickel (Ni), Silver (Ag), Tin (Sn), and Zinc (Zn). Lead (Pb) is ever present in round balls and it masks the presence of other elements. Bruce Kaiser developed a special filter for the Bruker Tracer, which reduces the effect of lead in the observed spectra. Rhodium (Rh) and Palladium (Pd) are present in the Bruker Tracer hardware, so their presence in the spectral readings should be largely ignored.

#### IV. Study Samples

This study examined a wide range of metallic round balls from numerous archaeological sites. While this collection is dominated by archaeological examples recovered from sites in southeastern North America, it also includes examples from Haiti, Nepal and several sites in northeastern North America. Appendix 1 contains tabular data on 953 samples included in the elemental analysis. These data include 245 samples collected during the 2017 workshop, as well as 708 previously collected samples. These data were generated as a report in Bruker's software program Artax. These are placed into 51 groups, as summarized in Table 1.

##### En Bas Saline, Haiti

En Bas Saline was a Taino town located on the northeastern coast of Haiti. A lead ball was excavated from the burned remains of a large structure, which was destroyed in the late 1400s. This settlement is considered to have been visited by Christopher Columbus. Thus, the En Bas Saline example likely represents the earliest lead ball in this elemental analysis project (Figure 6). It was intended for use in an arquebus. It also likely represents an example cast from European lead sources, since American lead deposits were not being exploited yet. Cobb provided the round ball for analysis in the 2017 workshop. This sample is included as Group 10 in Appendix 1. Figure 7 shows a close-up of the spectra of the En Bas Saline example. It reveals the presence of Tin (Sn) but no Antimony (Sb).



Figure 6. Lead Ball Excavated from En Bas Saline, Haiti (Photograph courtesy of Florida Museum of Natural History 2017).

**Table 1. Summary of Samples Examined.**

Group	Location	State	Type	Age	Samples	Method	Previous	Total
1	Beaufort/Grays Hill	SC	Battle	1779		4	27	27
2	Beaufort/Grays Hill	SC	Battle	1779	12	6		12
2	Beaufort/Grays Hill	SC	Battle	1779	23	7		23
3	Brier Creek, 9SN254	GA	Battle	1779		2	90	90
4	Brier Creek, 9SN254	GA	Battle	1779	24	7		24
5	Royal Arsenal, Nepal	Nepal	Arsenal	Unk.	1	9		1
6	Okfuskenena, 9TP9	GA	Town/Battle	1793		2	10	10
7	Camden	SC	Town/Battle	1780	3	9		3
7	Camden	SC	Town/Battle	1780	8	8		8
8	Carrs Fort, 9WS396	GA	Fort/Battle	1778-1779		2	19	19
9	Charlesfort/Santa Elena, 38BU162	SC	Fort/Town	1500s	12	6		12
10	EBS TT8-SEC9 (En Bas Saline)	Haiti	Fort	1492	1	8		1
11	Cowpens	SC	Battle	1781		1	30	30
11	Cowpens	SC	Battle	1781		4	6	6
12	Estateo, 9ST3	GA	Town	1700s		2	6	6
13	Fahm St., Savannah	GA	Battle	1779		2	2	2
14	Fort Daniel, 9GW623	GA	Fort	1813-1814	4	6		4
15	Fort Frederica, 9GN177	GA	Town	1736-1760	13	8		13
16	Fort King, 8MR60	FL	Fort	1827	33	8		33
17	Fort Moore, 38AK4	SC	Fort	1715	9	10		9
18	Fort Motte	SC	Fort/Battle	1780-1781	11	9		11
19	Fort Necessity	PA	Fort/Battle	1754	16	6		16
20	Fort Watson, 38CR1	SC	Fort/Battle	1781	2	9		2
21	Fort Hawkins, 9BI28	GA	Fort	1806-1821		2	43	43
22	Galphin's Trading Post, 38AK7	SC	Fort/Battle	1781	17	8		17
23	Guilford Courthouse	NC	Battle	1781		2	50	50
24	Hanging Rock	SC	Battle	1780	6	8		6
25	Kettle Creek, 9WS370	GA	Battle	1779		4	62	62
26	Kings Mountain	SC	Battle	1780		2	66	66
27	Madison Square, Savannah	GA	Battle	1779		2	14	14
28	Minuteman	MA	Battle	1775		2	30	30
29	Moores Creek	NC	Battle	1776		2	29	29
30	Mount Pleasant, 9EF169	GA	Town/Fort	1720-1763		2	27	27
31	Mount Pleasant, 9EF169	GA	Town/Fort	1720-1763		3	13	13
32	Ninety-Six	SC	Fort/Battle	1781		2	29	29
33	Purysburg	SC	Town/Battle	1732-1779		2	128	128
34	SR-Carved Ball (Savannah River)	SC	Isolated find	unk.	1	6		1
35	Shubrick's Plantation	SC	Battle	1781	4	9		4
36	Craig Road Site	NJ	Battle	1778	1	8		1
36	Petticoat Bridge	NJ	Battle	1776	1	8		1
36	Belle Terre Farm	NJ	Battle	1778	5	8		5
37	Spring Hill Redoubt, 9CH703	GA	Fort/Battle	1779		2	10	10
38	Stark Farm, 22OK778	MS	Battle	1500s-1700s	2	6		2
39	Tar Bluff	SC	Battle	1779	6	8		6
40	De Hita-Gonzales Site, 8SA7	FL	Town	1600s	3	8		3
41	Ximenez Fatio Site, 9SA34	FL	Town	1600s	2	8		2
42	Palm Row Site, 8SA36	FL	Town	1600s	1	8		1
43	Ximenez Fatio Site, 9SA34	FL	Town	1600s	1	8		1
44	22OK1172	MS	Town	1500s	1	5		1
45	Fountain of Youth, 8SJ31	FL	Fort	1565	1	8		1
46	King George Statue	NY	Statue	1776		6	17	17
47	Blackshear Prison, 9PR26	GA	Prison	1864	6			6
48	Camp Lawton Prison, 9JS1	GA	Prison	1864	3			3
49	Fort James Jackson, 9CH689	GA	Fort	1808-1905	2			2
50	Experimental artillery	N/A	Experiment	Modern	7			7
51	Brier Creek Modern	N/A	N/A	Modern	2			2
51	Replica Minie Ball	N/A	N/A	Modern	1			1
	<b>TOTAL</b>				<b>245</b>		<b>708</b>	<b>953</b>

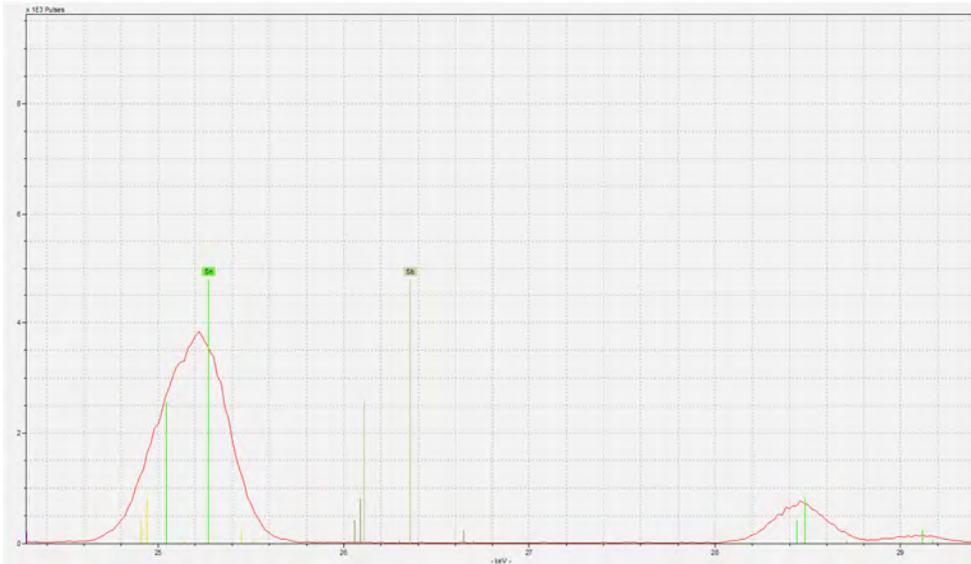


Figure 7. Spectra of Tin (Sn) and Antimony (Sb) En Bas Saline Sample.

### Fountain of Youth Site

The Fountain of Youth Site (8SJ31) is an early Spanish contact period site in St. Augustine, Florida. Cobb provided a single sample from the fountain of Youth Site for the 2017 workshop. This specimen is from the Menendez-era context, which dates from 1560-1570 (Deagan 2009:261, Table 6.7). It was intended for use in an arquebus and probably was made from imported European lead. This sample is included as Group 45 in Appendix 1. Figure 8 shows a portion of the spectra for this sample, highlighting Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) values. It reveals very slight traces of Cadmium (Cd) and Tin (Sn), virtually no Silver (Ag), and slightly elevated Tin (Sn) values.



Figure 8. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fountain of Youth Site Sample.

### De Hita-Gonzales Site

The De Hita-Gonzales Site (8SA7) is a Spanish colonial domestic site located in St. Augustine, Florida. Cobb provided three round ball specimens from this site for the 2017 workshop. These examples are from Spanish or Creole contexts (Shepherd 1938). This sample is included as Group 40 in Appendix 1. Figure 9 shows a close of their spectra, which reveals a very slight presence of Tin (Sn) and Antimony (Sb) and no Silver (Ag) or Cadmium (Cd).

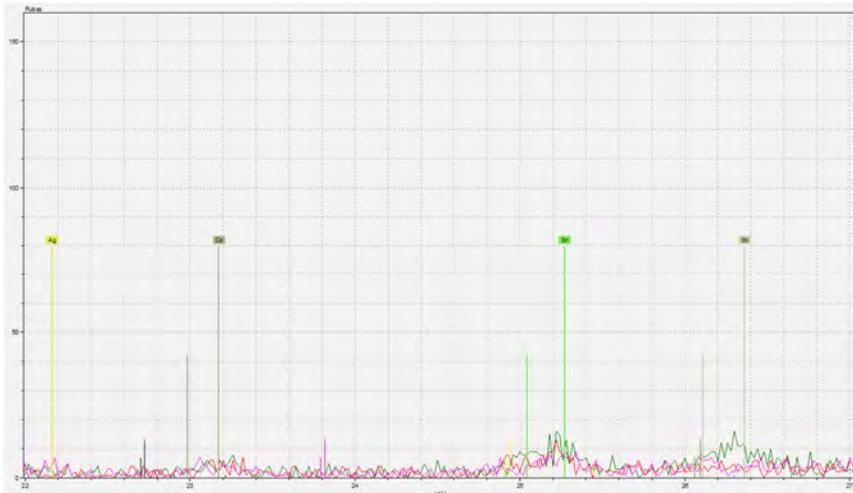
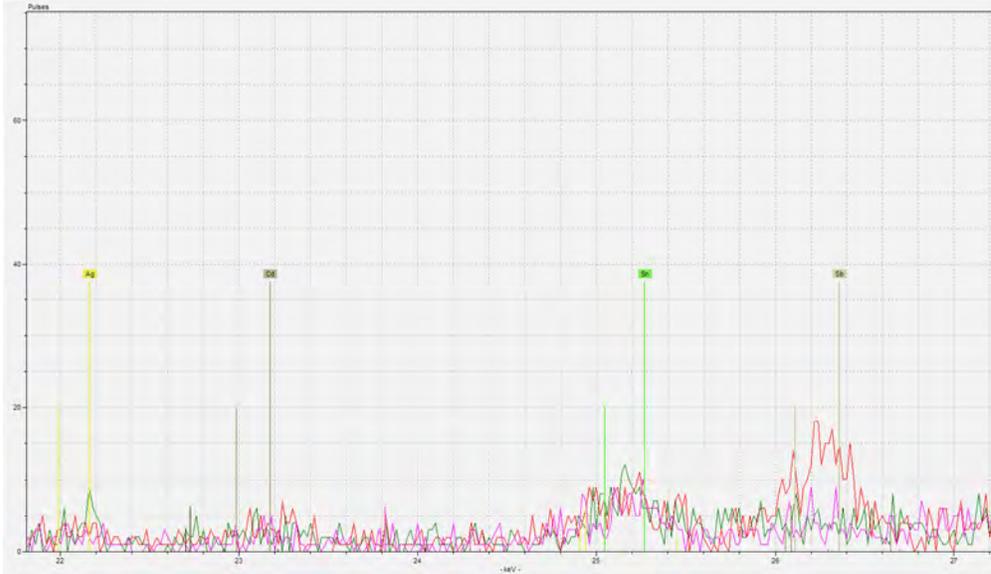


Figure 9. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) De Hita-Gonzales Site Sample.

## Ximenez Fatio Site

The Ximenez Fatio Site (9SA34) is a Spanish colonial domestic site located in St. Augustine, Florida. Cobb provided three round ball samples from this site for analysis in the 2017 workshop. This sample is included as Group 41 in Appendix 1. Figure 10 shows a close of their spectra, which reveals a very slight presence of Tin (Sn) and Antimony (Sb) and virtually no Silver (Ag) or Cadmium (Cd).



**Figure 10. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Ximenez Fatio Site Sample.**

## Palm Row Site

The Palm Row Site (9SA36) is a Spanish colonial domestic site located in St. Augustine, Florida. Cobb provided one round ball sample from this site for analysis in the 2017 workshop. This sample is included as Group 42 in Appendix

1. Figure 11 shows a close of their spectra, which reveals the presence of Tin (Sn), very slight Antimony (Sb) values and no Silver (Ag) or Cadmium (Cd).



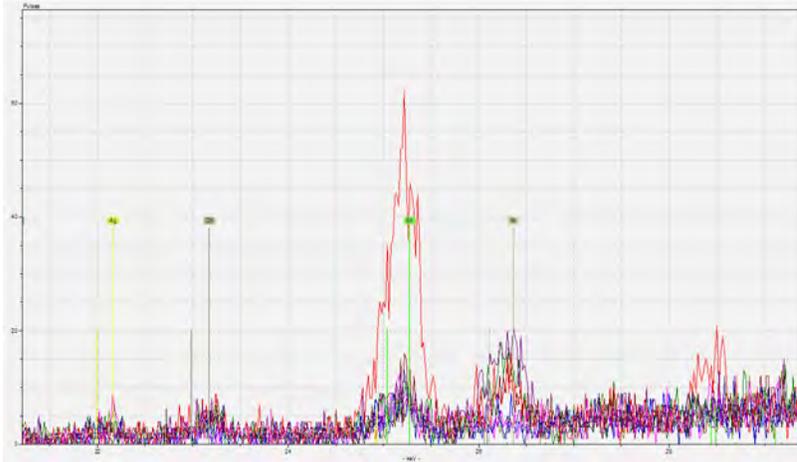
Figure 11. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Palm Row Site Sample.

### Spanish Florida Sites Combined

Figures 12 and 13 show close ups of the combined spectra from all of the Spanish Florida St. Augustine area examples. Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) are present in low frequencies. Tin (Sn) and Antimony (Sb) are present in low frequencies. Silver (Ag) and Cadmium (Cd) are barely perceptible in this assemblage.



Figure 12. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Combined Spanish Florida Samples.



**Figure 13. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Combined Spanish Florida Samples.**

### Charlesfort/Santa Elena

The French Charlesfort and subsequent Spanish settlement of Santa Elena are located in present-day Beaufort County, South Carolina. Both occupations date to the mid-Sixteenth Century. Archaeologists with SCIAA have explored this site. Smith and Legg provided 12 round ball examples from the site for analysis in the 2017 workshop. This sample is included as Group 9 in Appendix 1.

Figures 14 and 15 show portions of the spectra for the Charlesfort/Santa Elena sample. Nickel (Ni), Cadmium (Cd) and Antimony (Sb) are absent in the assemblage. Copper (Cu) and Zinc (Zn) values reveal traces of these two elements in all of the samples. Tin (Sn) is present in two samples and elevated Silver (Ag) values are evidenced in one sample.

Cluster analysis was performed on Antimony (Sb), Tin (Sn) and Silver (Ag) ratios for the Charlesfort/Santa Elena sample. Five clusters were identified (Table 2 and Figures 16 and 17). The dominant cluster (Segment 1) contained five of the 12 specimens (41.7% of the assemblage). Clusters 3 and 5 each contained single specimens. Cluster 5 has significantly elevated Tin (Sn) values compared to the rest of the assemblage. Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 1.57, Tin (Sn)/Rhodium (Rh), 3.21 and Silver (Ag)/Rhodium (Rh), 1.05.



Figure 14. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Charlesfort/Santa Elena Sample.

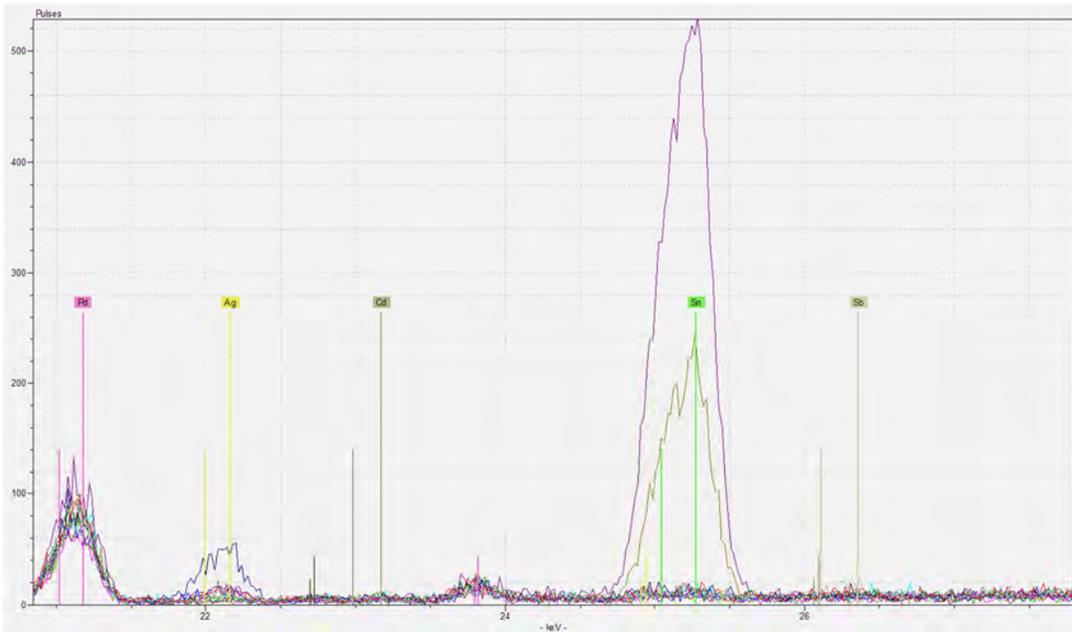
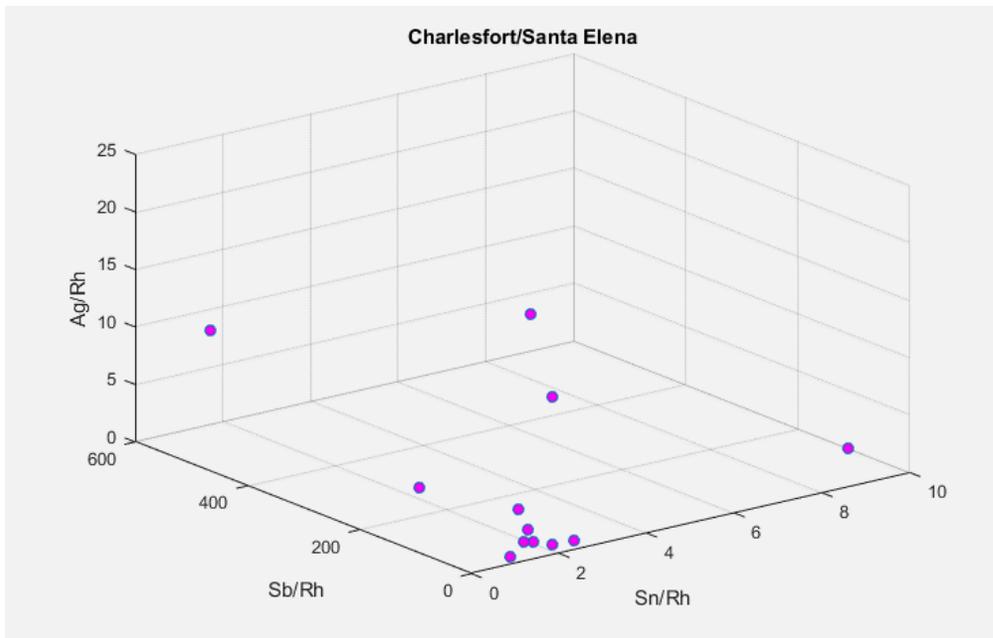


Figure 15. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Charlesfort/Santa Elena Sample.

**Table 2. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Charlesfort/Santa Elena Sample.**

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	1.57	3.21	1.05		
Segment 2	1.66	4.46	17.44		
Segment 3	8.64	4.86	3.18		
Segment 4	1.19	62.45	3.40		
Segment 5	0.80	528.60	10.30		
<b>AVERAGE</b>	2.01	62.15	5.32		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	5	41.7%	6.9		
Segment 2	2	16.7%	32.6		
Segment 3	1	8.3%	0.0		
Segment 4	3	25.0%	21053.0		
Segment 5	1	8.3%	0.0		
<b>TOTAL</b>	12	100.0%			
				<b>SSE Total</b>	<b>3.7</b>



**Figure 16. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in Charlesfort/Santa Elena Samples.**

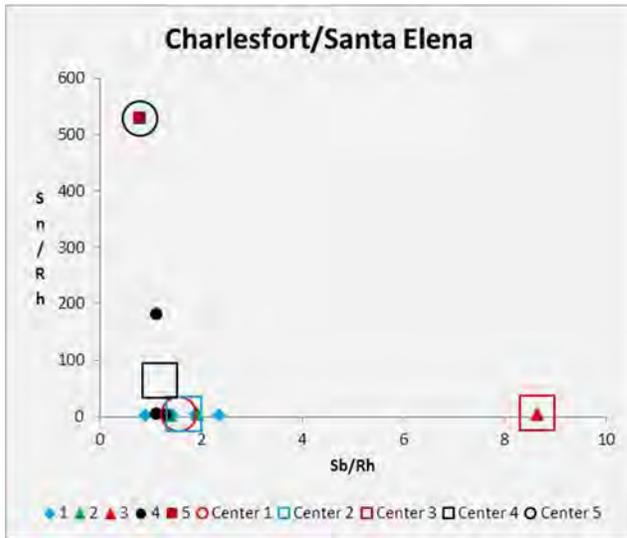


Figure 17. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Charlesfort/Santa Elena Sample.

## Stark Farm

Stark Farm (22OK778) is an early Contact Period site, possibly associated with Hernando de Soto's troops and their encounter with the Chickasaw, located in northeast Mississippi. Archaeologists from the University of Mississippi and SCIAA recently have studied the site (Boudreaux et al. 2016; Legg 2015, 2016). Smith and Legg provided one round ball from their metal detector survey of the Stark Farm site, as well as one round ball from a related site (22OK1172) in Mississippi. This sample is included as Group 38 in Appendix 1. Figures 18 and 19 show the spectra for the two Mississippi site for the elements Nickel (Ni), Copper (Cu), Zinc (Zn) and Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb). Both samples exhibit traces of Copper (Cu), but only the Stark Farm sample shows any trace of Tin (Sn) or Antimony (Sb).

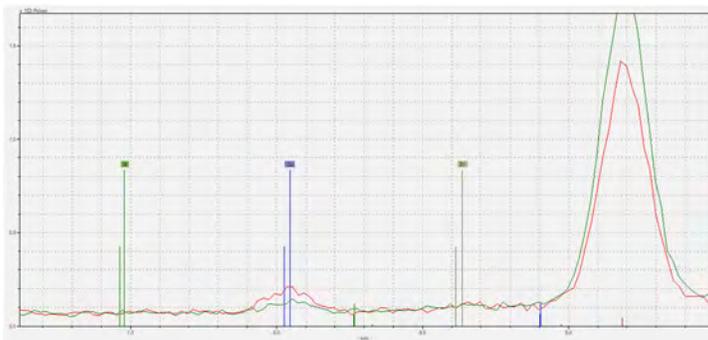


Figure 18. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) 22OK778 and 22OK1172 Samples.

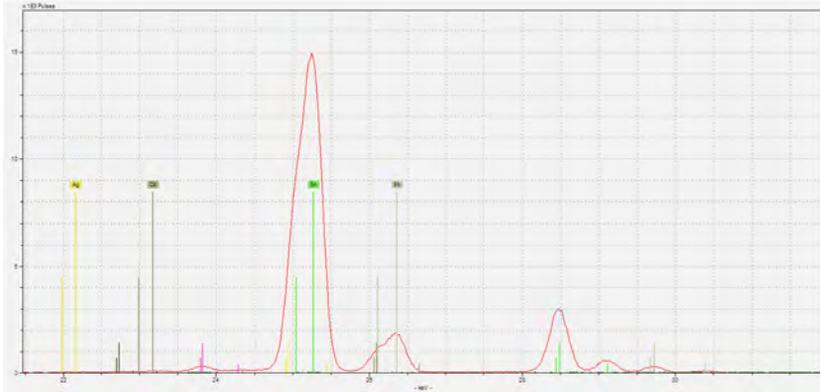


Figure 19. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) 22OK778 and 22OK1172 Samples.

## Fort Moore

Fort Moore was a British fort located on a bluff above the Savannah River in present-day Aiken County, South Carolina. It was constructed in 1716 and was used by the British military until 1763 (Maness 1986). No military engagements were ever reported at Fort Moore. Fort Moore was recorded as archaeological Site 38AK4 by Richard Polhemus in 1971 and listed in the NRHP in 1973. Archaeologists with the University of South Carolina conducted limited study of the site in the early 1970s. Archaeologists with SCIAA returned to the site in 2001 and conducted more work (Groover 2003). Archaeologist Tammy Herron provided a sample of nine round balls for the 2017 workshop. This sample is included as Group 17 in Appendix 1. Figures 20 and 21 show portions of the spectra for the Fort Moore samples. Nickel (Ni) and Copper (Cu) are present in low frequencies but Zinc (Zn) is not recognized. Cadmium (Cd), Tin (Sn) and Antimony (Sb) are present, but Silver (Ag) is barely evident.

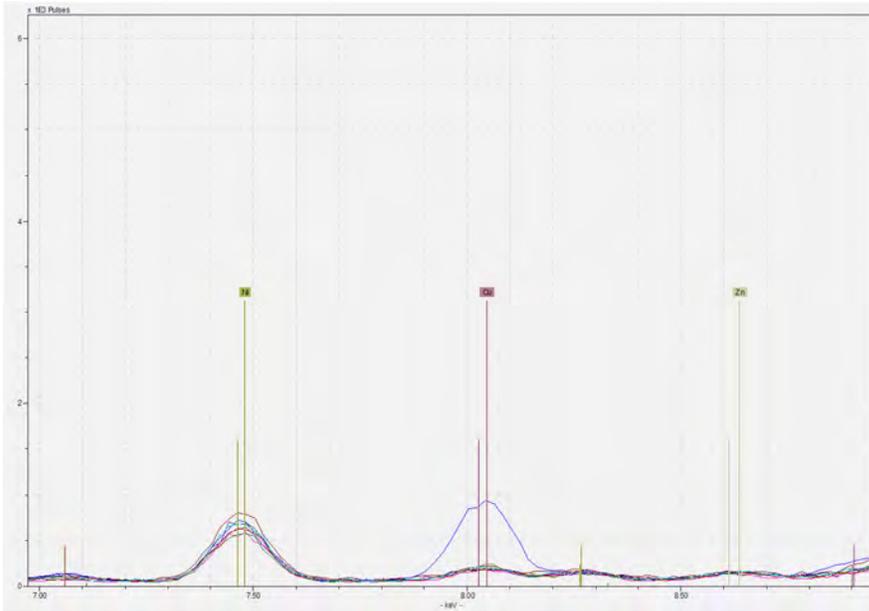


Figure 20. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Fort Moore Sample.

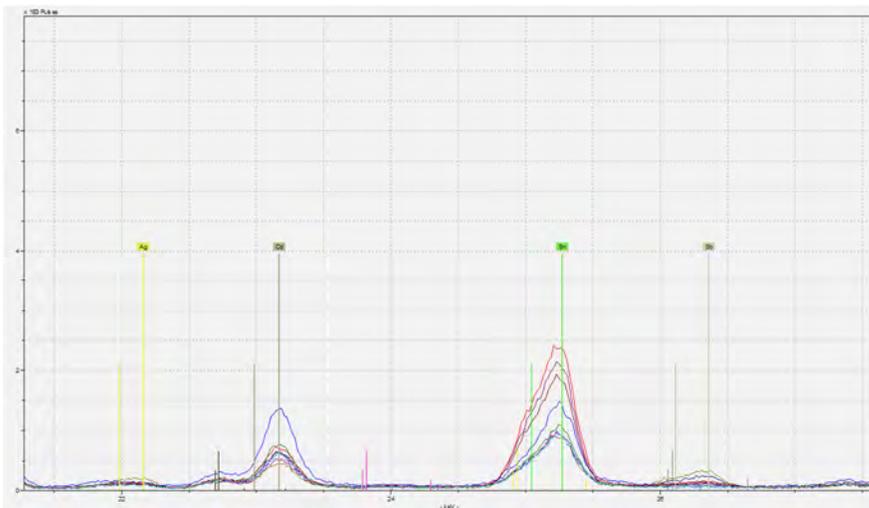


Figure 21. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Moore Sample.

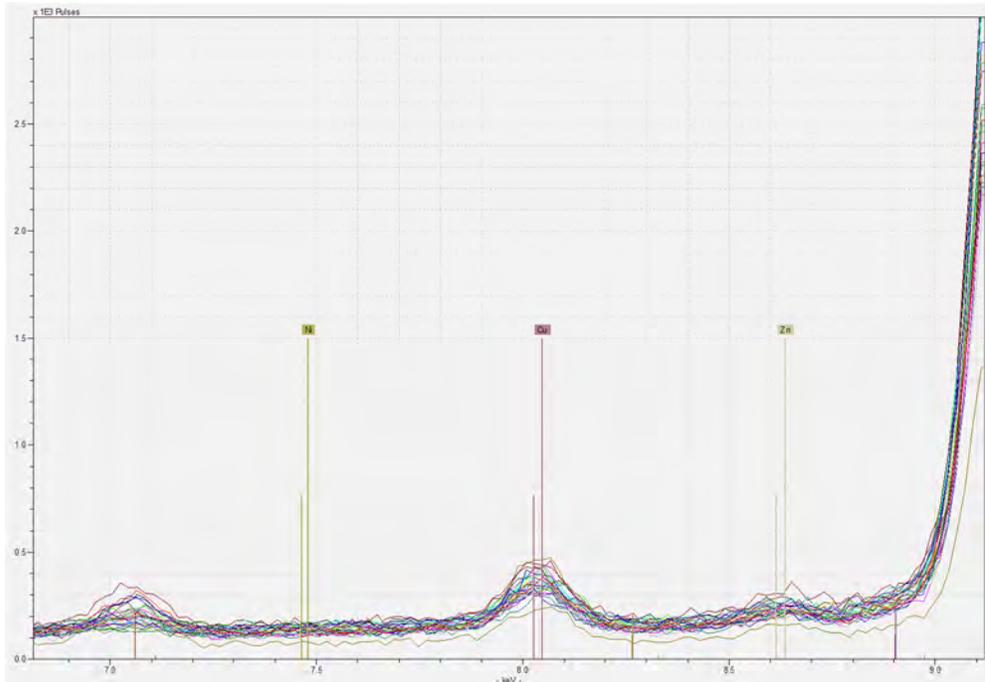
## Mount Pleasant

Immediately after the end of the Yamasee War (about 1720) a tribe of Yuchi Indians settled on a prominent bluff above the Savannah River in present-day Effingham County, Georgia. Their town attracted British deerskin traders, who established a post there. In 1739, these same deerskin traders were designated Georgia Rangers by General James Oglethorpe. The Yuchi warriors were designated a Yuchi Troop of Foot and these men served as allies to Georgia in their war with Spain. By 1751,

the Yuchi had left the Savannah River region. The Georgia Ranger fort at Mount Pleasant remained until about 1760. No military engagements were ever reported at Mount Pleasant. Archaeologists located and defined the Mount Pleasant settlement (Site 9EF169) in the late 1980s (Elliott 1991). Archaeologists returned to Mount Pleasant in 2010 to conduct additional survey work, which included intensive metal detector survey on a portion of the site.

Elliott sampled 27 round balls and related gang mold sprue from the Mount Pleasant collection in 2015. This sample is included as Group 30 in Appendix 1. Elliott provided another 13 round balls from Mount Pleasant for analysis in the 2015 workshop. These samples were analyzed using the “Black filter”. This sample is included as Group 31 in Appendix 1. Figures 22 and 23 show portions of the spectra for the Mount Pleasant (2015 green filter) samples. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Mount Pleasant (2015 green filter) samples. Five clusters were identified (Table 3 and Figures 24 and 25). The dominant cluster (Segment 3) contained 11 of 27 samples. Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.73, Tin (Sn)/Rhodium (Rh), 5.96 and Silver (Ag)/Rhodium (Rh), 0.18.



**Figure 22. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Mount Pleasant 2015 (Green Filter) Sample.**

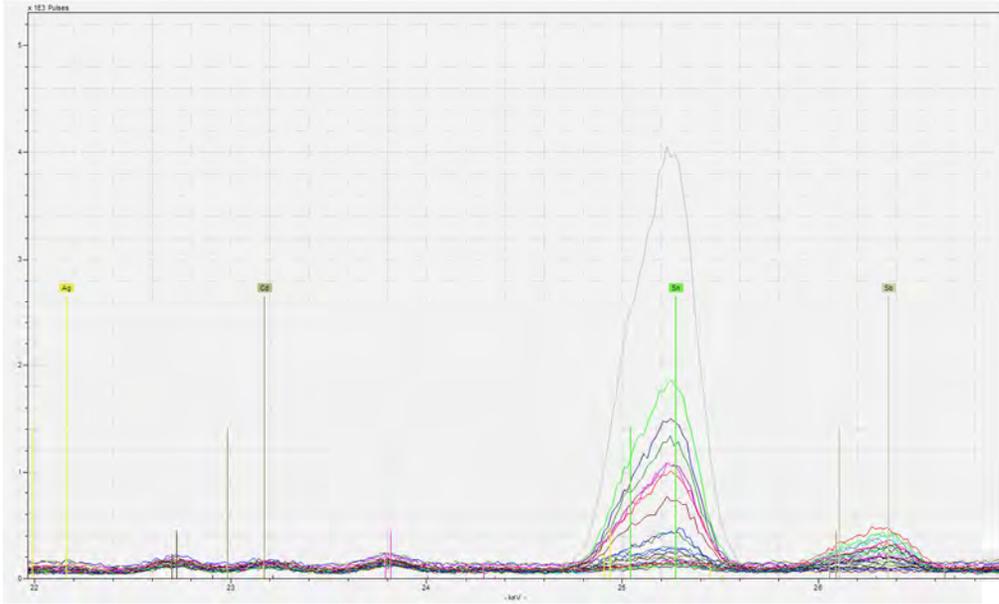


Figure 23. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Mount Pleasant 2015 (Green Filter) Sample.

Table 3. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Mount Pleasant 2015 (Green Filter) Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	0.29	1.20	0.07		
Segment 2	3.35	38.42	0.30		
Segment 3	0.73	5.96	0.18		
Segment 4	0.24	0.61	0.49		
Segment 5	2.62	1.19	0.16		
AVERAGE	1.27	4.47	0.18		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	5	18.5%	8.9		
Segment 2	1	3.7%	0.0		
Segment 3	11	40.7%	0.0		
Segment 4	2	7.4%	0.1		
Segment 5	8	29.6%	16.6		
TOTAL	27	100.0%			
				<b>SSE Total</b>	<b>26.2</b>

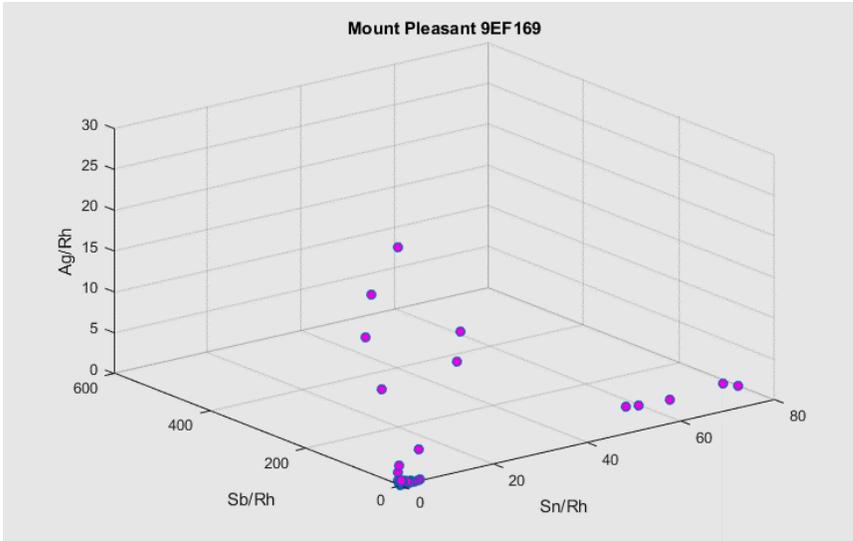


Figure 24. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in Mount Pleasant Composite 2015 (Green and Black Filter) Samples.

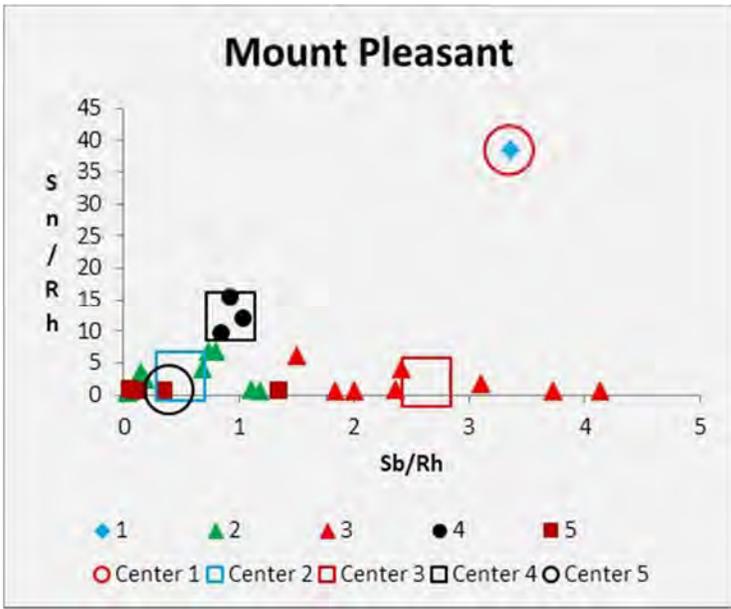


Figure 25. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Mount Pleasant 2015 (Green filter) Sample.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Mount Pleasant (2015 black filter) samples. Five clusters were identified (Table 4 and Figure 26). The dominant cluster (Segment 3) contained five of 13 samples. Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 61.66, Tin (Sn)/Rhodium (Rh), 20.41 and Silver (Ag)/Rhodium (Rh), 2.37.

Table 4. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Mount Pleasant 2015 (Black filter) Sample.

Mean/Centroid	Sb/Rh	Sn/Rh	Ag/Rh	0	0
Segment 1	40.62	370.41	5.09		
Segment 2	2.97	11.98	2.80		
Segment 3	61.66	20.41	2.37		
Segment 4	7.50	79.25	26.38		
Segment 5	20.19	236.00	3.73		
AVERAGE	38.80	147.92	5.22		
Respondents	Number	%	SSE/Segment		
Segment 1	4	30.8%	37680.7		
Segment 2	2	15.4%	29.7		
Segment 3	5	38.5%	0.0		
Segment 4	1	7.7%	0.0		
Segment 5	1	7.7%	0.0		
TOTAL	13	100.0%			
				<b>SSE Total</b>	<b>3.8</b>

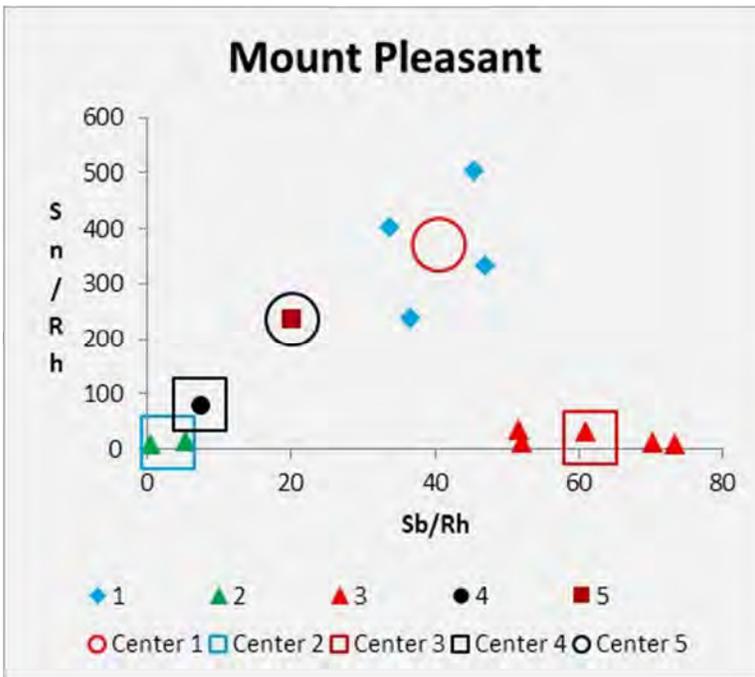


Figure 26. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Mount Pleasant 2015 (Black filter) Sample.

## Fort Frederica

Fort Frederica was a fortified British town located on St. Simons Island, Georgia. Seibert provided 11 round balls and two other lead items for analysis in the 2017 workshop. This sample is included as Group 15 in Appendix 1.

Figures 27 and 28 show portions of the spectra for the Fort Frederica samples. Nickel (Ni), Hafnium (Hf), Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs. One specimen displayed markedly higher Copper (Cu) and Zinc (Zn) photon values than did the rest of the samples.

Cluster analysis was performed on Sb, Tin (Sn) and Silver (Ag) ratios for the Fort Frederica round ball sample. Five clusters were identified (Table 5 and Figures 29 and 30). The dominant cluster (Segment 4) contained six of the 11 round balls (54.5% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 2.18, Tin (Sn)/Rhodium (Rh), 4.77 and Silver (Ag)/Rhodium (Rh), 1.44.

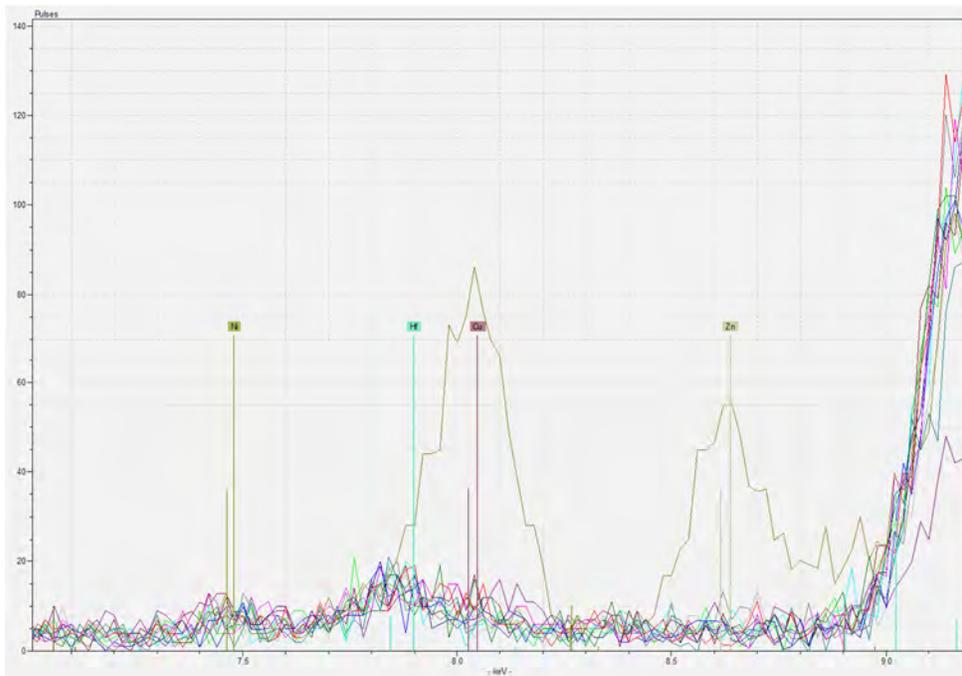


Figure 27. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Fort Frederica Sample.

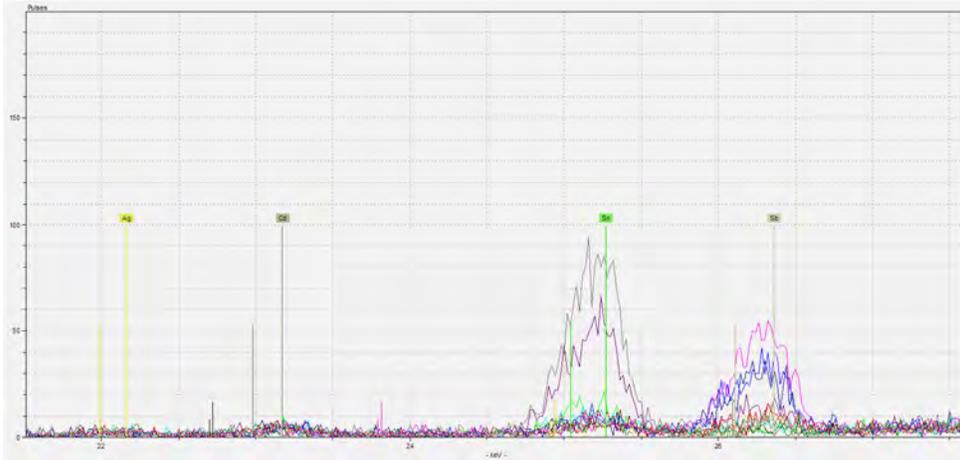


Figure 28. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Frederica Sample.

Table 5. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Frederica Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	28.67	5.14	2.76		
Segment 2	6.94	31.59	1.62		
Segment 3	36.98	5.47	1.53		
Segment 4	2.18	4.77	1.44		
Segment 5	2.00	69.40	1.24		
AVERAGE	11.33	13.24	1.57		
Respondents	Number	%	SSE/Segment		
Segment 1	1	9.1%	0.0		
Segment 2	1	9.1%	0.0		
Segment 3	2	18.2%	0.0		
Segment 4	6	54.5%	32.0		
Segment 5	1	9.1%	0.0		
TOTAL	11	100.0%			
				<b>SSE Total</b>	<b>4.5</b>

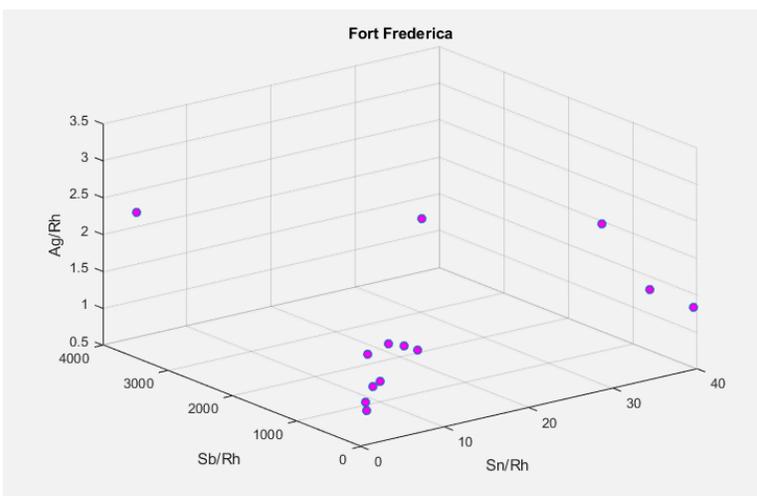


Figure 29. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Frederica Sample.

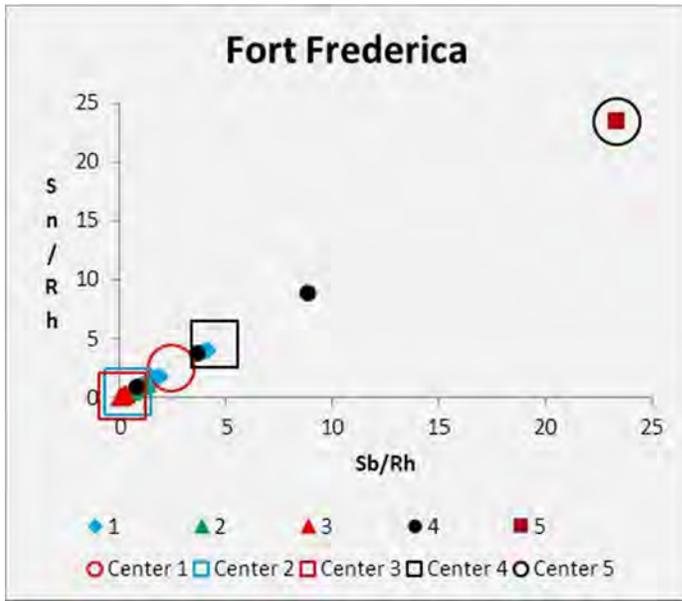


Figure 30. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Frederica Sample.

### Galphin's Trading Post

George Galphin was a deerskin trader whose base of operation was a fortified trading post located at Silver Bluff, South Carolina. His trading post possibly dates from the 1730s and was used until the end of the American Revolution. It was known as Fort Dreadnaught in the American Revolution, when it was the scene of a military engagement. Archaeologists with SCIAA have conducted excavations at 38AK7 since the 1970s. For the 2017 workshop archaeologist Tammy Herron provided a sample of 17 round ball ammunition excavated from Galphin's fortified site, which is recorded as Site 38AK7. This sample is included as Group 22 in Appendix 1. Figures 31 and 32 show portions of the spectra for the Galphins samples. Nickel (Ni), Hafnium (Hf), Copper (Cu), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Galphins sample. Five clusters were identified (Table 6 and Figures 33 and 34). The dominant cluster (Segment 2) contained eight of 17 specimens (47.1%). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 2.07, Tin (Sn)/Rhodium (Rh), 7.15 and Silver (Ag)/Rhodium (Rh), 1.86.

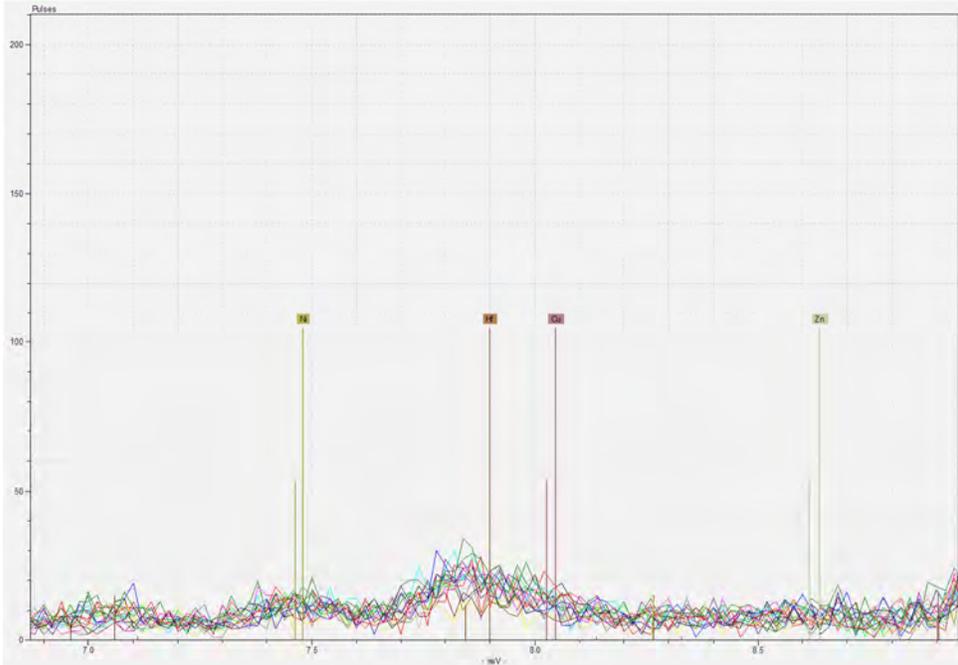


Figure 31. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Galphins Sample.

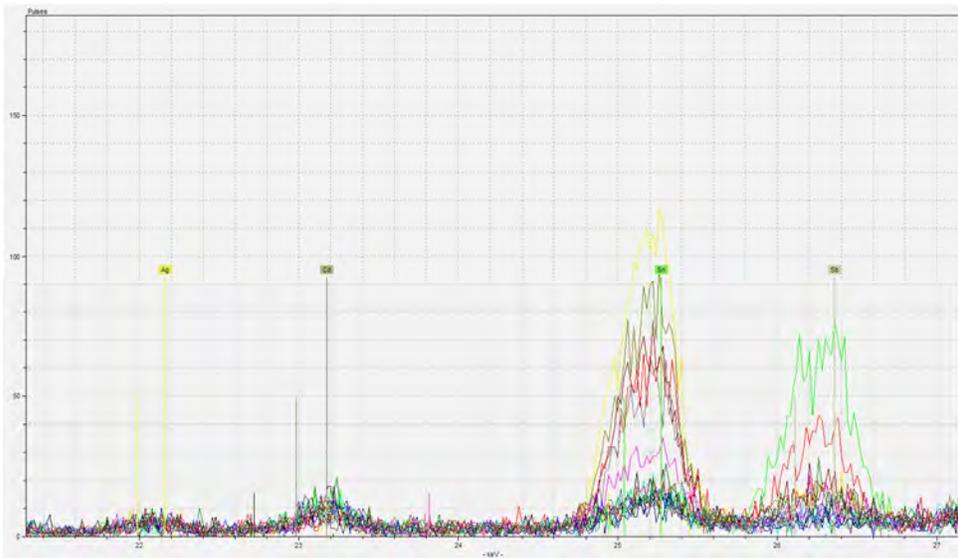


Figure 32. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Galphins Sample.

Table 6. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Galphins Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	18.30	6.84	1.70		
Segment 2	2.07	7.15	1.86		
Segment 3	33.33	4.37	1.09		
Segment 4	9.83	67.32	5.50		
Segment 5	7.04	41.43	2.76		
AVERAGE	7.24	24.13	2.50		
Respondents	Number	%	SSE/Segment		
Segment 1	1	5.9%	0.0		
Segment 2	8	47.1%	58.2	<b>SSE Total 10.6</b>	
Segment 3	1	5.9%	0.0		
Segment 4	2	11.8%	107.1		
Segment 5	5	29.4%	2299.8		
TOTAL	17	100.0%			

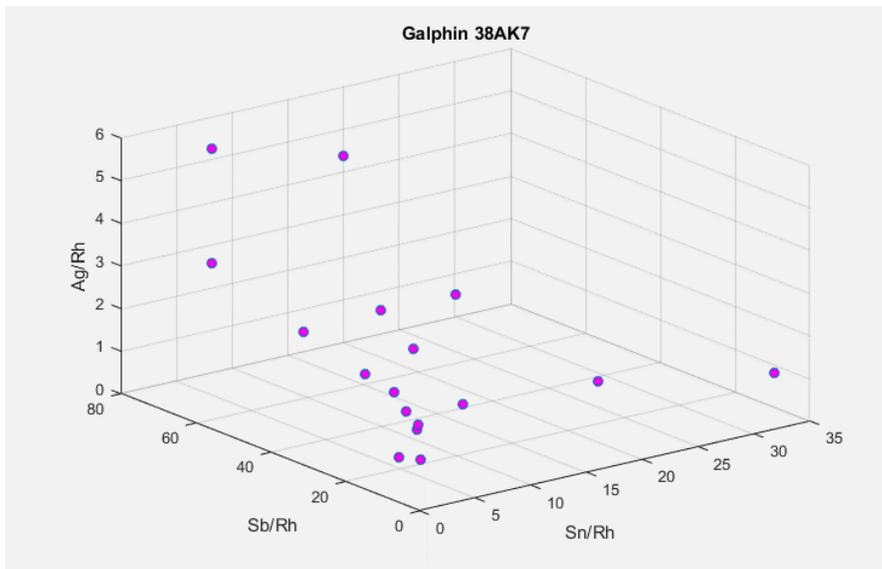


Figure 33. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Galphins Sample.

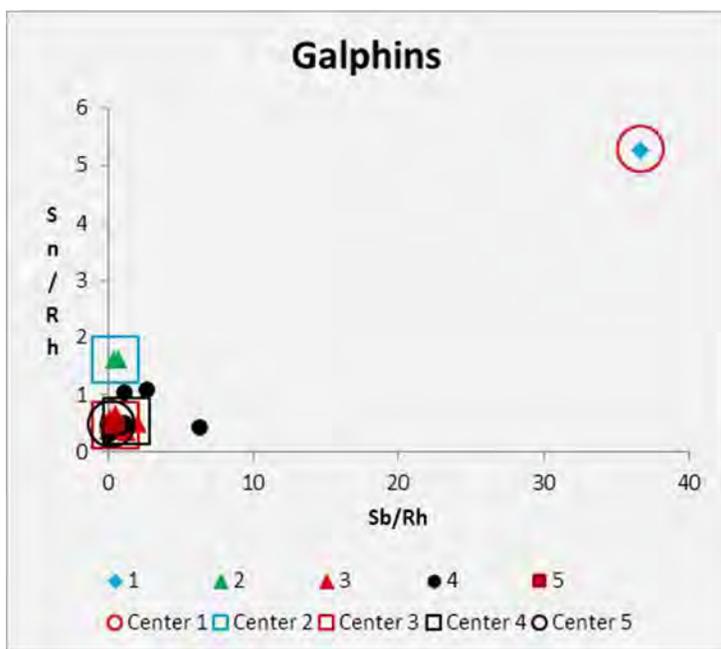


Figure 34. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Galphins Sample.

### Battle of Fort Necessity

Fort Necessity was an American French and Indian War-period fort and battle site located in western Pennsylvania. It is currently maintained by the National Park Service as a historical park. Frankum provided a sample of 16 round ball ammunition from the Fort Necessity battleground for analysis in the 2017 workshop. This sample is included as Group 19 in Appendix 1. Figures 35 and 36 show portions of the spectra for the Fort Necessity samples. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Fort Necessity sample. Five clusters were identified (Table 7 and Figures 37 and 38). The dominant cluster (Segment 2) contained six of 16 specimens. Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 2.62, Tin (Sn)/Rhodium (Rh), 17.93 and Silver (Ag)/Rhodium (Rh), 5.58.

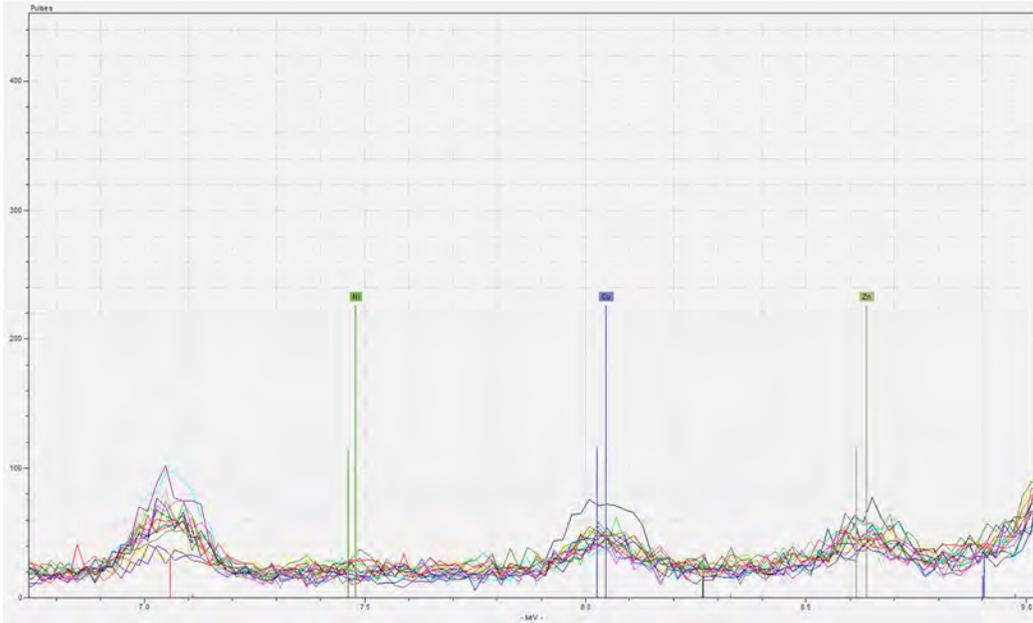


Figure 35. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Fort Necessity Sample.

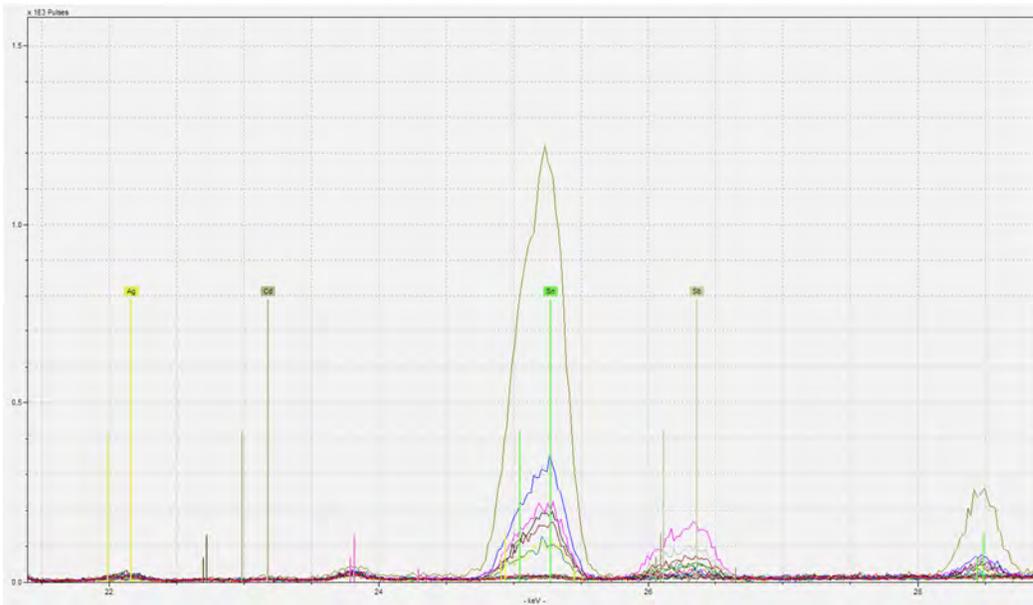


Figure 36. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Necessity Sample.

Table 7. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Necessity Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	13.30	64.70	6.58		
Segment 2	2.62	17.93	5.58		
Segment 3	17.76	533.13	4.91		
Segment 4	5.65	16.24	1.63		
Segment 5	51.65	48.07	2.32		
AVERAGE	14.85	61.20	4.06		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	2	12.5%	7829.4		
Segment 2	6	37.5%	6388.8	<b>SSE Total</b>	<b>7.2</b>
Segment 3	1	6.3%	0.0		
Segment 4	4	25.0%	924.0		
Segment 5	3	18.8%	3499.3		
TOTAL	16	100.0%			

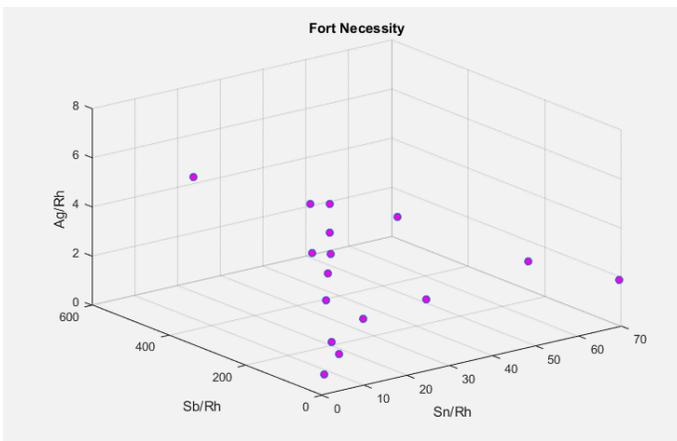


Figure 37. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Necessity Sample.

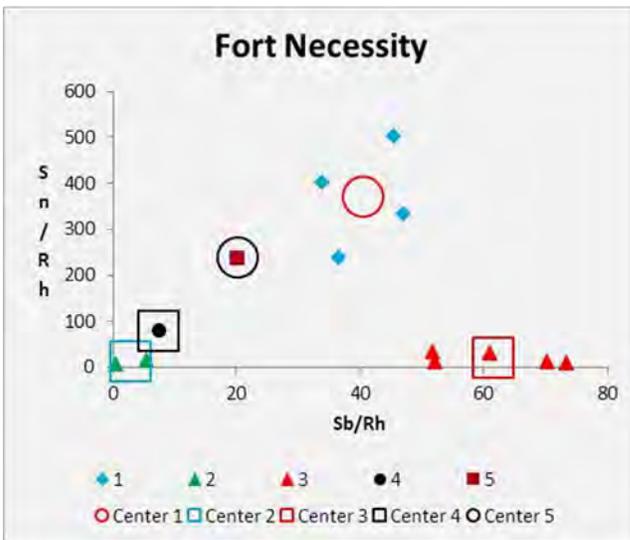


Figure 38. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Necessity Sample.

## Parker's Revenge, Minuteman National Park

Parker's Revenge is a battle in Massachusetts that took place on April 19, 1775. Conflict archaeology was conducted on the battlefield and Watters (2016) reported on the that study. Watters provided pXRF data on this collection for the 2015 workshop. This sample is included as Group 28 in Appendix 1. Figures 39 and 40 show portions of the spectra for the Minuteman samples. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figure 41 contains two graphs showing the distribution of Tin (Sn) and Antimony (Sb) in the Minuteman samples.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Minuteman Park sample. Five clusters were identified (Table 8 and Figure 42 and 43). The dominant cluster (Segment 4) contained 16 of 30 samples (53.3%). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.26, Tin (Sn)/Rhodium (Rh), 1.40 and Silver (Ag)/Rhodium (Rh), 0.14.

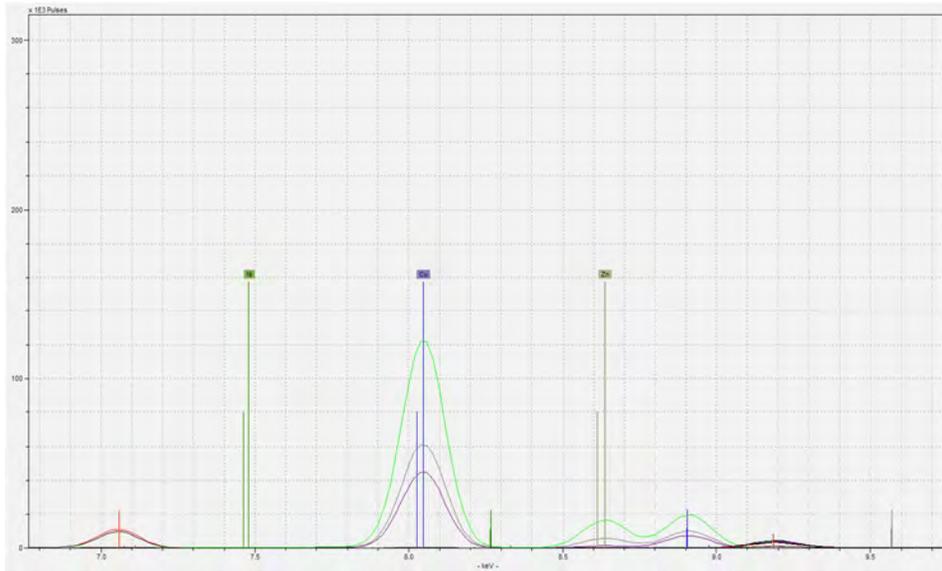


Figure 39. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Minuteman Sample.

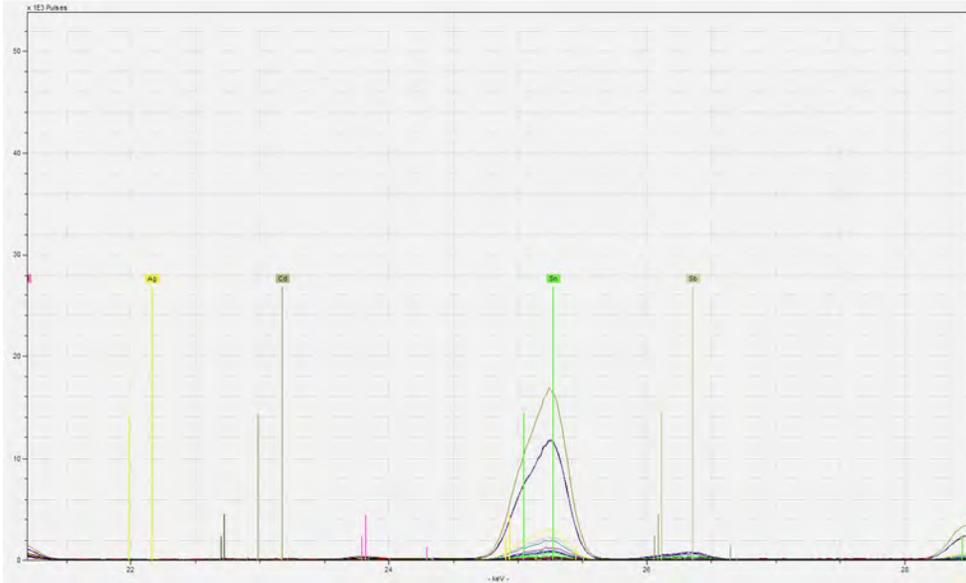


Figure 40. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Minuteman Sample.



Figure 41. Distribution of Tin (Sn) and Antimony (Sb) Photons in Minuteman Sample.

Table 8. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Minuteman Sample.

Mean/Centroid	Sb/Rh	Sn/Rh	Ag/Rh	0	0
Segment 1	5.20	144.46	0.35		
Segment 2	2.43	13.96	0.34		
Segment 3	7.15	7.49	0.17		
Segment 4	0.26	1.40	0.14		
Segment 5	1.58	34.02	2.20		
AVERAGE	1.78	21.89	0.41		
Respondents	Number	%	SSE/Segment		
Segment 1	3	10.0%	1840.8		
Segment 2	6	20.0%	890.5	<b>SSE Total</b>	<b>11.0</b>
Segment 3	2	6.7%	0.0		
Segment 4	16	53.3%	59.3		
Segment 5	3	10.0%	1911.8		
TOTAL	30	100.0%			

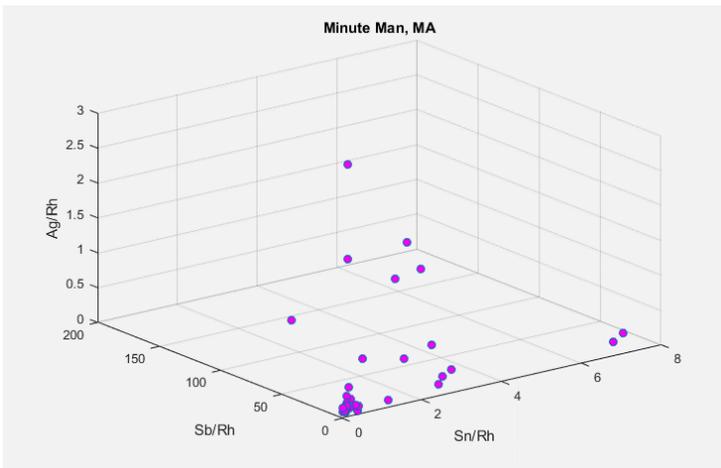


Figure 42. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in Minuteman Sample.

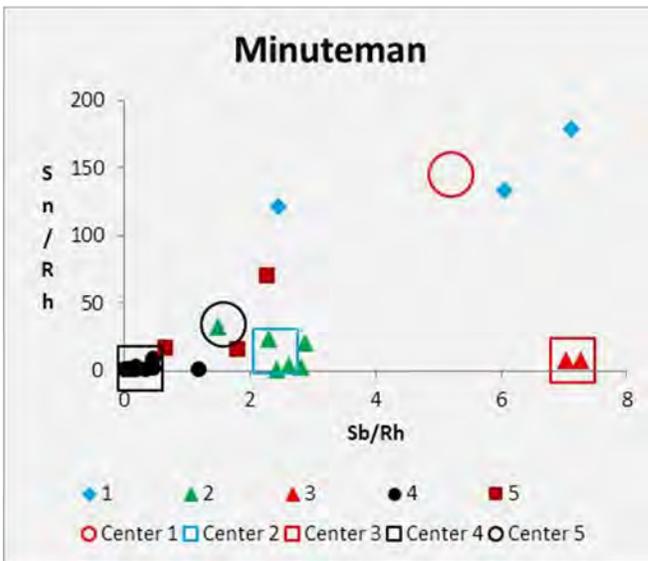


Figure 43. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Minuteman Sample.

## King George III Statue

A large metal statue of British King George III, which had been erected at the Bowling Green in New York City was torn down by a crowd of American Patriots on July 9, 1776 (Figure 44). Fragments of the statue were transported to Litchfield, Connecticut by Patriots where they were cast into bullets for the American troops. Other pieces of the statue, such as the two specimens in the New York Historical Society (Object Numbers 1878.4 and 2001.185) were taken by Loyalists, who hid them in their homes.

The New York Historical Society (NYHS) possesses several fragments of the King George statue that were not melted down for bullets. One metal fragment of the King George III statue in the NYHS collection was acquired in 1878 (Figure 45). It measures 14 x 33 x 44.4 cm. Another metal fragment in the NYHS collection was acquired in 2001 (Figure 46). It measures 22.9 x 35.6 x 20.3 cm. Seibert analyzed these two specimens in September 2014. Seibert and Sivilich (2016) then compared these data to archaeologically recovered bullets from northeastern battlefields. The elemental data from these two artifacts are included as Group 46 in Appendix 1. Figures 47 and 48 show portions of the spectra for the King George Statue samples. Nickel (Ni), Copper (Cu), Zinc (Zn), Silver (Ag), Cadmium (Cd) and Tin (Sn) display peaks in these graphs.



Figure 44. Circa 1913 Watercolor of Equestrian Statue of King George III, Bowling Green, New York City (NYHS 1923.118).



Figure 45. King George III Statue Fragment (NYHS 1878.4).



Figure 46. King George III Statue Fragment (NYHS 2001.185).

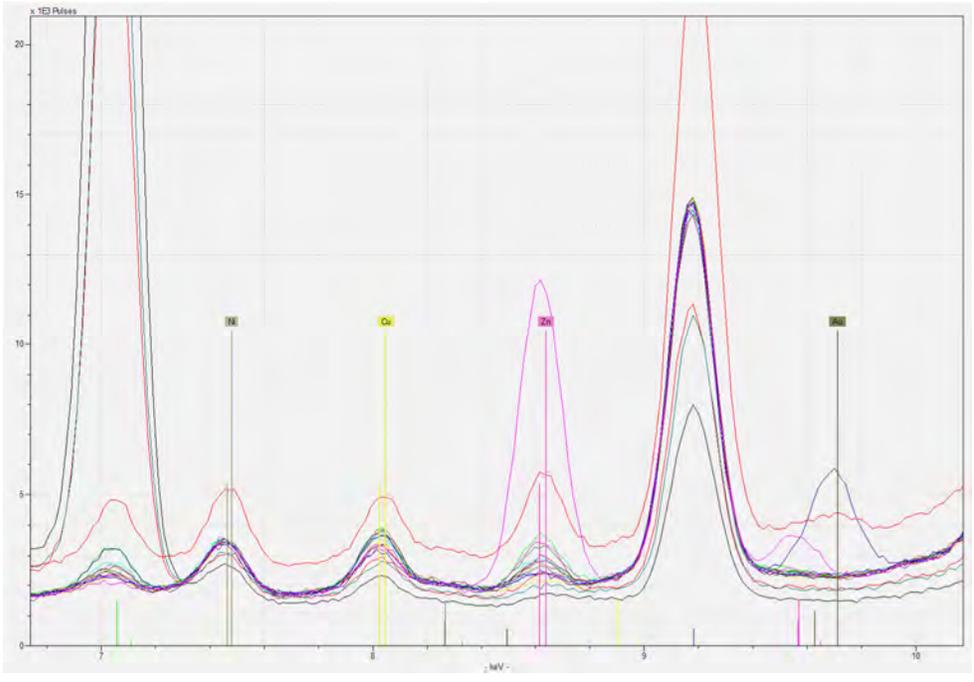


Figure 47. Spectra of Nickel (Ni), Copper (Cu), Zinc (Zn) and Gold (Au) King George Statue Sample.

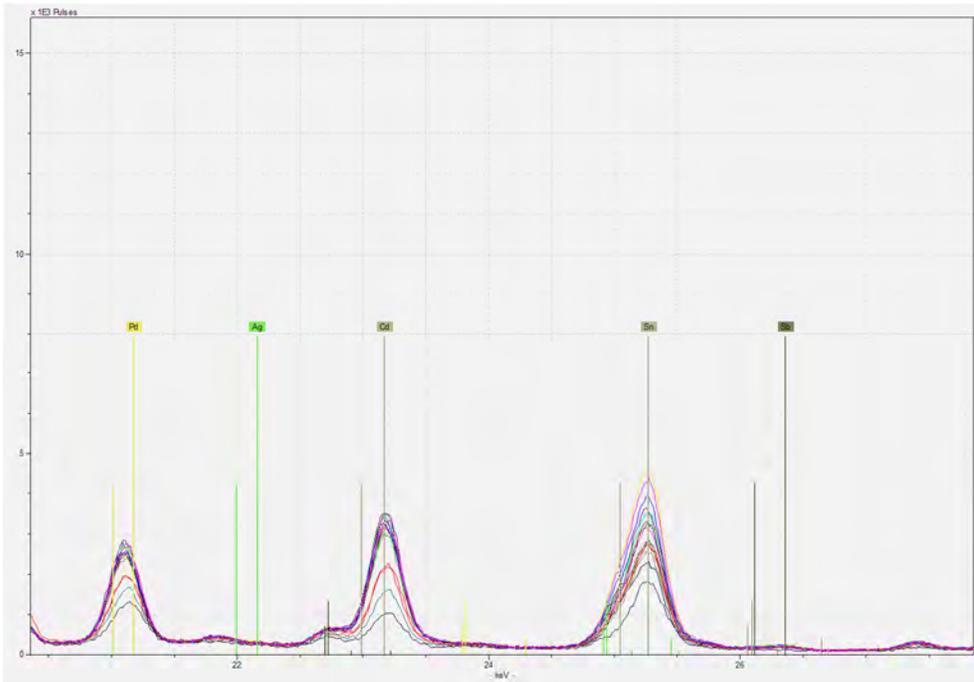


Figure 48. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) King George Statue Sample.

## Battle of Moores Creek Bridge

Moores Creek Bridge, located near Wilmington in present-day Pender County, North Carolina, was the site of military engagement in the American Revolution on February 27, 1776. The battle, which was an American victory, pitted about one thousand North Carolina Patriots against 750 North Carolina Loyalists. The battle site is currently operated by the National Park Service as the Moores Creek National Battlefield. Michael Seibert provided elemental data on a sample of 29 round ball ammunition from the Moores Creek Bridge battle site for the 2015 Workshop. This sample is included as Group 29 in Appendix 1. Figures 49 and 50 show portions of the spectra for the Moores Creek samples. Copper (Cu), Silver (Ag), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios from the Moores Creek sample. Five clusters were identified (Table 9 and Figures 51 and 52). The dominant cluster (Segment 4) contained 15 of 29 specimens (51.7% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.67, Tin (Sn)/Rhodium (Rh), 0.44 and Silver (Ag)/Rhodium (Rh), 0.35.

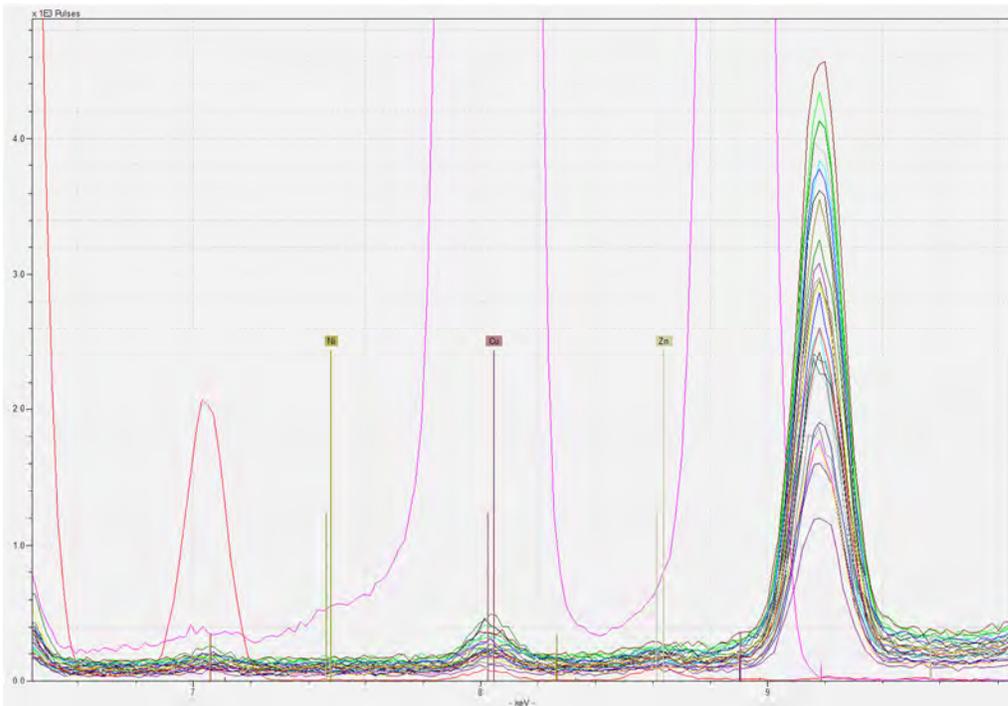


Figure 49. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Moores Creek Sample.

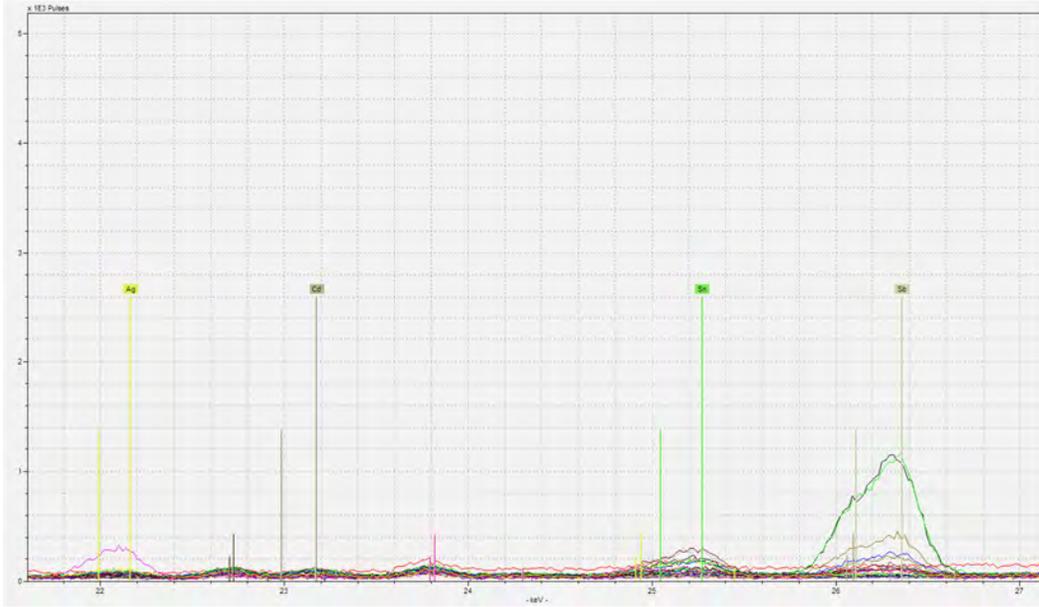


Figure 50. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Moores Creek Sample.

Table 9. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Moores Creek Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	1.21	0.86	5.19		
Segment 2	12.34	1.50	0.18		
Segment 3	0.55	0.41	1.22		
Segment 4	0.67	0.44	0.35		
Segment 5	0.84	1.86	0.52		
AVERAGE	1.53	0.92	0.64		
Respondents	Number	%	SSE/Segment		
Segment 1	1	3.4%	0.0		
Segment 2	2	6.9%	0.6	<b>SSE Total 11.7</b>	
Segment 3	3	10.3%	0.0		
Segment 4	15	51.7%	20.1		
Segment 5	8	27.6%	5.3		
TOTAL	29	100.0%			

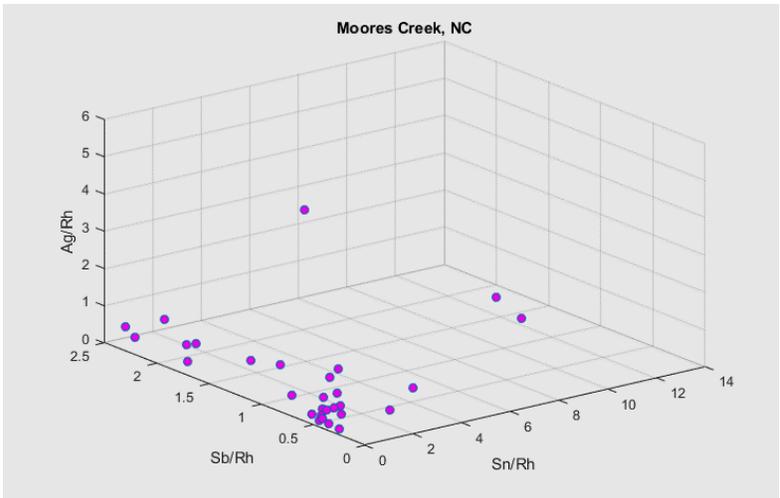


Figure 51. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Moores Creek.

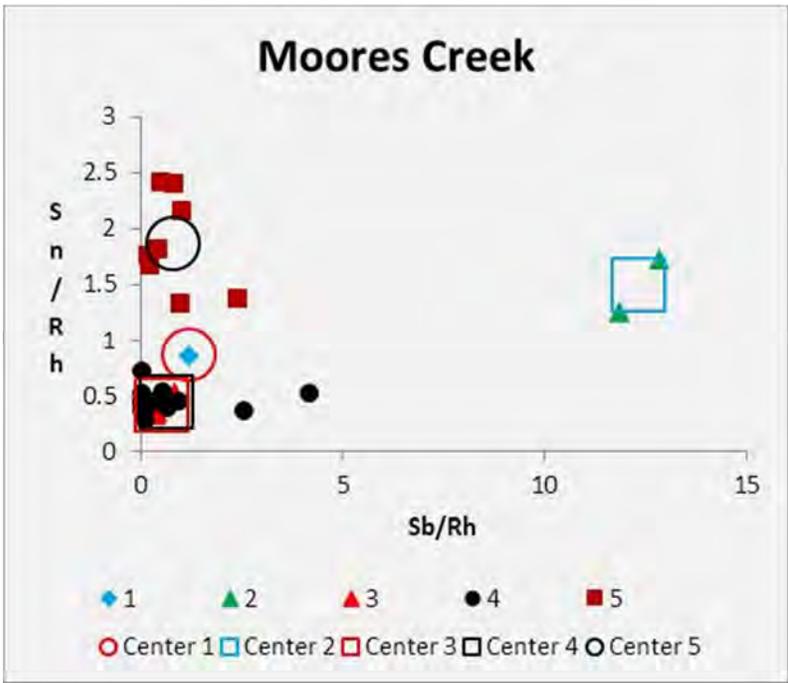
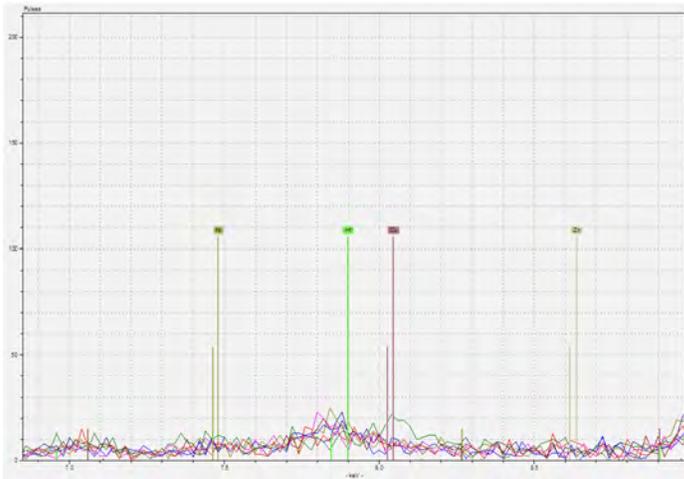


Figure 52. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Moores Creek.

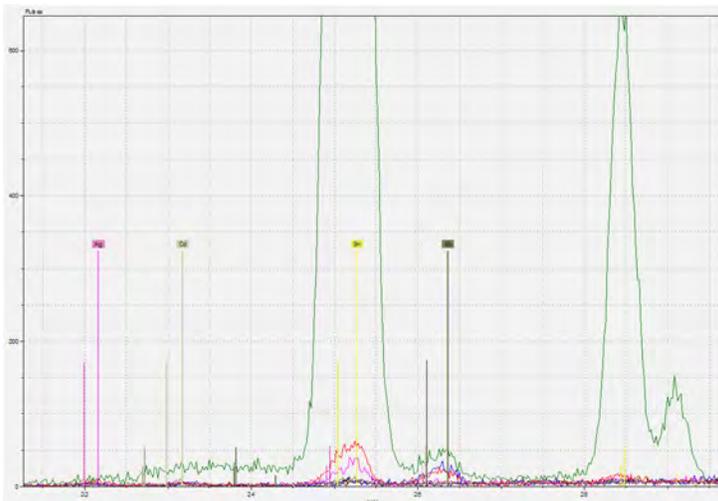
### New Jersey Battle Sites

Sivilich provided seven round balls from three Revolutionary War period battle sites in New Jersey. These include Petticoat Bridge, the Craig Road Site and Belle Terre Farm. The Petticoat Bridge skirmish took place on December 23, 1776 when

British and Hessian forces invaded New Jersey (Goos and Cain 2014). The other two sites are associated with the Battle of Monmouth, which took place on June 28, 1778 in Monmouth County (Frazza 2017). Belle Terre Farm, now incorporated into Monmouth Battlefield State Park (Avin 2011). The Craig Road Site is located at the Battle of Monmouth in Manalapan, New Jersey (Sivilich 2013). This sample is included as Group 36 in Appendix 1. Figures 53 and 54 show portions of the spectra for the Moores Creek samples. Hafnium (Hf), Copper (Cu), Tin (Sn) and Antimony (Sb) display peaks in these graphs. The Craig Road Site specimen (Sivilich 9LS26-1) was a Fusil-sized ball that displayed substantially higher content of Tin (Sn) and Antimony (Sb) than did any of the other New Jersey specimens.



**Figure 53. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) New Jersey Sites Sample.**



**Figure 54. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) New Jersey Sites Sample.**

## Battle of Beaufort

The Battle of Beaufort, also known as the Battle of Gray's Hill, was a military engagement of the American Revolution that took place on February 3, 1779 in Beaufort County, South Carolina. The Battle of Beaufort site was recently located by archaeologist Daniel Battle. Battle and Elliott analyzed a sample of 27 balls from the battlefield in 2016, and these data are included in this report. Battle provided a sample of 35 round ball ammunition from the Beaufort Battlefield for the 2017 workshop. These represent a combined total of 62 balls. Numerous examples from this assemblage are interpreted by Battle as representing fired American artillery case shot. Other specimens in this assemblage likely represent single shots from long arms. This sample is included as Groups 1 and 2 in Appendix 1.

Figures 55 and 56 show portions of the spectra for the Beaufort (2016) samples. Nickel (Ni), Hafnium (Hf), Copper (Cu), Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figures 57 and 58 show portions of the spectra for the Beaufort (2017) samples. Copper (Cu), Zinc (Zn), Silver (Ag), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on the Silver (Ag), Antimony (Sb) and Tin (Sn) ratios in the Battle of Beaufort combined samples. Five clusters were identified (Table 10 and Figures 59 and 60). The dominant cluster (Cluster 3) contained 23 of 62 specimens (37.1% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 7.39, Tin (Sn)/Rhodium (Rh), 12.72 and Silver (Ag)/Rhodium (Rh), 4.09.

Cluster analysis also was performed on the Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh) ratios in the Beaufort sample. Five clusters were identified (Table 11 and Figure 61). Two clusters (Segments 3 and 5) dominated the assemblage both containing nine specimens out of 27 total specimens (33.3%). Mean/centroids for Segment 3 were Nickel (Ni)/Rhodium (Rh), 2.79, Copper (Cu)/Rhodium (Rh), 7.20 and Zinc (Zn)/Rhodium (Rh), 0.41. Mean/centroids for Segment 5 were Nickel (Ni)/Rhodium (Rh), 4.31, Copper (Cu)/Rhodium (Rh), 10.92 and Zinc (Zn)/Rhodium (Rh), 0.55.

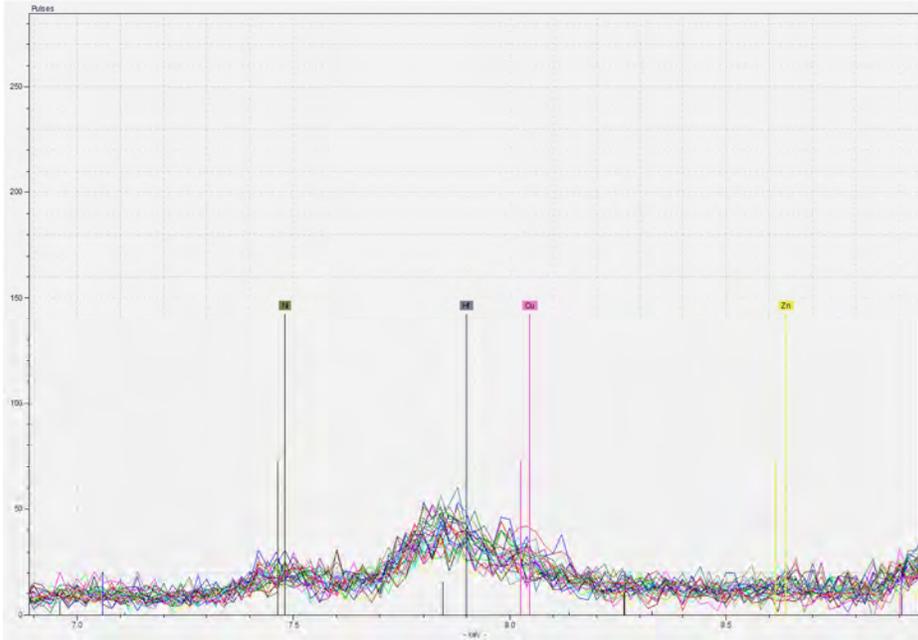


Figure 55. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Beaufort 2016 Sample.

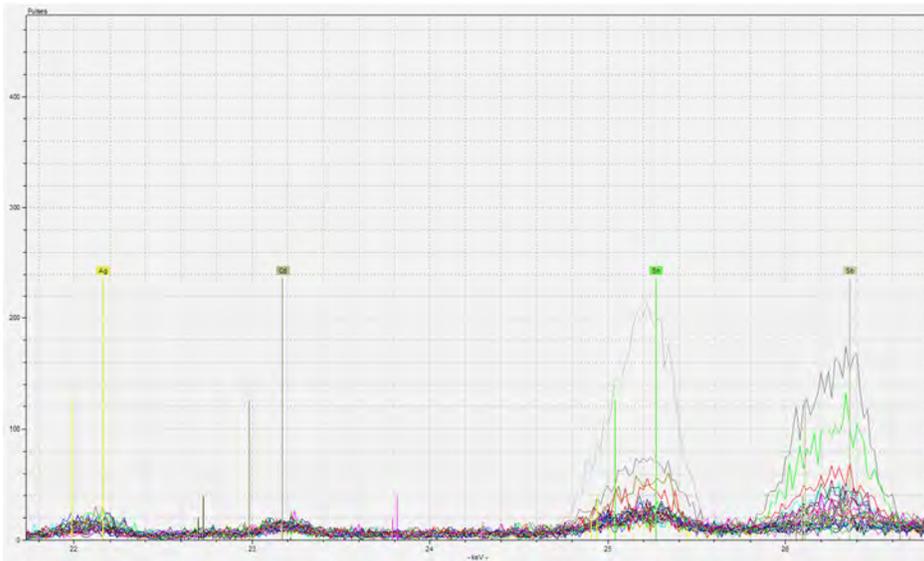


Figure 56. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Beaufort 2016 Sample.

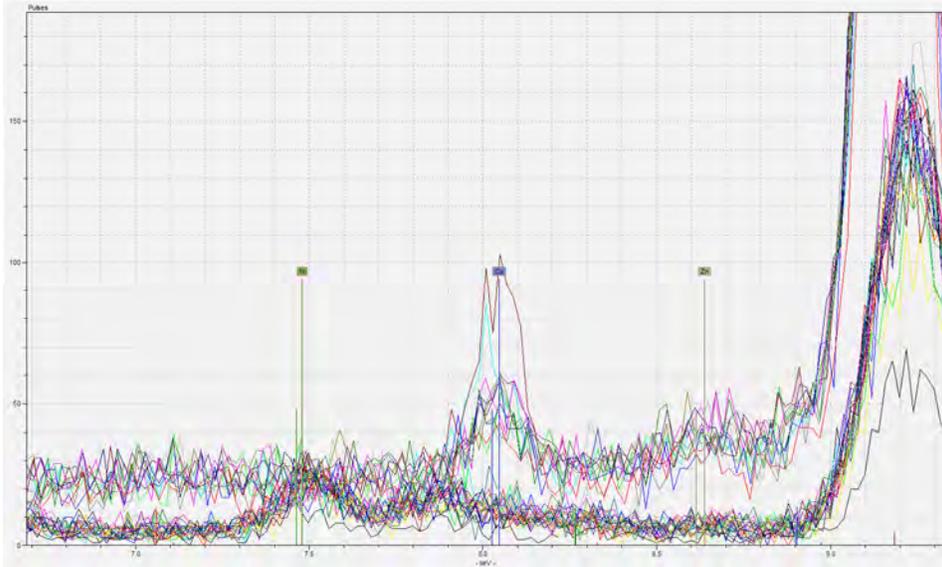


Figure 57. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Beaufort 2017 Sample.

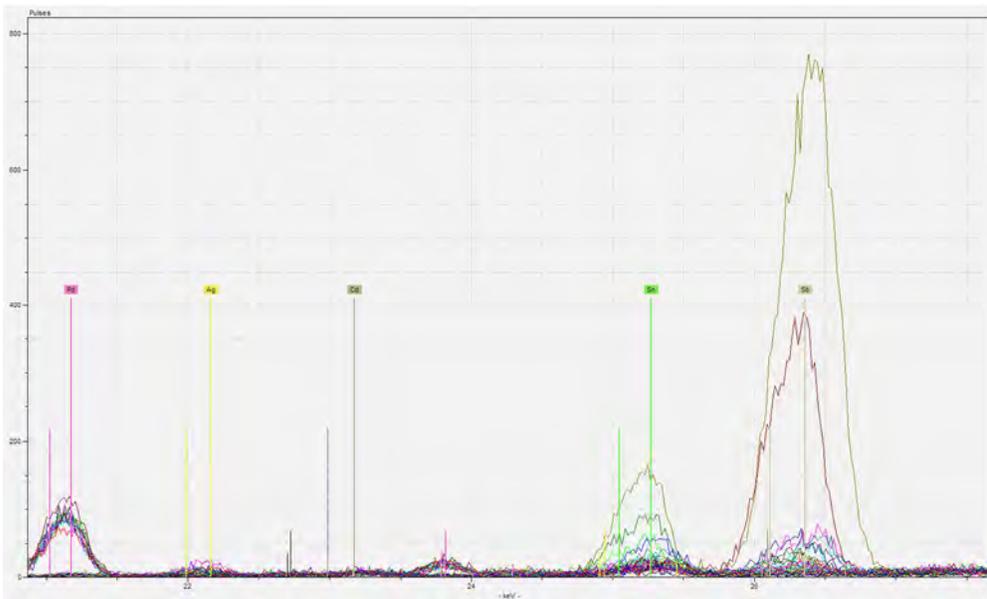


Figure 58. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Beaufort 2017 Sample.

Table 10. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Battle of Beaufort Composite Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	15.74	8.45	1.71		
Segment 2	13.49	7.97	6.94		
Segment 3	7.39	12.72	4.09		
Segment 4	16.51	43.99	2.25		
Segment 5	506.29	11.94	1.66		
AVERAGE	20.15	13.43	3.74		
Respondents	Number	%	SSE/Segment		
Segment 1	19	30.6%	13584.9		
Segment 2	13	21.0%	8313.9	<b>SSE Total 59.1</b>	
Segment 3	23	37.1%	0.0		
Segment 4	6	9.7%	4527.5		
Segment 5	1	1.6%	0.0		
TOTAL	62	100.0%			

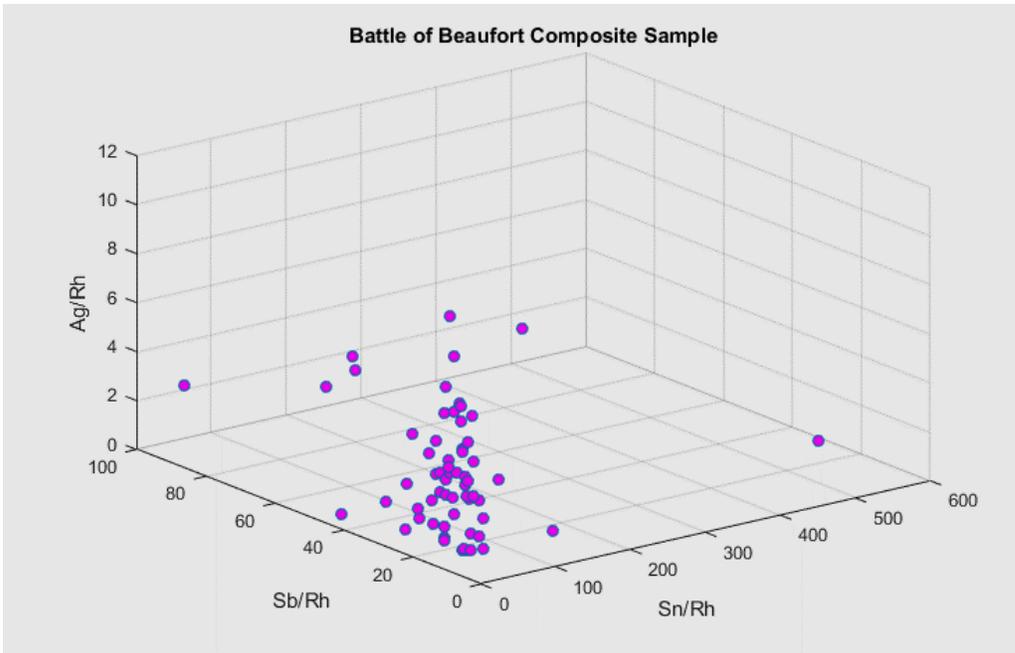


Figure 59. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in Battle of Beaufort Samples (2016 and 2017 Combined).

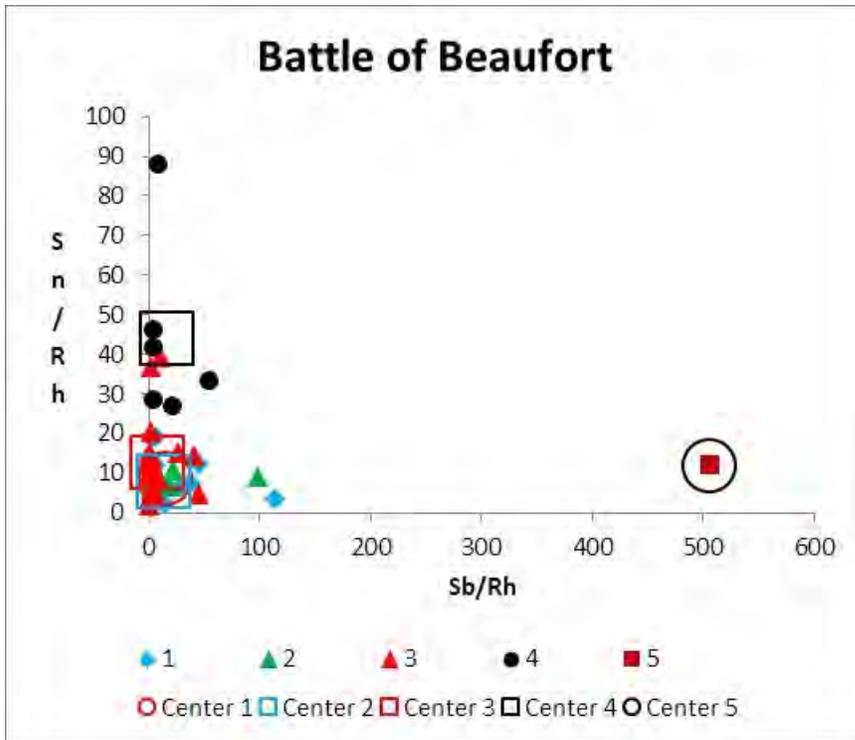


Figure 60. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Battle of Beaufort Composite Sample.

Table 11. Output for Five Clusters/Segments, Nickel (Ni), Copper (Cu) and Zinc (Zn) Ratios, Beaufort (2016) Sample.

Mean/Centroid	<i>Ni/Rh</i>	<i>Cu/Rh</i>	<i>Zn/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	6.58	15.61	0.37		
Segment 2	6.33	24.10	2.76		
Segment 3	2.79	7.20	0.41		
Segment 4	5.19	12.52	1.80		
Segment 5	4.31	10.92	0.55		
<b>AVERAGE</b>	4.45	11.33	0.64		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	6	22.2%	56.2		
Segment 2	1	3.7%	0.0		
Segment 3	9	33.3%	0.0		
Segment 4	2	7.4%	0.8		
Segment 5	9	33.3%	18.6		
<b>TOTAL</b>	27	100.0%			
				<b>SSE Total</b>	<b>19.0</b>

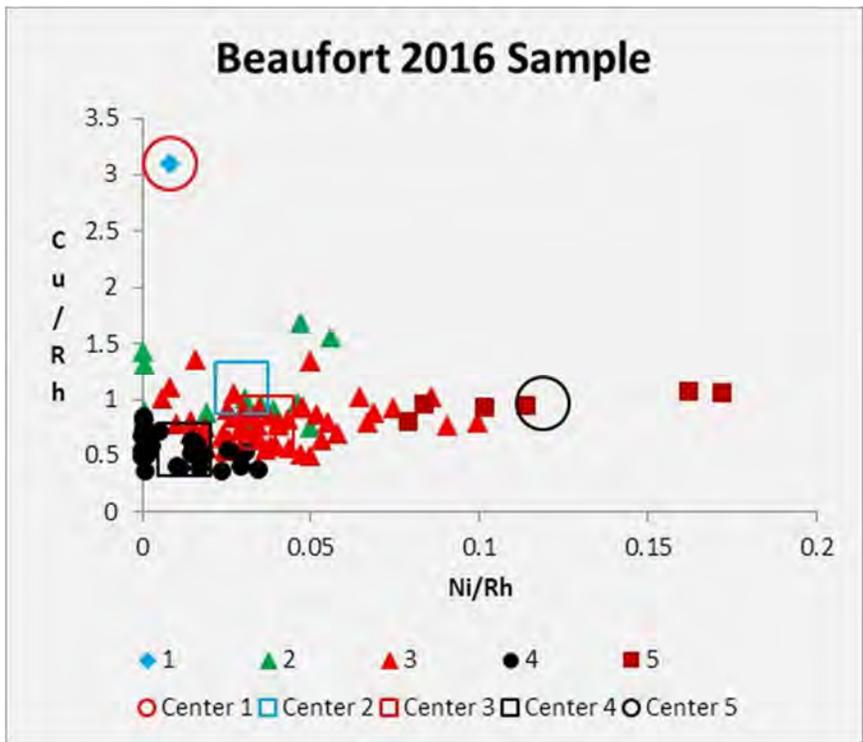


Figure 61. Central Means Chart for Five Segments, Nickel (Ni), Copper (Cu) and Zinc (Zn) Ratios, Beaufort (2016) Sample.

### Battle of Carr's Fort

Captain Robert Carr commanded a company of Wilkes County militia and he maintained a fort at his home in the eastern Georgia piedmont. The fort was used in 1778 and early 1779. On February 10, 1779, the nearly-empty fort was taken over by British and Loyalist recruits. The fort was quickly surrounded by Georgia and South Carolina militia and a short siege ensued. The Americans called off the siege when they received word of an approaching larger British force. The battle is considered an American victory. The following month Carr's Fort was attacked by Creek Indian Loyalists, Captain Carr was killed and the fort was likely burned. The Carr's Fort Battlefield was located and studied in 2013 by archaeologists (Elliott and Davis 2014). In 2015 Elliott sampled 19 round balls from the Carr's Fort Battlefield collection at the Laboratory of Archaeology, University of Georgia. This sample is included as Group 8 in Appendix 1. Figures 62 and 63 show portions of the spectra for the Carr's Fort samples. Copper (Cu), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was conducted on Silver (Ag), Antimony (Sb) and Tin (Sn) ratios in the Carr's Fort sample. Five clusters were identified (Table 12 and Figures 64 and 65). The dominant cluster (Segment 5) contained 6 of 19 specimens (31.6% of the

assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 1.16, Tin (Sn)/Rhodium (Rh), 30.50 and Silver (Ag)/Rhodium (Rh), 0.14.

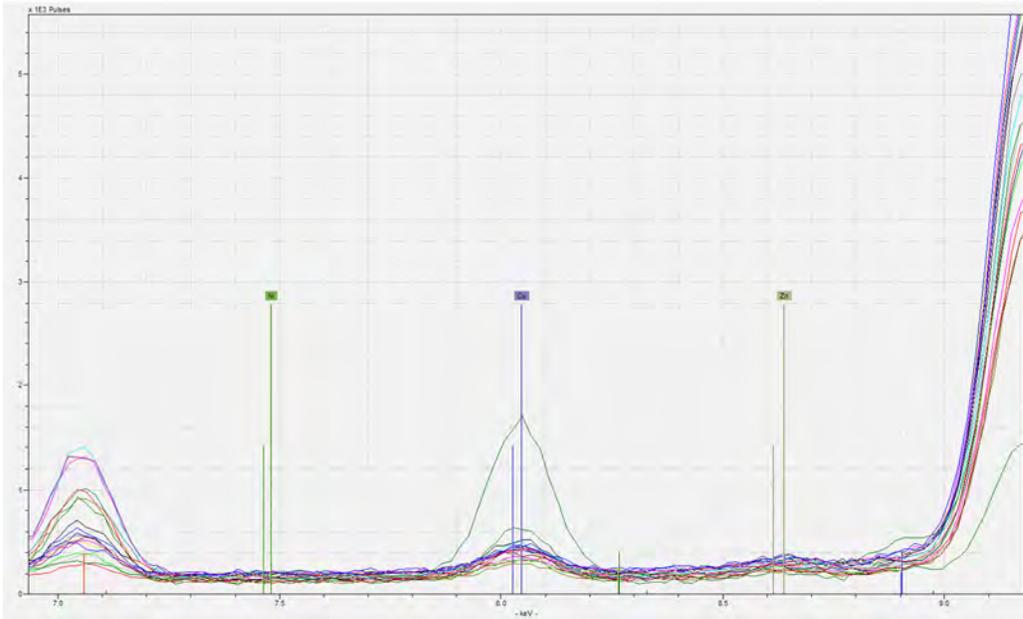


Figure 62. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Carrs Fort Sample.

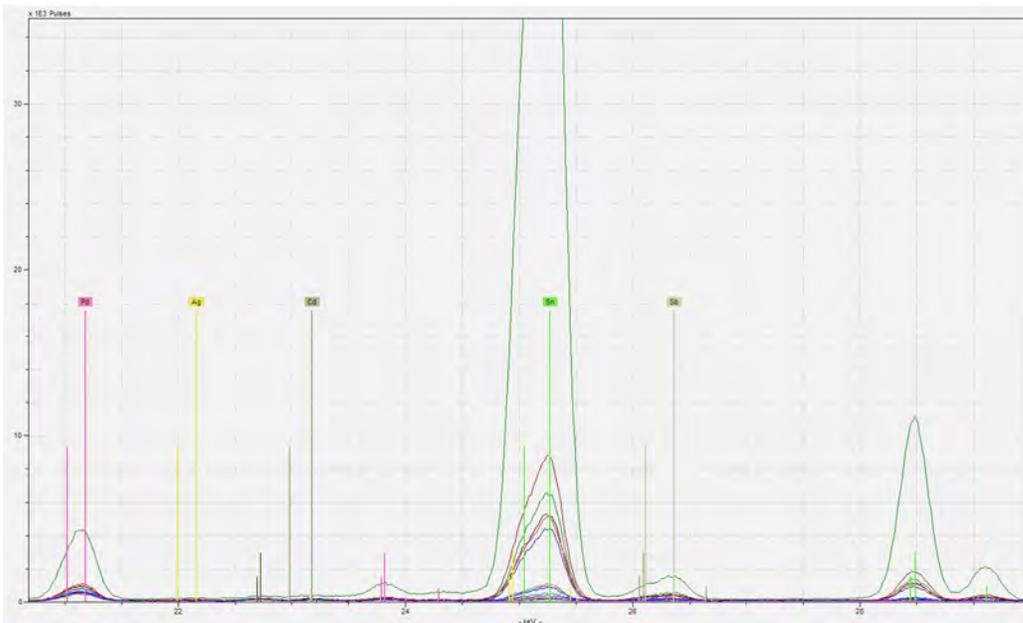
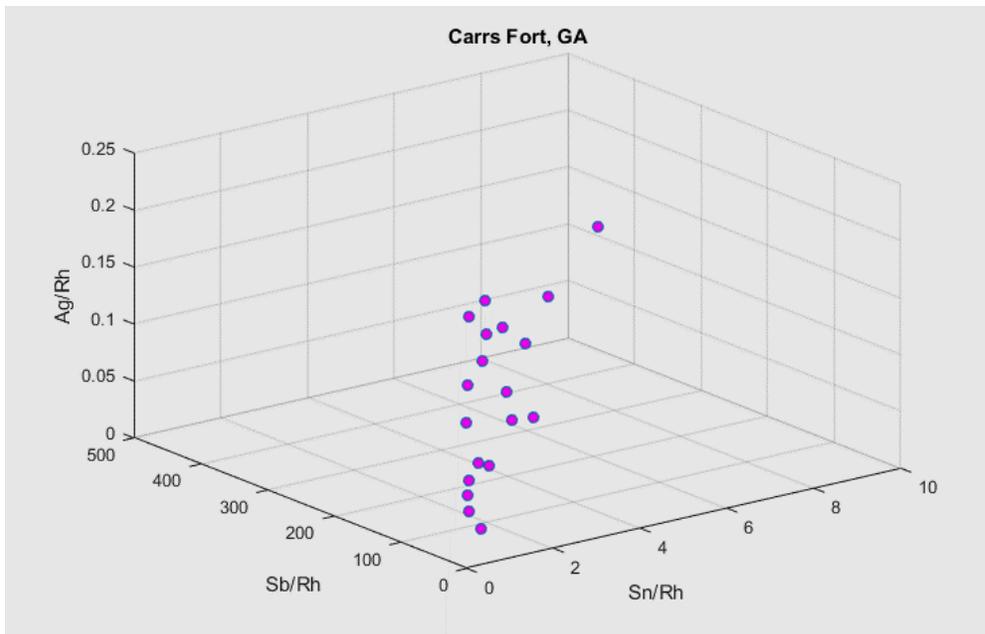


Figure 63. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Carrs Fort Sample.

**Table 12. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Carrs Fort Sample.**

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	0.28	0.94	0.20		
Segment 2	1.06	12.29	0.12		
Segment 3	9.36	411.92	0.12		
Segment 4	1.87	34.38	0.19		
Segment 5	0.23	1.77	0.07		
<b>AVERAGE</b>	<b>1.16</b>	<b>30.50</b>	<b>0.14</b>		
Respondents	Number	%	SSE/Segment		
Segment 1	5	26.3%	1.6		
Segment 2	4	21.1%	303.8	<b>SSE Total</b>	<b>2.9</b>
Segment 3	1	5.3%	0.0		
Segment 4	3	15.8%	289.1		
Segment 5	6	31.6%	23.0		
<b>TOTAL</b>	<b>19</b>	<b>100.0%</b>			



**Figure 64. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Carrs Fort Sample.**

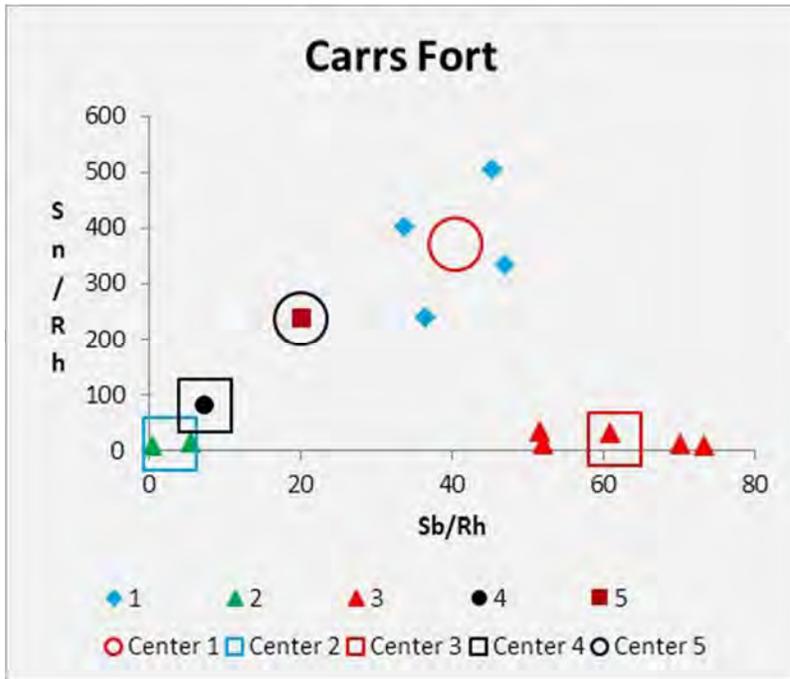


Figure 65. Central Means Charts for Five Segments, Silver (Ag), Tin (Sn) and Antimony (Sb) Ratios, Carrs Fort Sample.

### Battle of Kettle Creek

Archaeologists located and defined the Kettle Creek Battlefield in 2008 (Elliott 2009). This site is located in rural Wilkes County, Georgia in the piedmont region. In 2017 Elliott sampled 63 round balls from the Kettle Creek Battlefield collection at the Washington-Wilkes History Museum in Washington, Georgia. This sample is included as Group 25 in Appendix 1. Figures 66 and 67 show portions of the spectra for the Kettle Creek samples. Nickel (Ni), Hafnium (Hf), Copper (Cu), Zinc (Zn), Silver (Ag), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figures 68 and 69 show graphs of the distribution of Tin (Sn) and Antimony (Sb) in the Kettle Creek sample.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Kettle Creek sample. Five clusters were identified (Table 13 and Figures 70 and 71). The dominant cluster (Segment 2) contained 35 of 63 total items (55.6% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 6.66, Tin (Sn)/Rhodium (Rh), 22.93 and Silver (Ag)/Rhodium (Rh), 2.11.

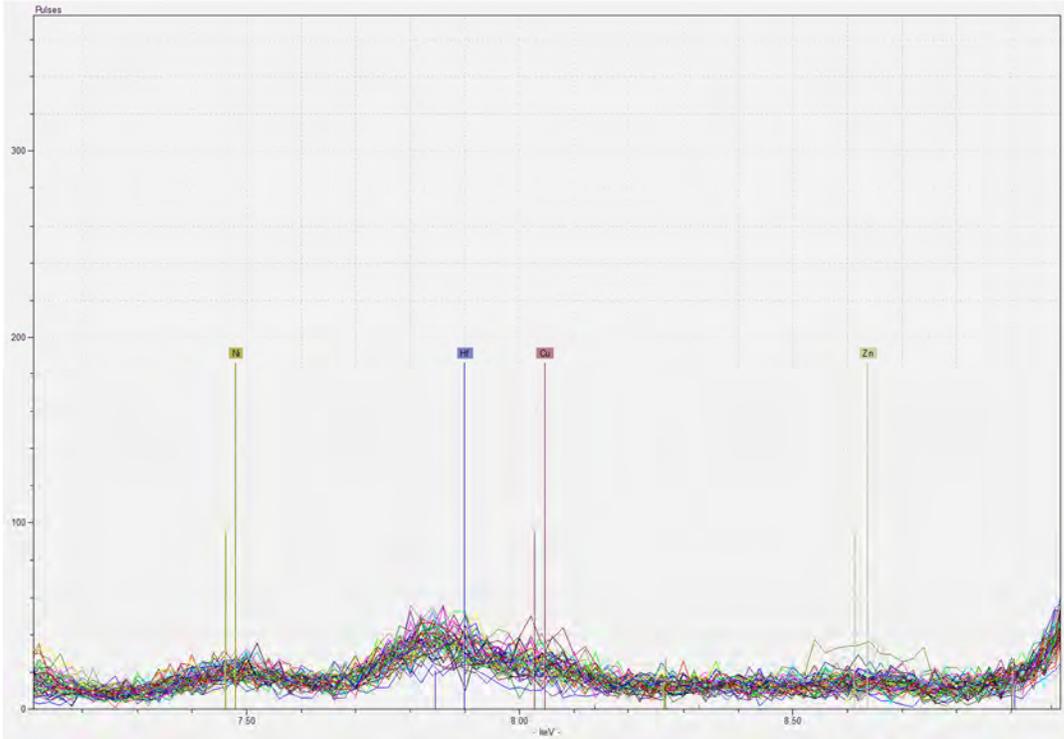


Figure 66. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Kettle Creek.

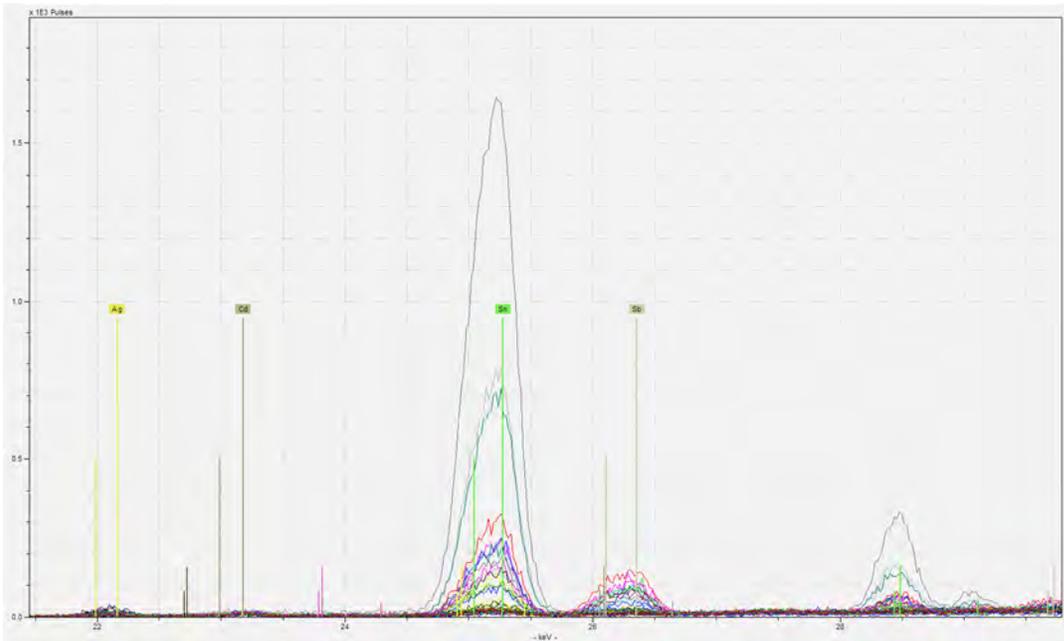


Figure 67. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Kettle Creek Sample.

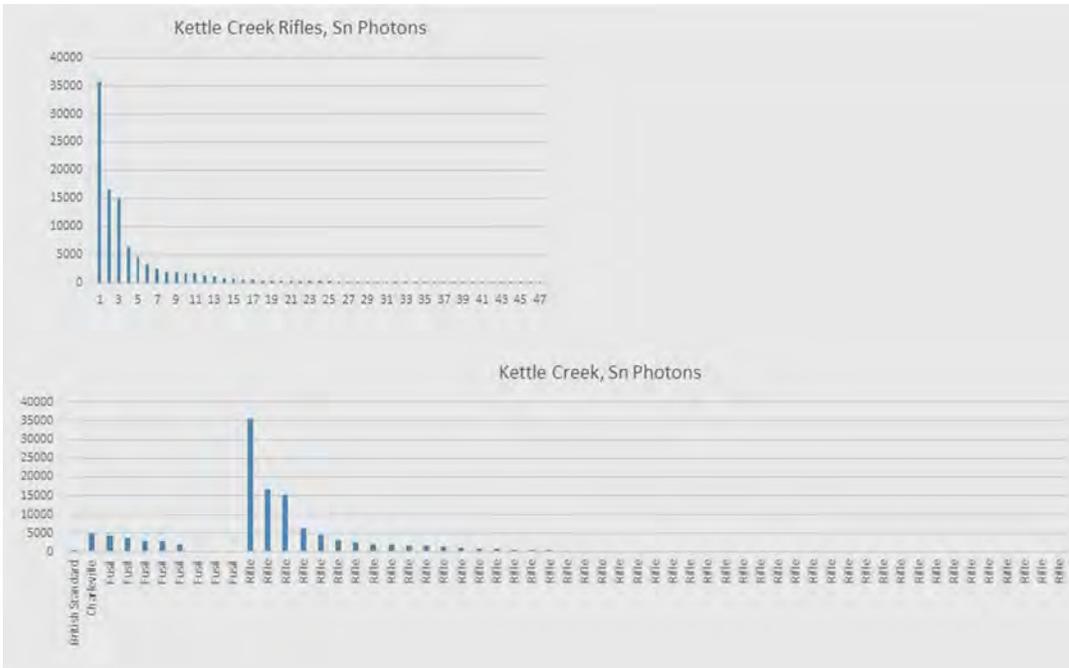


Figure 68. Tin (Sn) Photons in Kettle Creek Sample.

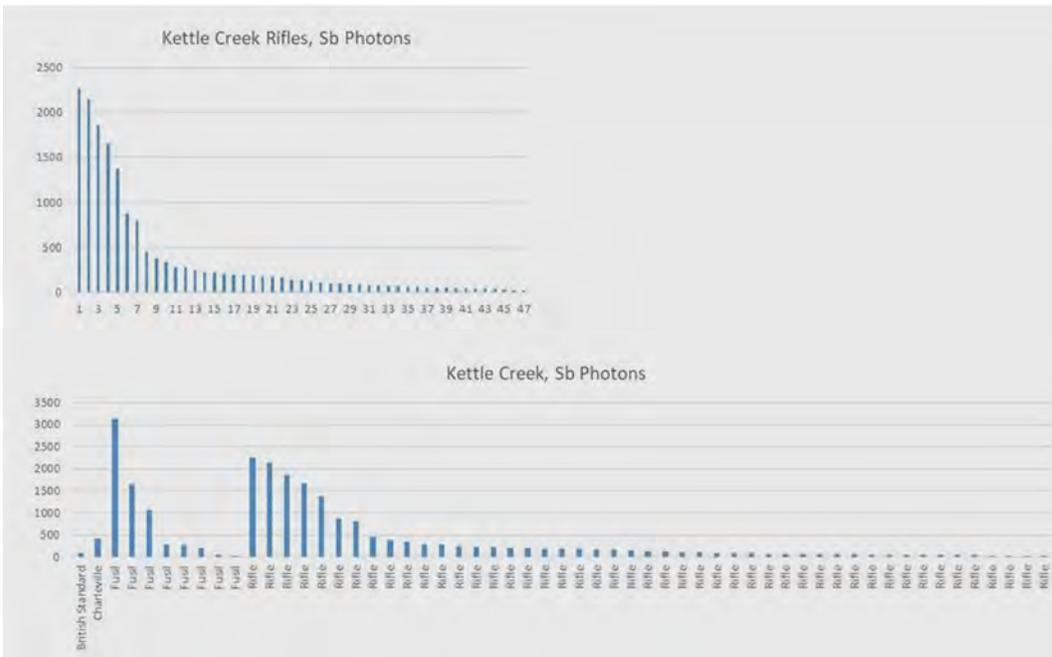


Figure 69. Antimony (Sb) Photons in Kettle Creek Sample.

Table 13. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Kettle Creek Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	81.37	31.19	6.66		
Segment 2	6.66	22.93	2.11		
Segment 3	7.93	32.13	4.01		
Segment 4	2.75	405.85	2.24		
Segment 5	2.12	13.51	7.66		
AVERAGE	11.09	42.98	3.39		
Respondents	Number	%	SSE/Segment		
Segment 1	4	6.3%	8147.9		
Segment 2	35	55.6%	37900.7		
Segment 3	15	23.8%	0.0		
Segment 4	3	4.8%	58125.9		
Segment 5	6	9.5%	473.0		
TOTAL	63	100.0%			
				<b>SSE Total</b>	<b>62.4</b>

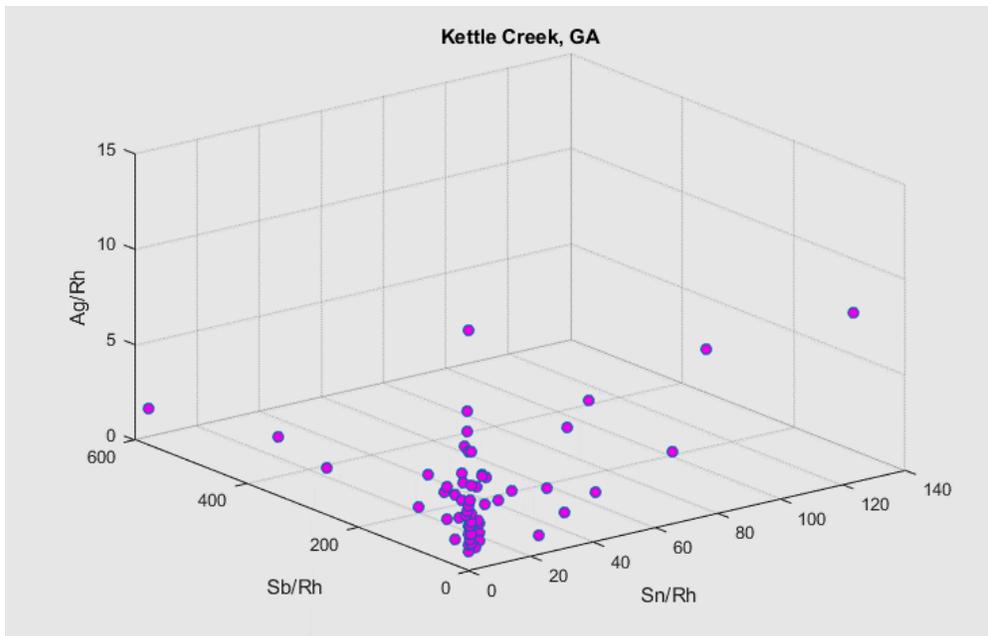


Figure 70. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Kettle Creek Sample.

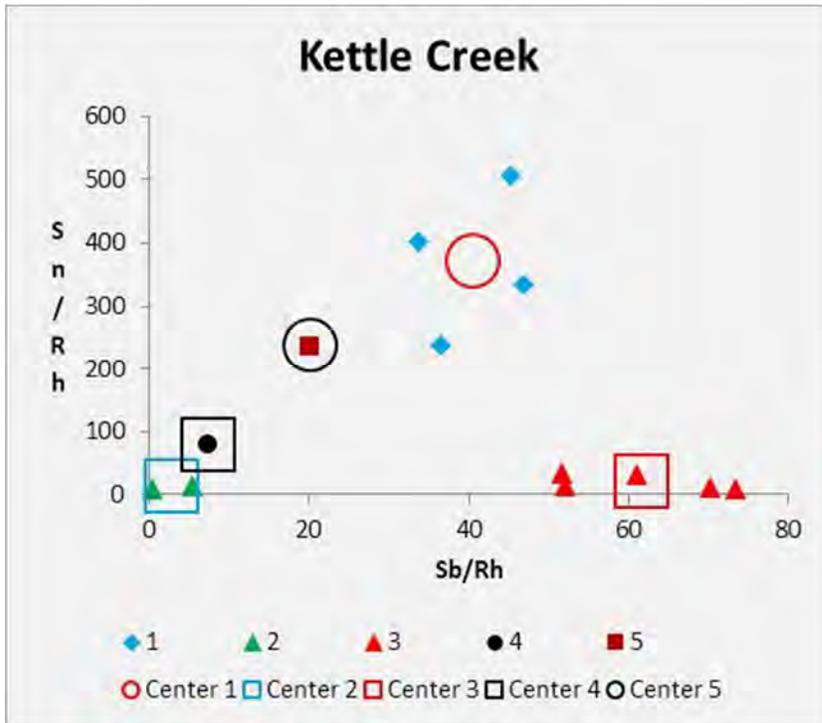


Figure 71. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Kettle Creek Sample.

## Battle of Brier Creek

In early 1779 American forces commanded by General John Ashe were encamped on the north side of Brier Creek near its confluence with the Savannah River in present-day Screven County. These troops were surprised by British forces on March 3, 1779 and the Americans were dealt a devastating blow. In 2014 and 2015 archaeologists studied the battlefield remains, which were recorded as Site 9SN254 (Battle and Owens 2015). A sample of 90 round balls from that study were sampled in 2015 by Elliott and Battle. This sample is included as Group 3 in Appendix 1.

Archaeologists returned to the Brier Creek Battlefield in early 2017 and conducted more intensive survey of a small portion of the battlefield. The technical report of that effort by Brockington & Associates is in draft form at the time of this writing. Butler and his colleagues provided 24 round ball samples from that study for the 2017 project. This sample is included as Group 4 in Appendix 1.

Figures 72 and 73 show portions of the spectra for the Brier Creek (2015) sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figures 74 and 75 show portions of the spectra for the Brier Creek (2017) sample. Nickel (Ni), Copper (Cu), Zinc (Zn), Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the 2015 Brier Creek samples. Five clusters were identified (Table 14, Figures 76 and 77). This clustering was compared with the suspected weapon type for the Brier Creek 2015 sample. The dominant cluster (Segment 4) contained 37 of 91 specimens (40.7% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.10, Tin (Sn)/Rhodium (Rh), 0.54 and Silver (Ag)/Rhodium (Rh), 0.11. This cluster was dominant among the British Standard balls (19 of 31 specimens, or 61.2 percent of the British Standard balls. Cluster 1 dominated the rifle balls (8 of 19 specimens, or 42.1%). Cluster 5 dominated the fusil balls (7 of 15 specimens, or 46.7%).

Pearson's Chi-square tests was run on these results to determine if the clusters defined for the three ratios (Silver (Ag)/Rhodium (Rh), Tin (Sn)/Rhodium (Rh) and Antimony (Sb)/Rhodium (Rh)) were significant when compared with the results by bullet size (Rifles, Fusils, Charleville and British Standard balls (Table 15). This exercise yielded a Chi-square value of 39.981 and a P value of 0.0008. The null hypothesis, which states that the frequency distribution of certain events observed in the sample is consistent with the theoretical distribution, is rejected. The alternative hypothesis, that there is a difference between the distributions, is accepted at the 0.01 confidence level.

Cluster analysis also was performed on Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh) ratios for the Brier Creek (2015) sample. Four clusters were identified (Table 16 and Figure 78). The dominant cluster (Segment 3) contained 33 of 91 specimens (36.3% of assemblage). Cluster 1 dominated the assemblage of rifles, fusils and Charleville muskets, while Cluster 3 was dominant among British Standard balls. Mean/centroids for this cluster were Nickel (Ni)/Rhodium (Rh), 0.03, Copper (Cu)/Rhodium (Rh), 0.52 and Zinc (Zn)/Rhodium (Rh), 0.11.

Pearson's Chi-square tests was run on these results to determine if the clusters defined for the three ratios (Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh)) were significant when compared with the results by weapon type (Rifles, Fusils, Charleville and British Standard balls (Table 17). This exercise yielded a Chi-square value of 22.918 and a P value of 0.0284. The null hypothesis, which states that the frequency distribution of certain events observed in the sample is consistent with the theoretical distribution, is rejected. The alternative hypothesis, that there is a difference between the distributions, is accepted at the 0.05 confidence level. At the 0.01 confidence level, however, the null hypothesis is accepted.

The 2017 sample from Brier Creek produced different results in the cluster analysis compared to the 2015 sample (Table 18 and Figures 79 and 80). This likely the

result of sampling a smaller portion of the battlefield, which contained a subset of the site wide bullet types and to the smaller sample size (n-24). This clustering was compared with the suspected weapon type for the Brier Creek 2017 sample. The dominant cluster (Segment 1) contained eight of 24 specimens (33.3% of the assemblage). This cluster included five fusil balls (38.5% of the fusil balls). Cluster 5, which comprised 16.7 percent of the assemblage was dominated by rifle balls (50% of the rifle balls). Mean/centroids for Segment 1 were Antimony (Sb)/Rhodium (Rh), 1.31, Tin (Sn)/Rhodium (Rh), 7.23 and Silver (Ag)/Rhodium (Rh), 1.12.

Pearson's Chi-square tests was run on these results to determine if the clusters defined for the three ratios (Silver (Ag)/Rhodium (Rh), Tin (Sn)/Rhodium (Rh) and Antimony (Sb)/Rhodium (Rh)) were significant when compared with the results by weapon type (Rifles, Fusils, Charleville and British Standard balls (Table 19). This exercise yielded a Chi-square value of 15.996 and a P value of 0.4532. The null hypothesis, which states that the frequency distribution of certain events observed in the sample is consistent with the theoretical distribution, must be accepted.

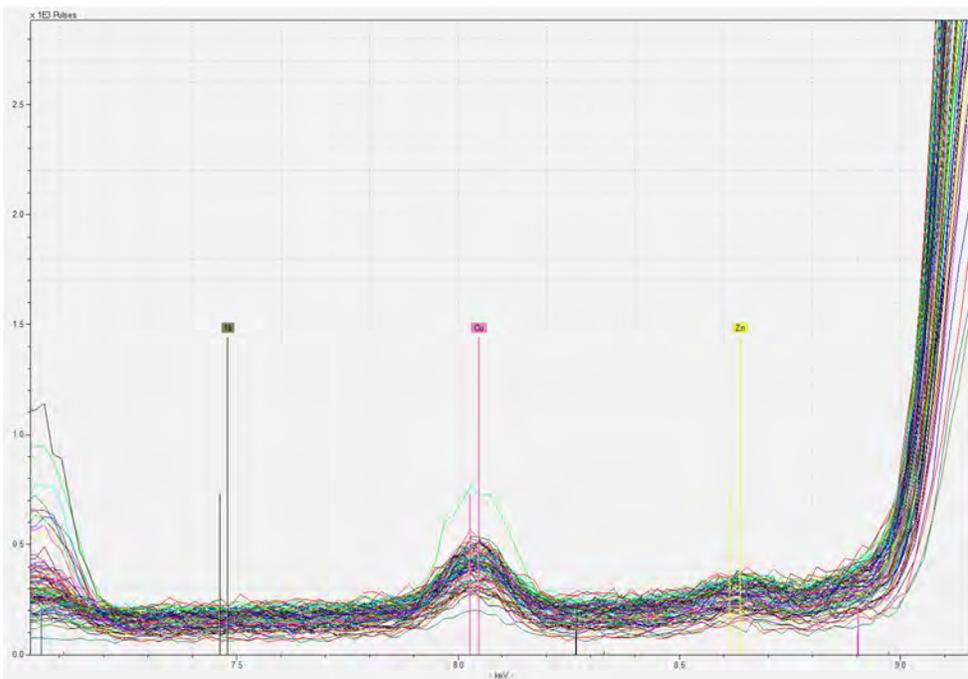


Figure 72. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Brier Creek 2015 Sample.

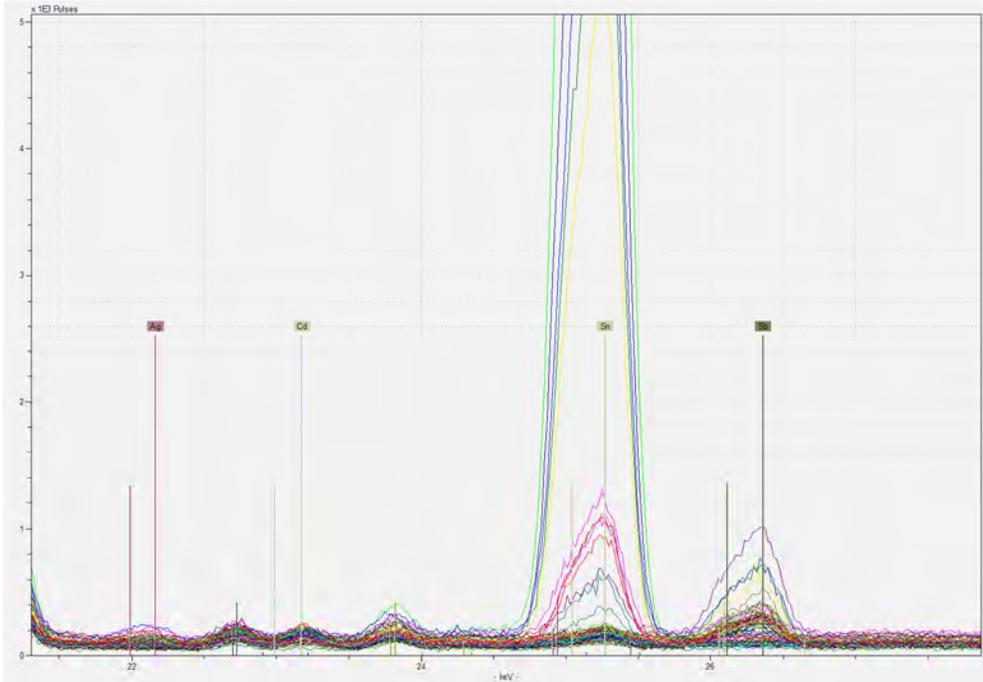


Figure 73. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Brier Creek 2015 Sample.

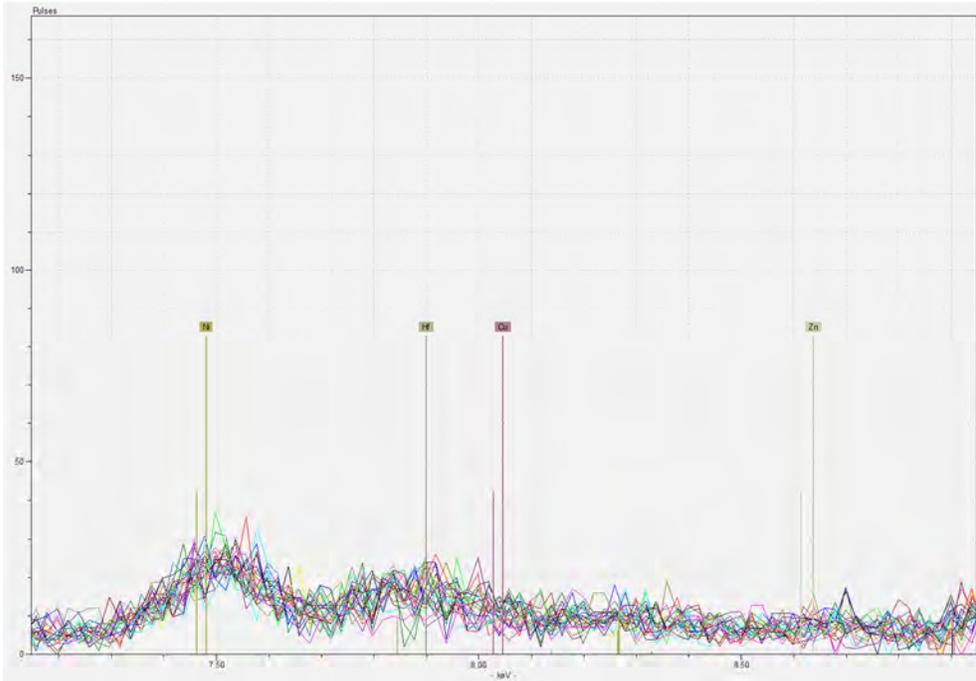


Figure 74. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Brier Creek 2017 Sample.

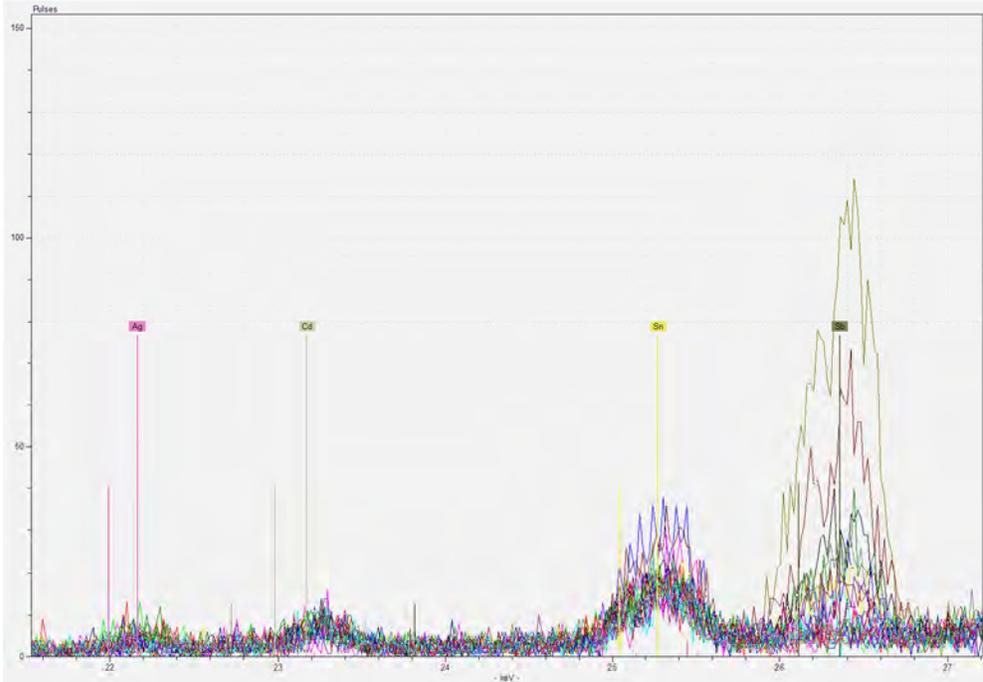


Figure 75. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Brier Creek 2017 Sample.

Table 14. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Brier Creek 2015 Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	0.80	7.59	0.42		
Segment 2	2.36	3.04	0.11		
Segment 3	1.63	122.86	0.16		
Segment 4	0.10	0.54	0.11		
Segment 5	1.01	0.66	0.06		
<b>AVERAGE</b>	<b>0.80</b>	<b>4.68</b>	<b>0.14</b>		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	14	15.4%	2855.8		
Segment 2	12	13.2%	819.8	<b>SSE Total</b>	<b>109.7</b>
Segment 3	2	2.2%	0.0		
Segment 4	37	40.7%	22.8		
Segment 5	26	28.6%	27.5		
<b>TOTAL</b>	<b>91</b>	<b>100.0%</b>			

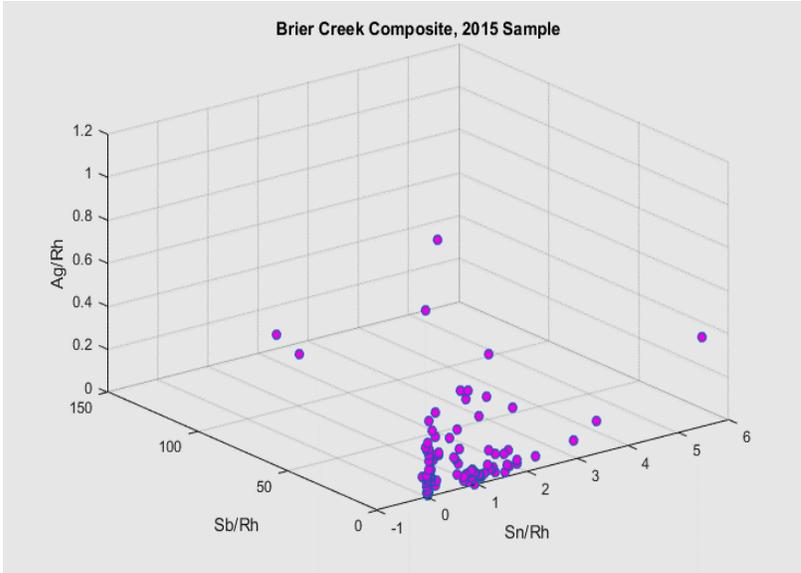


Figure 76. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Brier Creek 2015 Sample.

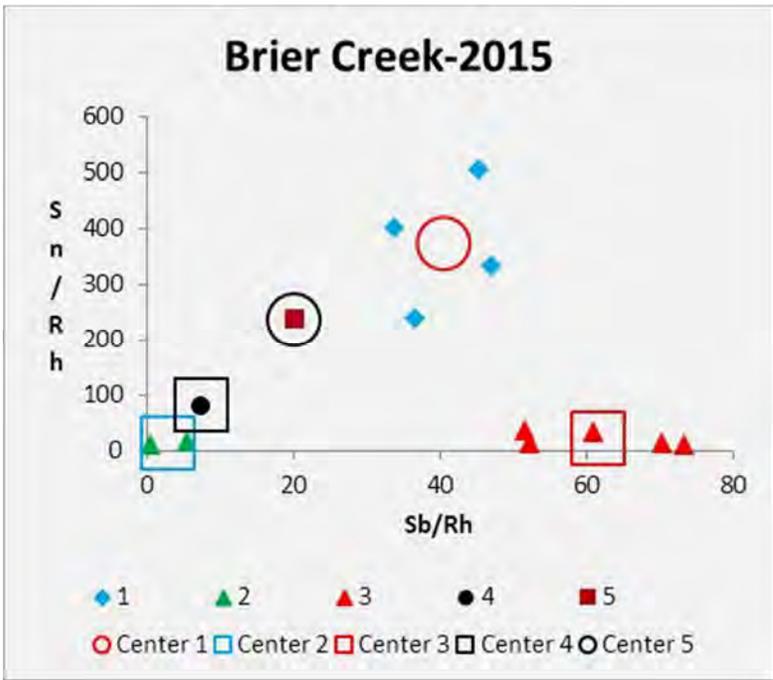


Figure 77. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Brier Creek 2015 Sample.

Table 15. Chi-square Calculations, Silver (Ag), Tin (Sn) and Antimony (Sb) Ratios and Weapon Type, Brier Creek 2015 Sample.

	Brier Creek Balls					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	
<b>Rifle</b>	8 2.92 ( 8.82)	3 2.51 ( 0.10)	2 0.42 ( 6.00)	4 7.73 ( 1.80)	2 5.43 ( 2.17)	<b>19</b>
<b>Fusil</b>	1 2.31 ( 0.74)	1 1.98 ( 0.48)	0 0.33 ( 0.33)	6 6.10 ( 0.00)	7 4.29 ( 1.72)	<b>15</b>
<b>Charleville</b>	0 0.46 ( 0.46)	2 0.40 ( 6.51)	0 0.07 ( 0.07)	1 1.22 ( 0.04)	0 0.86 ( 0.86)	<b>3</b>
<b>British</b>	3 4.77 ( 0.66)	2 4.09 ( 1.07)	0 0.68 ( 0.68)	19 12.60 ( 3.25)	7 8.86 ( 0.39)	<b>31</b>
<b>Other</b>	2 3.54 ( 0.67)	4 3.03 ( 0.31)	0 0.51 ( 0.51)	7 9.35 ( 0.59)	10 6.57 ( 1.79)	<b>23</b>
	<b>14</b>	<b>12</b>	<b>2</b>	<b>37</b>	<b>26</b>	<b>91</b>

$\chi^2 = 39.981$ ,  $df = 16$ ,  $\chi^2/df = 2.50$ ,  $P(\chi^2 > 39.981) = 0.0008$

Table 16. Output for Four Clusters/Segments, Nickel (Ni), Copper (Cu) and Zinc (Zn) Ratios, Brier Creek 2015 Sample.

Mean/Centroid	Ni/Rh	Cu/Rh	Zn/Rh	0	0
Segment 1	0.01	0.91	0.17		
Segment 2	0.01	0.45	0.08		
Segment 3	0.03	0.52	0.11		
Segment 4	0.05	0.87	0.21		
AVERAGE	0.02	0.64	0.13		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	23	25.3%	0.9		
Segment 2	25	27.5%	0.2	<b>SSE Total</b>	<b>1.7</b>
Segment 3	33	36.3%	0.3		
Segment 4	10	11.0%	0.2		
TOTAL	91	100.0%			

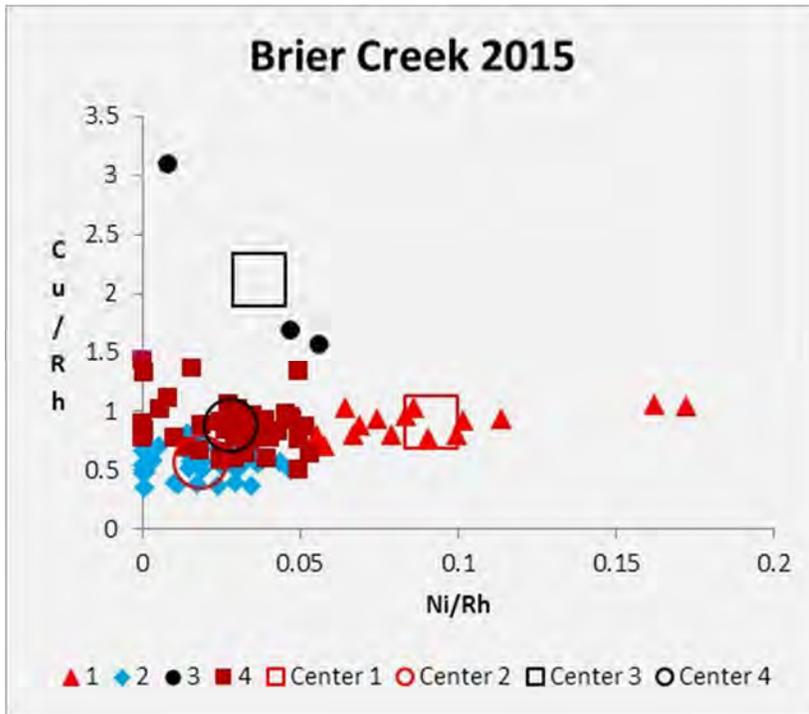


Figure 78. Central Means Chart for Four Segments, Nickel (Ni), Copper (Cu) and Zinc (Zn) Ratios, Brier Creek (2015) Sample.

Table 17. Chi-square Calculations, Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh) ratios and Weapon Type, Brier Creek 2015 Sample.

	Brier Creek 2015 Ni Cu Zn Ratios				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	
Rifle	7 4.80 ( 1.01)	3 5.22 ( 0.94)	5 6.89 ( 0.52)	4 2.09 ( 1.75)	19
Fusil	6 3.79 ( 1.29)	4 4.12 ( 0.00)	4 5.44 ( 0.38)	1 1.65 ( 0.26)	15
Charleville	3 0.76 ( 6.63)	0 0.82 ( 0.82)	0 1.09 ( 1.09)	0 0.33 ( 0.33)	3
British	4 7.84 ( 1.88)	11 8.52 ( 0.72)	15 11.24 ( 1.26)	1 3.41 ( 1.70)	31
Other	3 5.81 ( 1.36)	7 6.32 ( 0.07)	9 8.34 ( 0.05)	4 2.53 ( 0.86)	23
	23	25	33	10	91

$\chi^2 = 22.918$ ,  $df = 12$ ,  $\chi^2/df = 1.91$ ,  $P(\chi^2 > 22.918) = 0.0284$

Table 18. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Brier Creek 2017 Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	1.31	7.23	1.12		
Segment 2	3.17	11.23	2.57		
Segment 3	15.07	17.28	7.38		
Segment 4	13.09	25.79	2.52		
Segment 5	24.10	6.95	1.03		
AVERAGE	8.27	11.51	2.22		
Respondents	Number	%	SSE/Segment		
Segment 1	8	33.3%	23.4		
Segment 2	7	29.2%	105.5	<b>SSE Total</b>	<b>18.6</b>
Segment 3	2	8.3%	0.0		
Segment 4	3	12.5%	10.1		
Segment 5	4	16.7%	748.7		
TOTAL	24	100.0%			

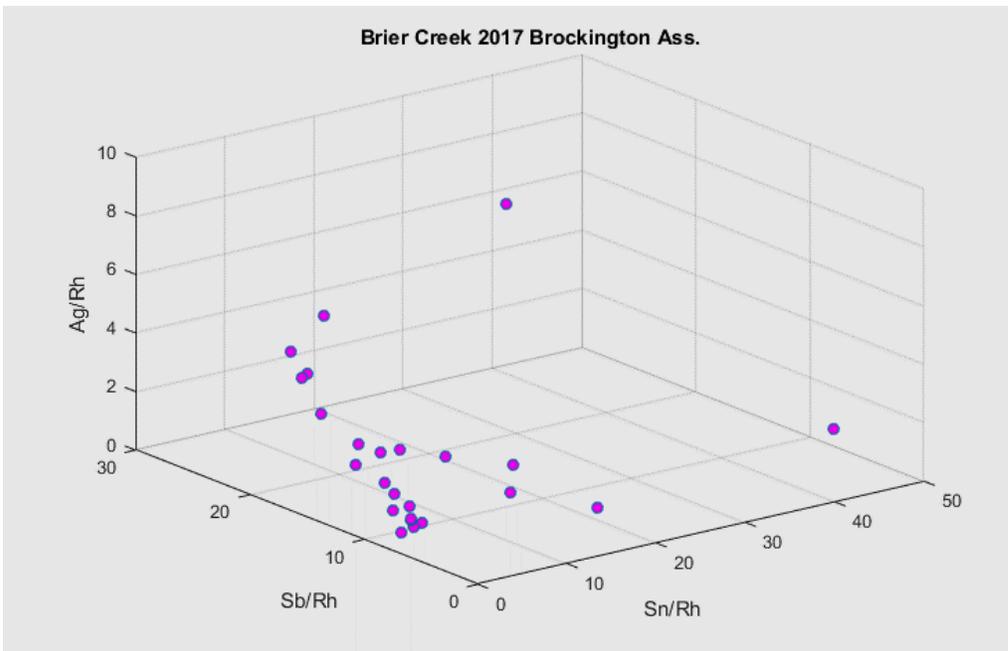


Figure 79. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Brier Creek 2017 Sample.

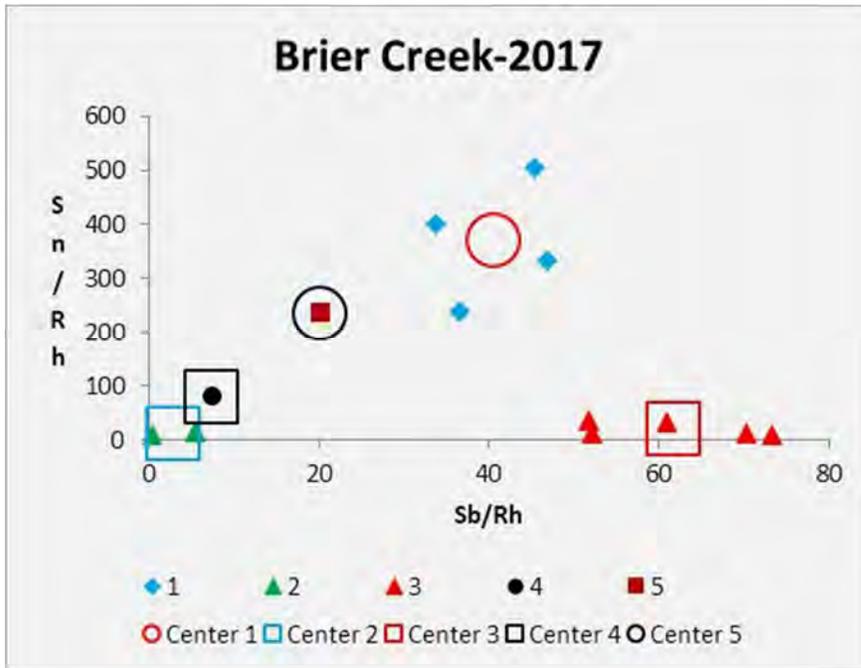


Figure 80. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Brier Creek 2017 Sample.

Table 19. Chi-square Calculations on Silver (Ag), Antimony (Sb) and Tin (Sn) Ratios by Weapon Type, Brier Creek (2017) Sample.

	Brier Creek Balls (2017 Sample)					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	
<b>Rifle</b>	2 2.00 ( 0.00)	1 1.75 ( 0.32)	0 0.50 ( 0.50)	0 0.75 ( 0.75)	3 1.00 ( 4.00)	<b>6</b>
<b>Fusil</b>	5 4.33 ( 0.10)	3 3.79 ( 0.17)	2 1.08 ( 0.78)	2 1.62 ( 0.09)	1 2.17 ( 0.63)	<b>13</b>
<b>Charleville</b>	0 0.33 ( 0.33)	1 0.29 ( 1.72)	0 0.08 ( 0.08)	0 0.12 ( 0.12)	0 0.17 ( 0.17)	<b>1</b>
<b>British</b>	0 1.00 ( 1.00)	2 0.88 ( 1.45)	0 0.25 ( 0.25)	1 0.38 ( 1.04)	0 0.50 ( 0.50)	<b>3</b>
<b>Other</b>	1 0.33 ( 1.33)	0 0.29 ( 0.29)	0 0.08 ( 0.08)	0 0.12 ( 0.12)	0 0.17 ( 0.17)	<b>1</b>
	<b>8</b>	<b>7</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>24</b>

$\chi^2 = 15.996$ ,  $df = 16$ ,  $\chi^2/df = 1.00$ ,  $P(\chi^2 > 15.996) = 0.4532$

## Battle of Purysburg

Purysburg was a village in present-day Jasper County, South Carolina. In early 1779 it served as headquarters for the American forces commanded by General Benjamin Lincoln. The lightly defended town was attacked by a large British force in April, 1779. Archaeologists located and identified the Purysburg Battlefield (Elliott 2016b). In 2015 Elliott analyzed 149 round ball and related specimens from the Purysburg battlefield. This sample is included as Group 33 in Appendix 1. Figures 81 and 82 show portions of the spectra for the Purysburg sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for 128 balls the Purysburg sample. Five clusters were identified (Table 20). The dominant cluster (Segment 2) contained 45 of 128 specimens (35.2% of the assemblage). Segment 2 was most common for the Rifle and Fusil balls. Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.29, Tin (Sn)/Rhodium (Rh), 1.13 and Silver (Ag)/Rhodium (Rh), 0.16.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for 97 balls the Purysburg subset sample. Five clusters were identified (Table 21 and Figures 83 and 84). The dominant cluster (Segment 2) contained 31 of 97 specimens (32% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.37, Tin (Sn)/Rhodium (Rh), 1.22 and Silver (Ag)/Rhodium (Rh), 0.10.

Pearson's Chi-square tests was run on these results to determine if the clusters defined for the three ratios (Silver (Ag)/Rhodium (Rh), Tin (Sn)/Rhodium (Rh) and Antimony (Sb)/Rhodium (Rh)) were significant when compared with the results by weapon type (Rifles, Fusils, Charleville and British Standard balls (Table 22). This exercise yielded a Chi-square value of 106.148 and a P value of 0.0000. The null hypothesis, which states that the frequency distribution of certain events observed in the sample is consistent with the theoretical distribution, is rejected. The alternative hypothesis, that there is a difference between the distributions, is accepted at the 0.01 confidence level.

Cluster analysis also was performed on Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh) ratios in the Purysburg subset sample. Four clusters were identified (Table 23 and Figure 85). Segment 4 dominated the assemblage with 42 of 97 specimens. Segment 4 dominated the Rifle balls (20 of 41 specimens). Segments 2 and 4 equally dominated the Fusil balls (17 each of 42 specimens). Segment 2 dominated the Charleville balls (8 of 13

specimens). Mean/centroids for Segment 4 were Nickel (Ni)/Rhodium (Rh), 0.03, Copper (Cu)/Rhodium (Rh), 0.79 and Zinc (Zn)/Rhodium (Rh), 0.13.

Pearson's Chi-square tests was run on these results to determine if the clusters defined for these three ratios (Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh)) were significant when compared with the results by weapon type (Rifles, Fusils, Charleville and British Standard balls (Table 24). This exercise yielded a Chi-square value of 5.545 and a P value of 0.7844. The null hypothesis, which states that the frequency distribution of certain events observed in the sample is consistent with the theoretical distribution, must be accepted.

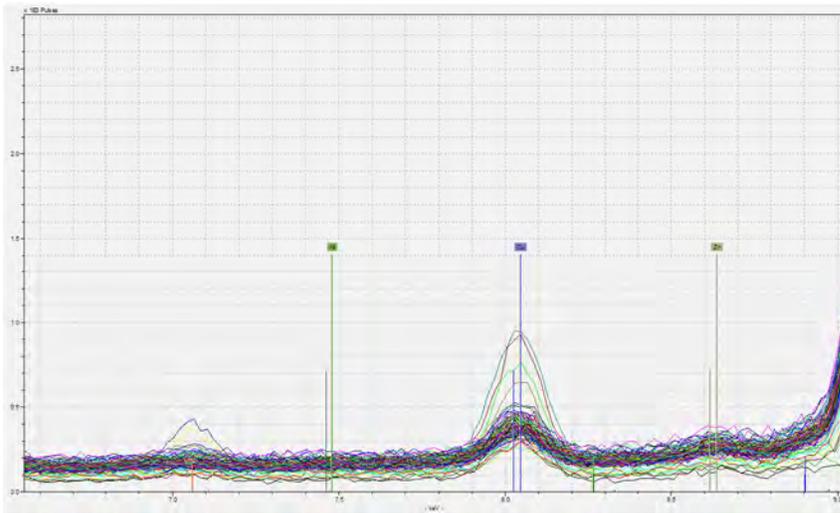


Figure 81. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Purysburg Sample.

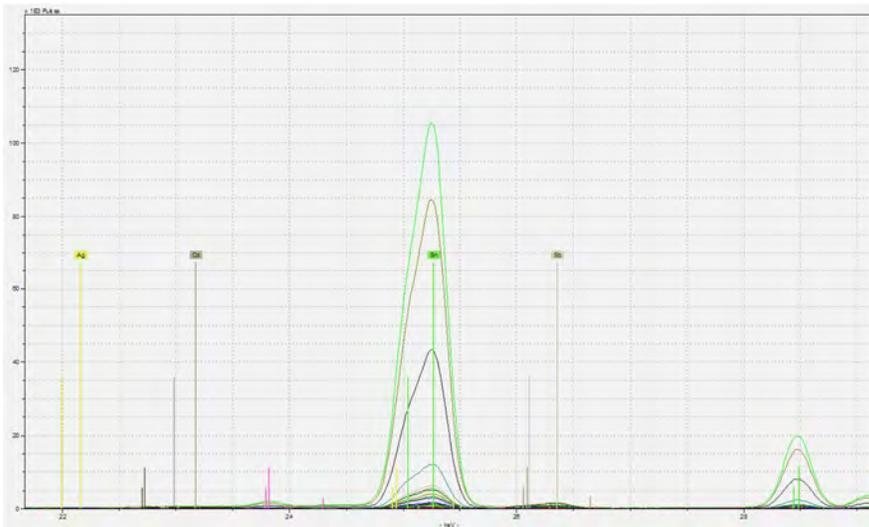


Figure 82. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Purysburg Sample.

Table 20. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Purysburg Composite Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	4	5
Segment 1	1.93	11.92	0.49		
Segment 2	0.29	1.13	0.16		
Segment 3	2.02	6.68	0.29		
Segment 4	3.12	7.45	0.16		
Segment 5	1.65	409.18	0.00		
<b>AVERAGE</b>	<b>1.63</b>	<b>17.27</b>	<b>0.21</b>		
Respondents	Number	%	SSE/Segment		
Segment 1	42	32.8%	6,989	<b>SSE Total</b>	<b>38,437</b>
Segment 2	45	35.2%	93		
Segment 3	8	6.3%	614		
Segment 4	30	23.4%	4,721		
Segment 5	3	2.3%	26,021		
<b>TOTAL</b>	<b>128</b>	<b>100.0%</b>	<b>38,437</b>		

Table 21. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Purysburg Subset Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	3.26	5.43	0.15		
Segment 2	0.37	1.22	0.10		
Segment 3	1.65	409.18	0.00		
Segment 4	2.43	15.16	0.41		
Segment 5	0.24	2.80	0.32		
<b>AVERAGE</b>	<b>1.48</b>	<b>17.81</b>	<b>0.21</b>		
Respondents	Number	%	SSE/Segment		
Segment 1	24	24.7%	2161.5	<b>SSE Total</b>	<b>101.8</b>
Segment 2	31	32.0%	77.9		
Segment 3	3	3.1%	0.0		
Segment 4	18	18.6%	8485.2		
Segment 5	21	21.6%	780.1		
<b>TOTAL</b>	<b>97</b>	<b>100.0%</b>			

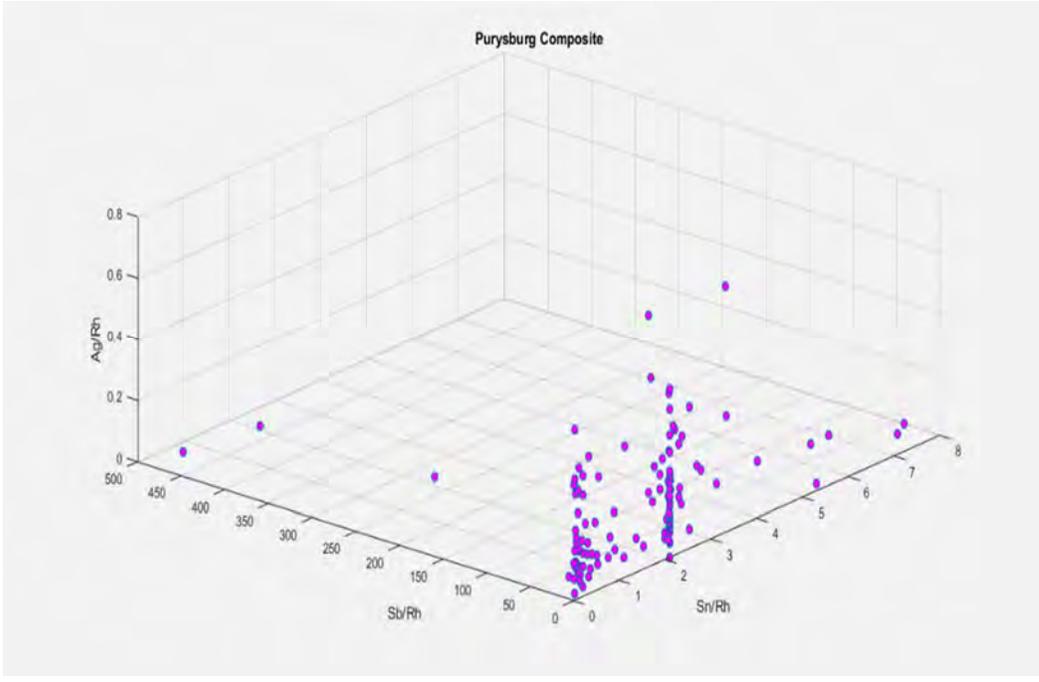


Figure 83. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Purysburg Sample.

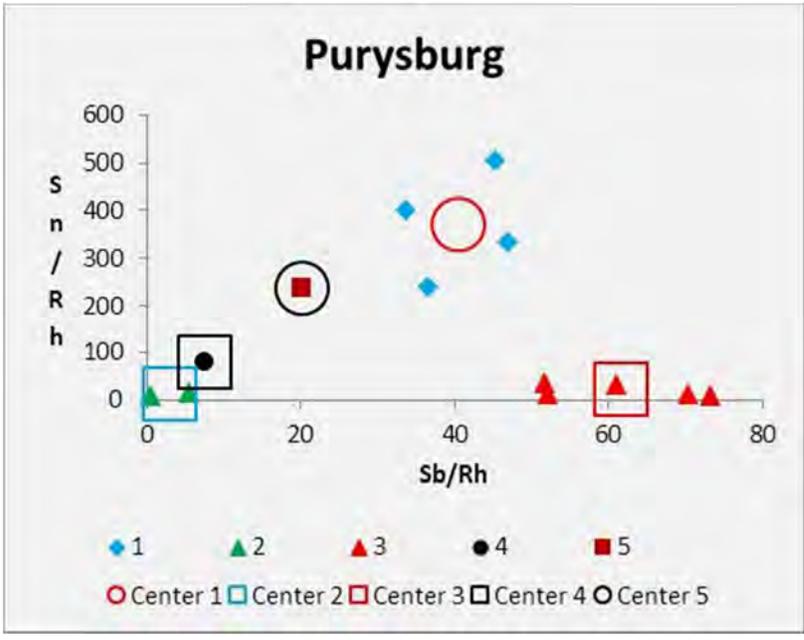


Figure 84. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Purysburg Sample (Subset).

Table 22. Chi-square Calculations for Silver (Ag), Tin (Sn) and Sh Ratios and Weapon Type, Purysburg Sample.

	Purysburg Balls					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	
<b>Rifle</b>	7 13.24 ( 2.94)	22 14.53 ( 3.84)	3 2.58 ( 0.07)	8 9.69 ( 0.29)	1 0.97 ( 0.00)	<b>41</b>
<b>Fusil</b>	5 13.56 ( 5.40)	23 14.88 ( 4.43)	1 2.65 ( 1.02)	12 9.92 ( 0.44)	1 0.99 ( 0.00)	<b>42</b>
<b>Charleville</b>	3 4.20 ( 0.34)	0 4.61 ( 4.61)	3 0.82 ( 5.81)	7 3.07 ( 5.03)	0 0.31 ( 0.31)	<b>13</b>
<b>British</b>	0 0.65 ( 0.65)	0 0.71 ( 0.71)	1 0.13 ( 6.06)	0 0.47 ( 0.47)	1 0.05 ( 19.21)	<b>2</b>
<b>Other</b>	26 9.36 ( 29.57)	0 10.28 ( 10.28)	0 1.83 ( 1.83)	3 6.85 ( 2.16)	0 0.69 ( 0.69)	<b>29</b>
	<b>41</b>	<b>45</b>	<b>8</b>	<b>30</b>	<b>3</b>	<b>127</b>

$\chi^2 = 106.148$ ,  $df = 16$ ,  $\chi^2/df = 6.63$ ,  $P(\chi^2 > 106.148) = 0.0000$

Table 23. Output for four Clusters/Segments, Nickel (Ni/Rh), Copper (Cu/Rh) and Zinc (Zn/Rh) Ratios, Purysburg Subset Sample.

Mean/Centroid	Ni/Rh	Cu/Rh	Zn/Rh	0	0
Segment 1	0.09	0.90	0.17		
Segment 2	0.02	0.57	0.09		
Segment 3	0.04	2.11	0.22		
Segment 4	0.03	0.87	0.15		
AVERAGE	0.03	0.79	0.13		
Respondents	Number	%	SSE/Segment		
Segment 1	15	15.3%	0.2		
Segment 2	38	38.8%	0.6	<b>SSE Total</b>	<b>4.1</b>
Segment 3	3	3.1%	1.5		
Segment 4	42	42.9%	1.9		
TOTAL	98	100.0%			

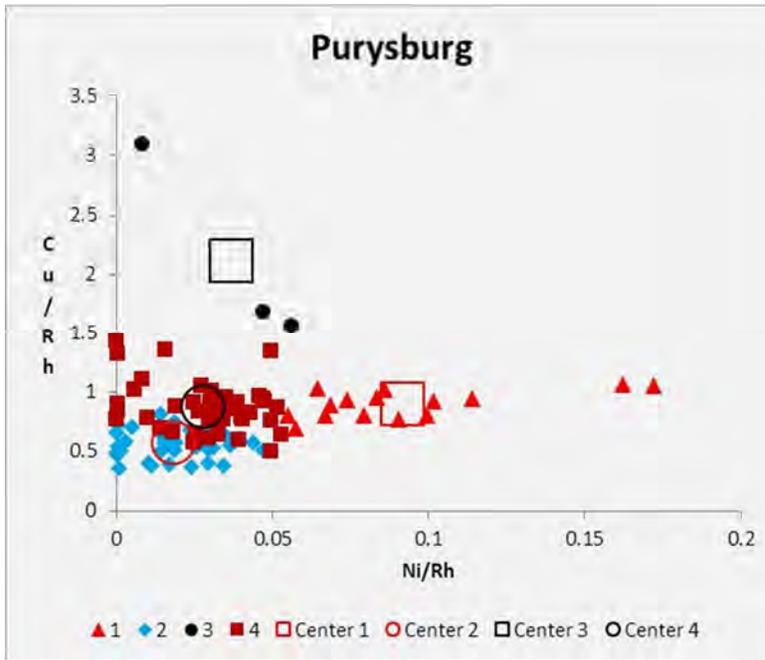


Figure 85. Central Means Chart for Four Segments, Nickel (Ni/Rh), Copper (Cu/Rh) and Zinc (Zn/Rh) Ratios, Purysburg Subset Sample.

Table 24. Chi-square Calculations for Nickel (Ni)/Rhodium (Rh), Copper (Cu)/Rhodium (Rh) and Zinc (Zn)/Rhodium (Rh) ratios and Weapon Type, Purysburg Sample.

	Purysburg Ni Cu Zn Ratios				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	
Rifle	7 6.28 (0.08)	12 15.90 (0.96)	2 1.26 (0.44)	20 17.57 (0.34)	41
Fusil	7 6.43 (0.05)	17 16.29 (0.03)	1 1.29 (0.06)	17 18.00 (0.06)	42
Charleville	1 1.99 (0.49)	8 5.04 (1.74)	0 0.40 (0.40)	4 5.57 (0.44)	13
British	0 0.31 (0.31)	1 0.78 (0.06)	0 0.06 (0.06)	1 0.86 (0.02)	2
	15	38	3	42	98

$\chi^2 = 5.545$ ,  $df = 9$ ,  $\chi^2/df = 0.62$ ,  $P(\chi^2 > 5.545) = 0.7844$

## Madison Square

Madison Square is located in Savannah, Georgia. It was the location of British fortifications that were attacked during the Siege of Savannah in September and

October 1779. Archaeologists explored this location in 2007 and recovered a well-preserved British ditch that contained ammunition related to the siege (Elliott and Elliott 2009). In 2015 Elliott and Moreton analyzed 13 round balls and one gambling die likely made from a musket ball from the archaeological collections from Madison Square, which are housed at the Coastal Historical Society in Savannah. This sample is included as Group 27 in Appendix 1. Figures 86 and 87 show portions of the spectra for the Madison Square sample. Copper (Cu), Zinc (Zn), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figure 88 shows a graph of the Tin (Sn) and Antimony (Sb) in the Madison Square sample.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for 14 balls in the Madison Square sample. Five clusters were identified (Table 25 and Figures 89 and 90). The dominant cluster (Segment 3) contained five of 14 specimens (35.7% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.47, Tin (Sn)/Rhodium (Rh), 1.51 and Silver (Ag)/Rhodium (Rh), 0.05.

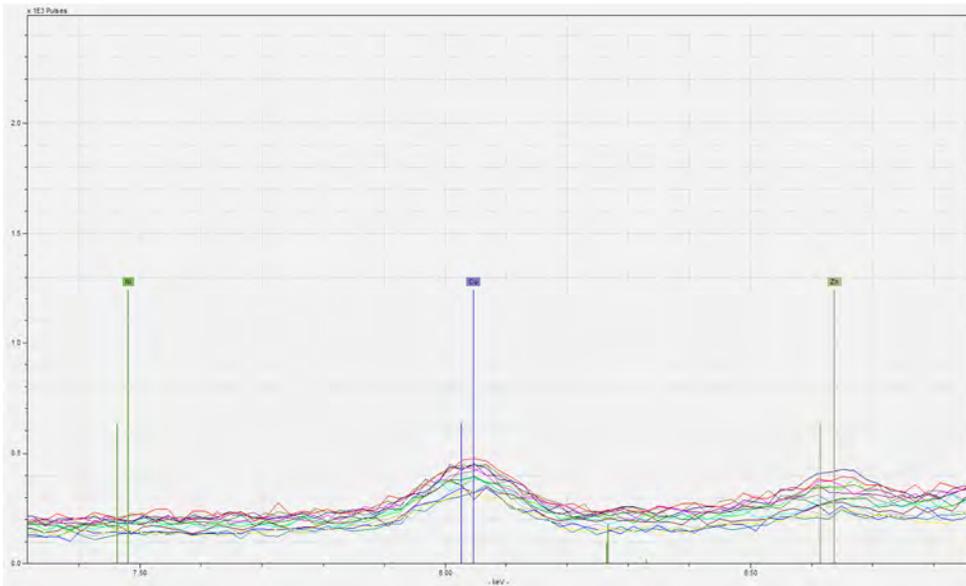


Figure 86. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Madison Square Sample.

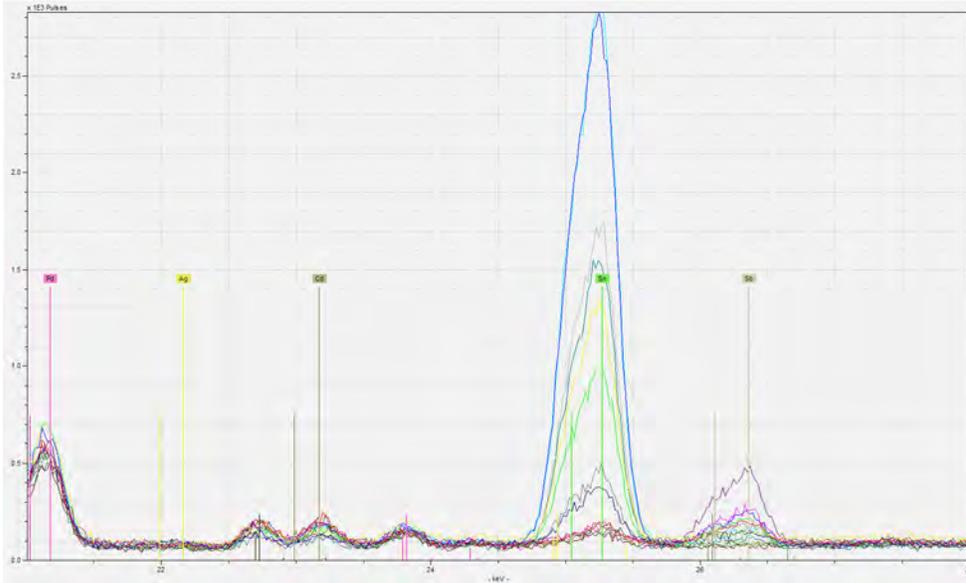


Figure 87. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Madison Square Sample.

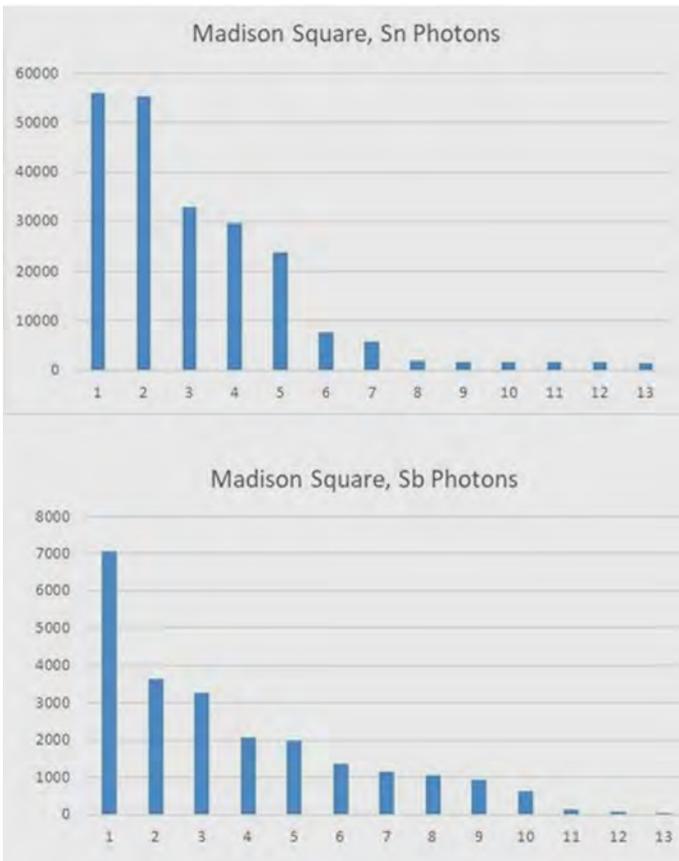


Figure 88. Distribution of Tin (Sn) and Antimony (Sb) Photons in Madison Square Sample.

Table 25. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Madison Square Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	0.43	14.94	0.11		
Segment 2	0.11	2.30	0.09		
Segment 3	0.47	1.51	0.05		
Segment 4	1.65	0.38	0.05		
Segment 5	1.51	25.62	0.15		
AVERAGE	0.52	6.26	0.08		
Respondents	Number	%	SSE/Segment		
Segment 1	3	21.4%	0.3		
Segment 2	4	28.6%	31.2	<b>SSE Total 6.3</b>	
Segment 3	5	35.7%	0.0		
Segment 4	1	7.1%	0.0		
Segment 5	1	7.1%	0.0		
TOTAL	14	100.0%			

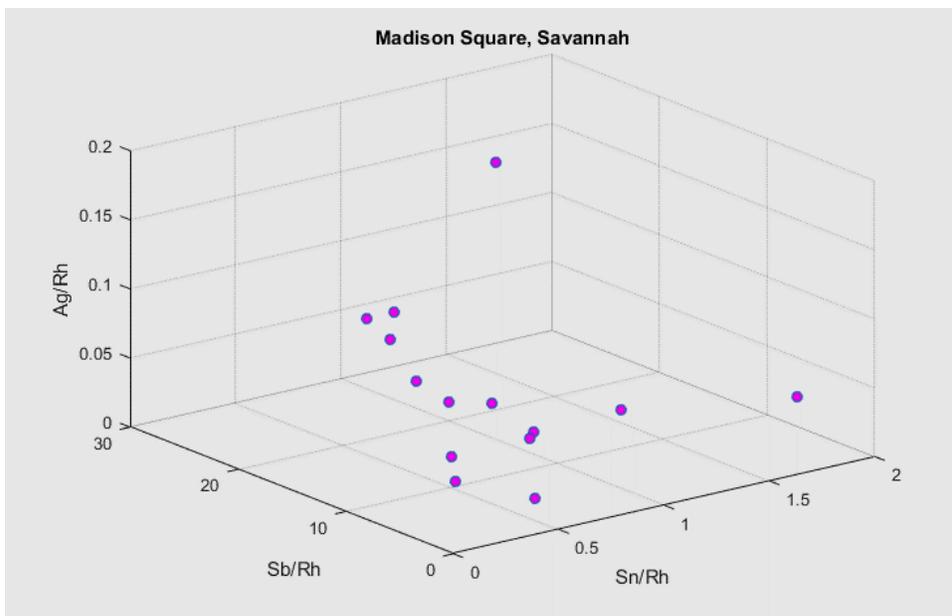


Figure 89. Scattergram of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Madison Square Sample.

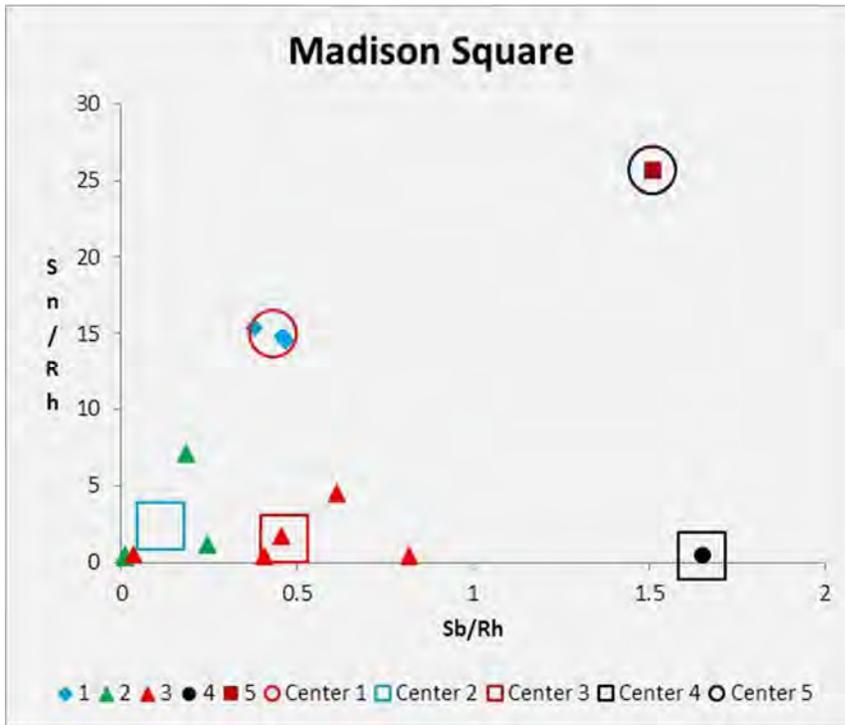


Figure 90. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Madison Square Sample.

## Spring Hill

The British erected an earthen redoubt at Spring Hill beyond the southwestern limits of Savannah in September and early October, 1779. On October 9, 1779, this redoubt was the primary attack point of French and American forces who had besieged the city for several weeks. Archaeologists located a portion of the British ditch work at Spring Hill redoubt (R. Elliott 2011). In 2015 Elliott and Moreton analyzed 10 round balls from the archaeological collections from Spring Hill redoubt, which are housed at the Coastal Historical Society in Savannah. This sample is included as Group 37 in Appendix 1. Figures 91 and 92 show portions of the spectra for the Spring Hill sample. Copper (Cu), Zinc (Zn), Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Spring Hill sample. Five clusters were identified (Table 26 and Figures 93 and 94). The dominant cluster (Segment 5) contained five of 10 specimens (35.2% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.23, Tin (Sn)/Rhodium (Rh), 0.54 and Silver (Ag)/Rhodium (Rh), 0.17.

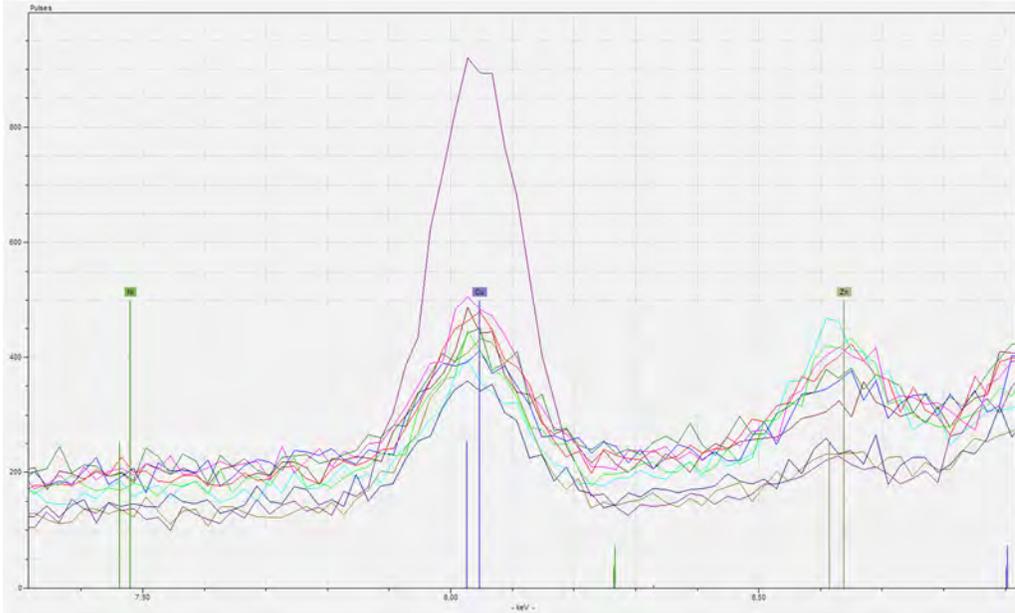


Figure 91. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Spring Hill Sample.

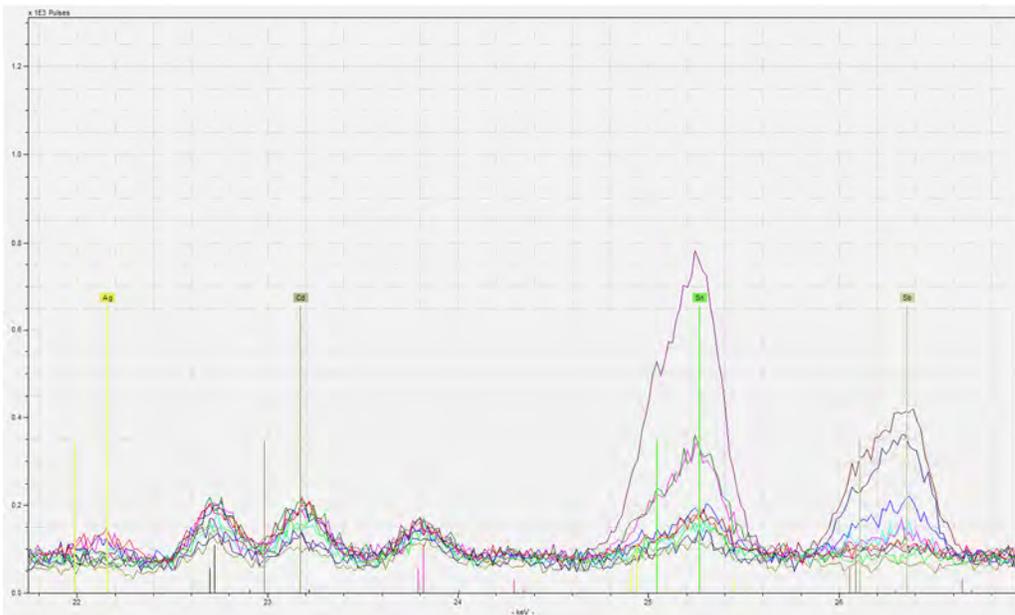


Figure 92. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Spring Hill Sample.

Table 26. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Spring Hill Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	2.74	0.50	0.12		
Segment 2	0.05	0.69	0.04		
Segment 3	1.32	0.31	0.09		
Segment 4	0.04	4.44	0.06		
Segment 5	0.23	0.54	0.17		
AVERAGE	0.54	0.93	0.12		
Respondents	Number	%	SSE/Segment		
Segment 1	1	10.0%	0.0		
Segment 2	2	20.0%	0.2	<b>SSE Total 2.2</b>	
Segment 3	1	10.0%	0.0		
Segment 4	1	10.0%	0.0		
Segment 5	5	50.0%	0.4		
TOTAL	10	100.0%			

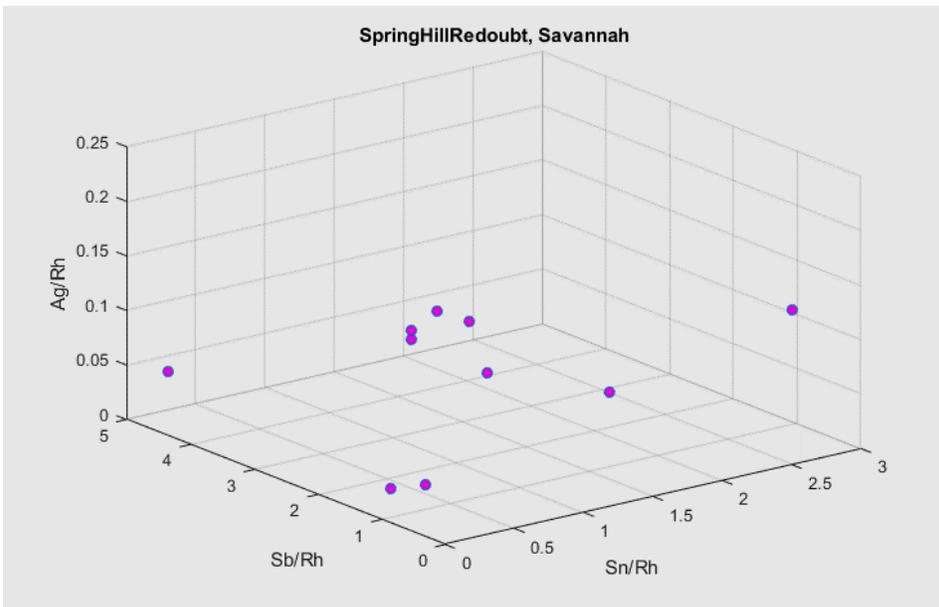


Figure 93. Scattergram of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Spring Hill Sample.

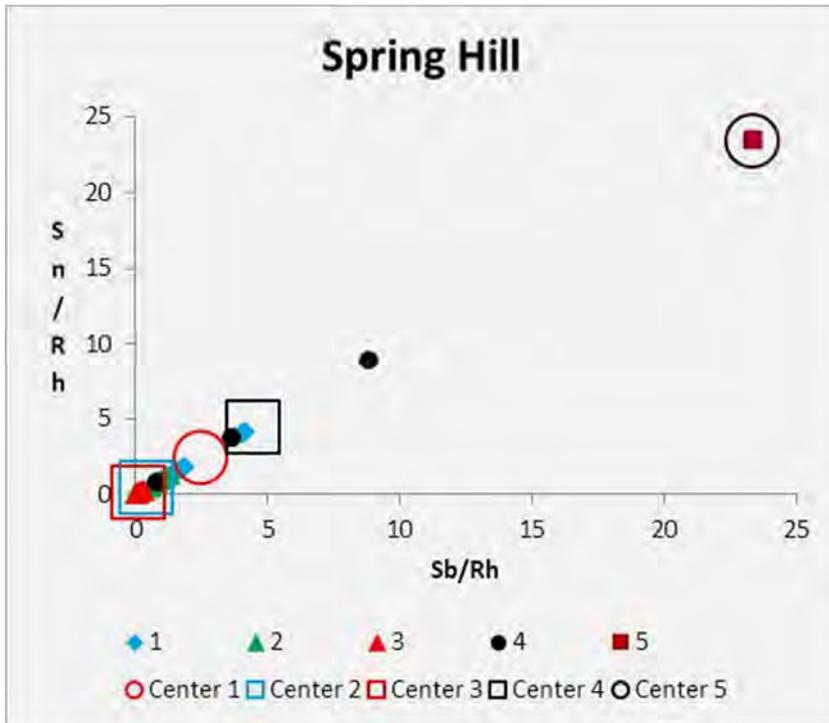


Figure 94. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Spring Hill Sample.

## Fahm Street

Fahm Street is located in western Savannah, Georgia. In October, 1779, when it was the scene of a Revolutionary War engagement, it was located outside town along the British defensive perimeter. Archaeologists explored a portion of Fahm Street in the 1980s, when Fahm Street was extended (Wood 1985). Two round balls in the Fahm Street Extension collection, which is housed at the Coastal Heritage Society, was analyzed by Elliott and Moreton in 2015. This sample is included as Group 13 in Appendix 1.

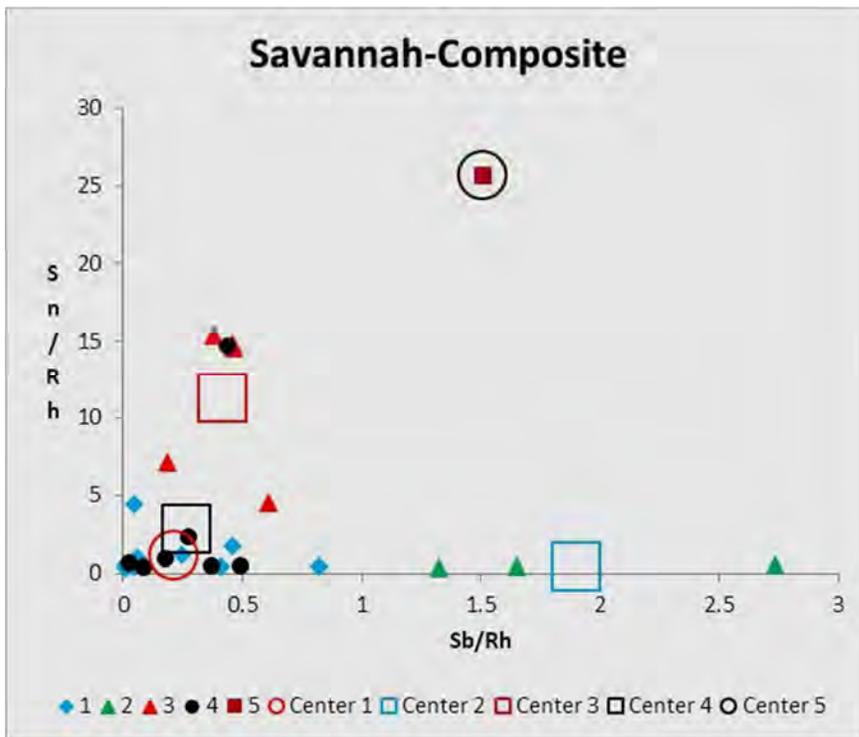
## Savannah Composite

The composite sample from the Battle of Savannah, which includes samples from Madison Square, Spring Hill and Fahm Street, were examined collectively. Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for the composite Savannah sample. Five clusters were identified (Table 27 and Figure 95). The dominant cluster (Segment 1) contained 10 items (38.5% of the assemblage). It has a mean/centroid of 0.21 for Sb, 1.10 for Tin (Sn) and 0.06 for Ag. This cluster dominated at Madison Square

but was a minority at Spring Hill. Cluster 4 was confined to the Spring Hill and Fahm Street assemblage, while Clusters 3 and 5 were restricted to Madison Square.

**Table 27. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Savannah Composite Sample.**

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	0.21	1.10	0.06		
Segment 2	1.90	0.40	0.09		
Segment 3	0.42	11.29	0.09		
Segment 4	0.27	2.80	0.19		
Segment 5	1.51	25.62	0.15		
AVERAGE	0.51	4.38	0.11		
Respondents	Number	%	SSE/Segment		
Segment 1	10	38.5%	15.0		
Segment 2	3	11.5%	1.1	<b>SSE Total 24.3</b>	
Segment 3	5	19.2%	0.0		
Segment 4	7	26.9%	166.5		
Segment 5	1	3.8%	0.0		
TOTAL	26	100.0%			



**Figure 95. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Savannah Composite Sample.**

### Battle of Camden

Camden was an eighteenth century town and battlefield in present-day Kershaw County in the South Carolina piedmont. In 1780, it was the scene of major military

engagements between the British and American forces. Archaeologists with SCIAA conducted several battlefield archaeology studies at various portions of the Camden Battlefield. John Allison provided a sample of 11 round shot from Camden for the 2017 workshop. These include two case shot and nine musket balls. This sample is included as Group 7 in Appendix 1. Figures 96 and 97 show portions of the spectra for the Camden sample. Copper (Cu), Tin (Sn) and Antimony (Sb) display peaks in these graphs. One specimen (Camden 83-001) contains higher amounts of Tin (Sn) and Antimony (Sb) than the rest of the assemblage. The Camden assemblage was too small for any meaningful cluster analysis.

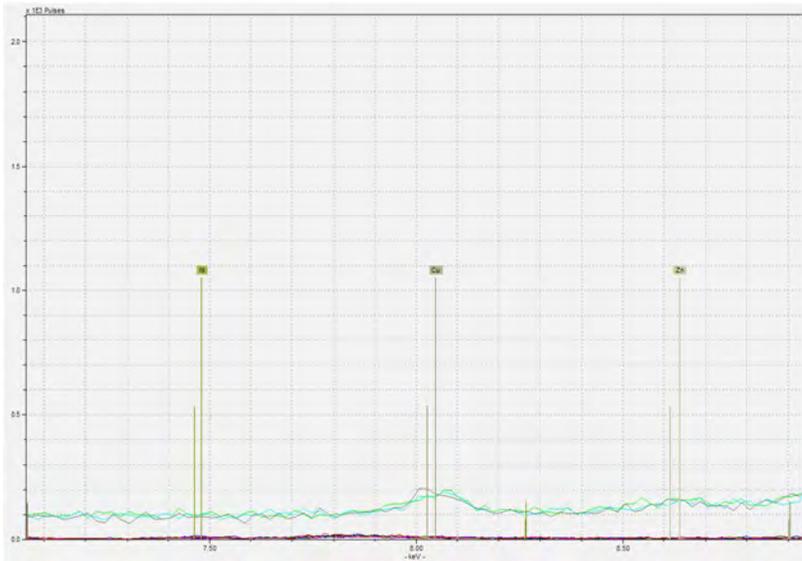


Figure 96. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Camden Sample.

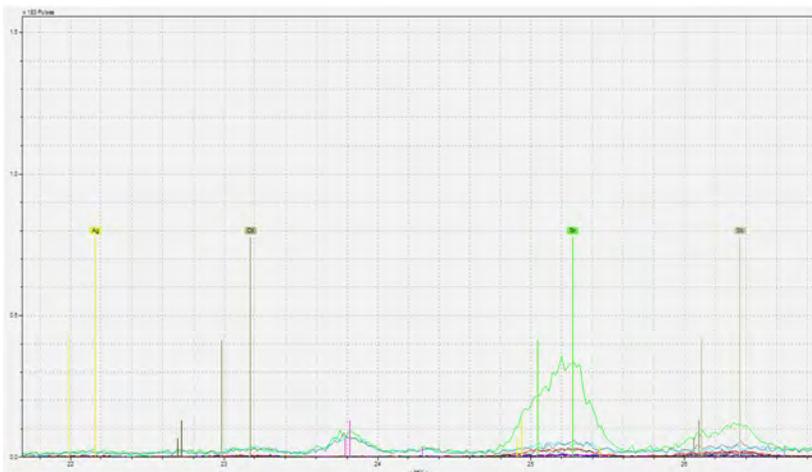


Figure 97. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Camden Sample.

## Kings Mountain

The battle of Kings Mountain, South Carolina took place on October 7, 1780. The battlefield is located in Cherokee County, South Carolina and is currently operated by the National Park Service as the Kings Mountain National Military Park. The battle, which was an American victory, pitted about 900 Patriot militia against 1,105 Loyalist militia (Draper 1881). In 2015 Seibert analyzed 66 round ball samples from the National Park Service collections from Kings Mountain. This sample is included as Group 26 in Appendix 1. Figures 98 and 99 show portions of the spectra for the Kings Mountain sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for 66 balls in the Kings Mountain sample. Five clusters were identified (Table 28; Figures 100 and 101). The dominant cluster (Segment 5) contained 26 of 66 specimens (39.4% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.51, Tin (Sn)/Rhodium (Rh), 2.65 and Silver (Ag)/Rhodium (Rh), 0.30.

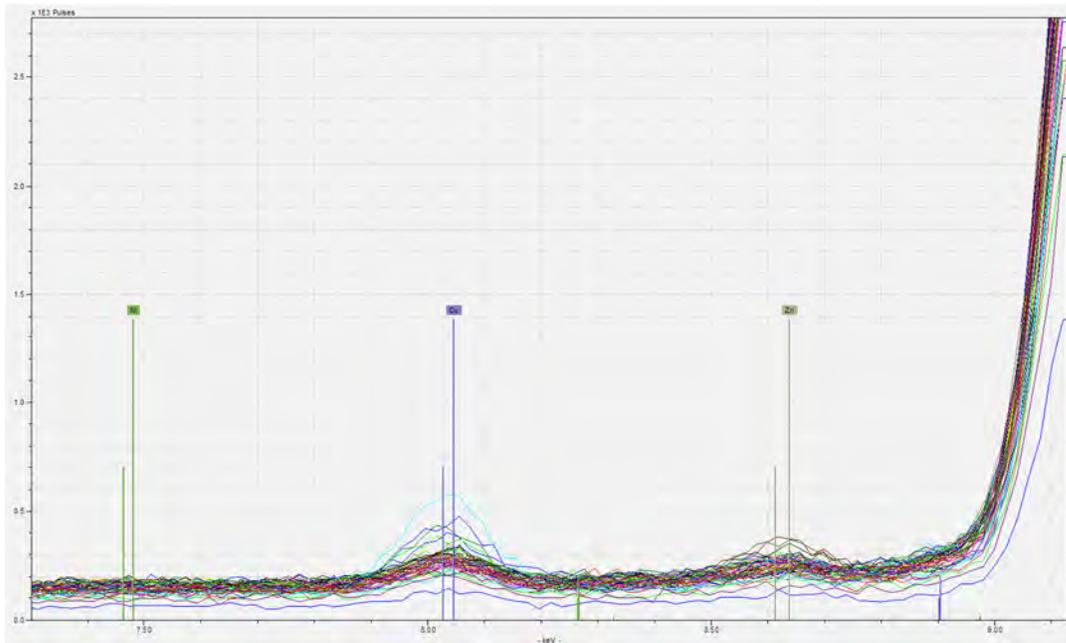


Figure 98. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn), Kings Mountain Sample.

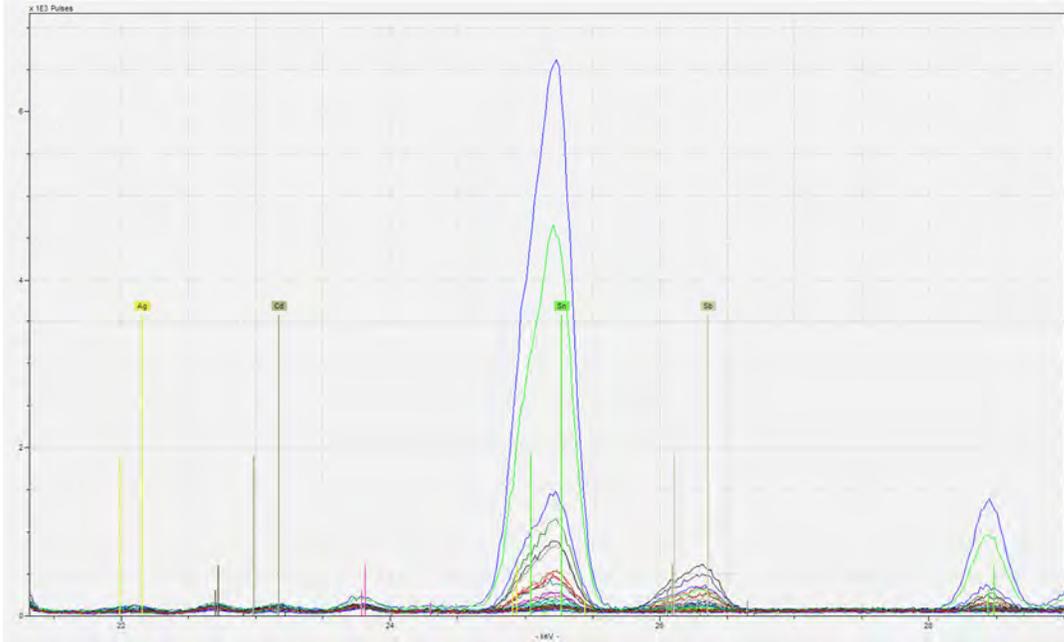


Figure 99. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb), Kings Mountain Sample.

Table 28. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Kings Mountain Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>o</i>	<i>o</i>
Segment 1	0.21	2.09	0.16		
Segment 2	0.33	0.75	0.11		
Segment 3	2.23	39.49	0.51		
Segment 4	4.80	5.01	0.43		
Segment 5	0.51	2.65	0.30		
AVERAGE	0.69	4.35	0.24		
Respondents	Number	%	SSE/Segment		
Segment 1	15	22.7%	150.4		
Segment 2	18	27.3%	9.2	<b>SSE Total 62.1</b>	
Segment 3	4	6.1%	0.0		
Segment 4	3	4.5%	32.8		
Segment 5	26	39.4%	539.4		
TOTAL	66	100.0%			

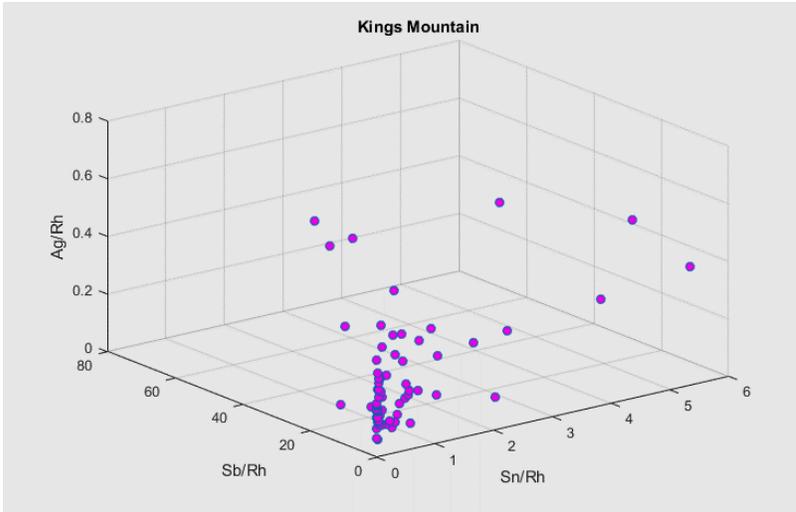
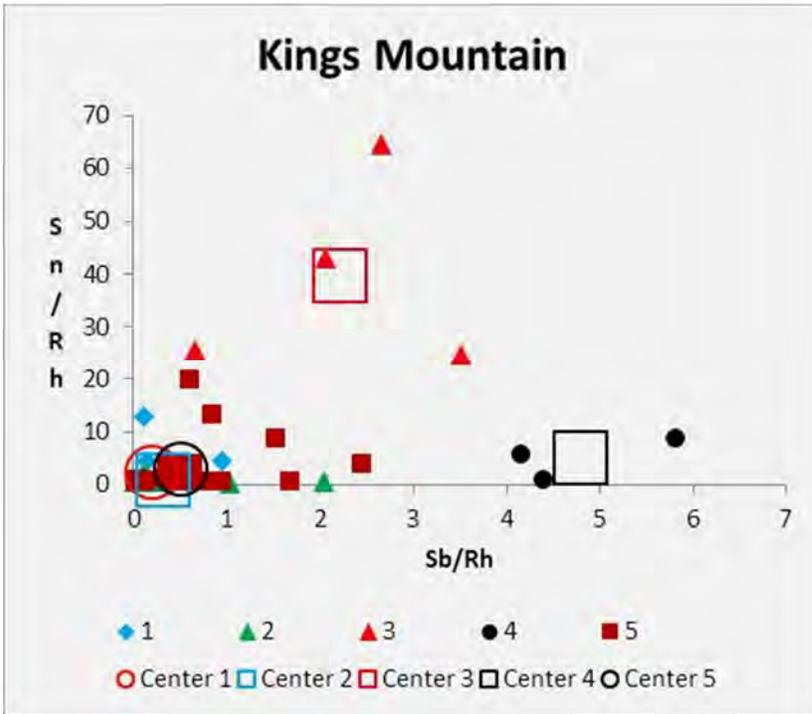


Figure 100. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in Kings Mountain Sample.



victory, pitted approximately 1,900 Patriots against 1,150 British and Loyalist troops. Most of the battlefield is currently managed by the National Park Service as the Cowpens National Battlefield. Archaeologists recently completed a metal detector survey of portions of the battlefield (Seibert 2016a-b). Seibert provided 36 round ball samples from the National Park Service's Cowpens collection, which he analyzed in 2012. Some of these specimens were analyzed again at the December 2015 workshop. The Cowpens sample is included as Group 11 in Appendix 1. Figures 102 and 103 show close-ups of the Cowpens spectra for those samples where information was collected for 500 seconds per sample. Nickel (Ni), Copper (Cu) and Zinc (Zn) are present in low levels in most of these samples. High Cadmium (Cd) levels are present in these samples. Many contain higher Cadmium levels than Tin (Sn) or Antimony (Sb), which are also present in most samples.

Cluster analysis was performed on the Silver (Ag), Antimony (Sb) and Tin (Sn) ratios from the Cowpens sample. Four clusters were identified (Table 29; Figures 104 and 105). The dominant cluster (Segment 1) contained 25 of 36 balls (69.4%). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.00, Tin (Sn)/Rhodium (Rh), 0.36 and Silver (Ag)/Rhodium (Rh), 0.05. Three of these clusters (Segments 1, 2 and 4) were relatively similar, while the fourth (Segment 3) consisted of a single specimen with notably higher Antimony (Sb), Tin (Sn) and Silver (Ag) values.

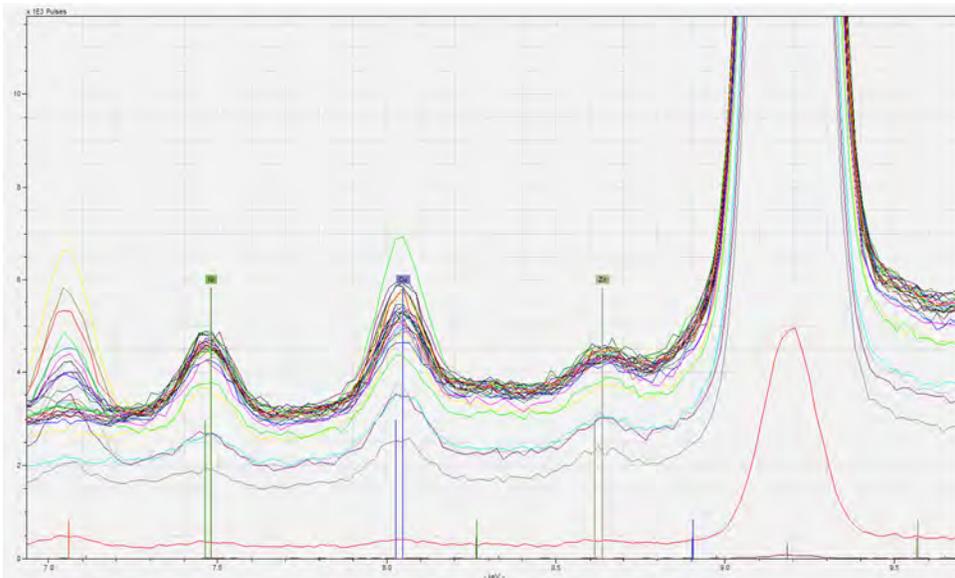


Figure 102. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Cowpens Sample.

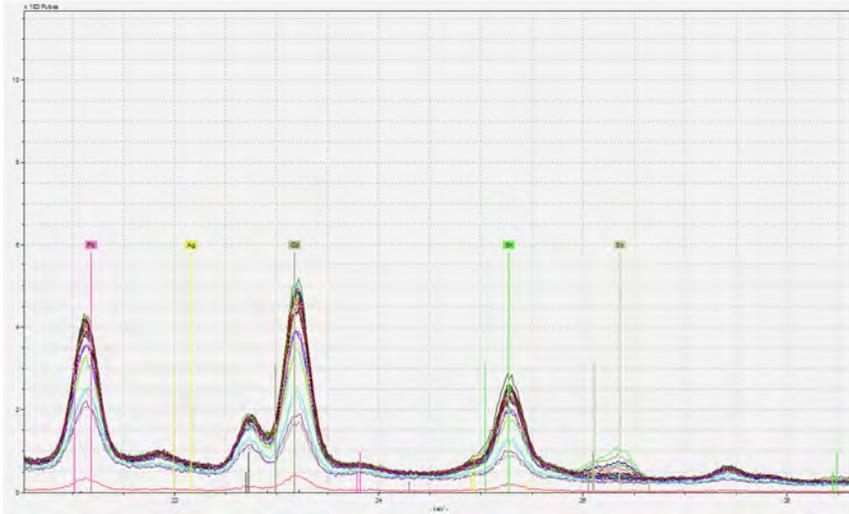


Figure 103. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Cowpens Sample.

Table 29. Output for Four Clusters/Segments, Silver (Ag), Tin (Sn) and Antimony (Sb) Ratios, Cowpens Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	<i>0</i>	<i>0</i>
Segment 1	0.00	0.36	0.05		
Segment 2	0.06	0.43	0.08		
Segment 3	0.55	1.46	0.46		
Segment 4	0.06	0.40	0.30		
AVERAGE	0.03	0.41	0.08		
Respondents	Number	%	SSE/Segment		
Segment 1	25	69.4%	0.1		
Segment 2	8	22.2%	0.0	<b>SSE Total 0.2</b>	
Segment 3	1	2.8%	0.0		
Segment 4	2	5.6%	0.0		
TOTAL	36	100.0%			

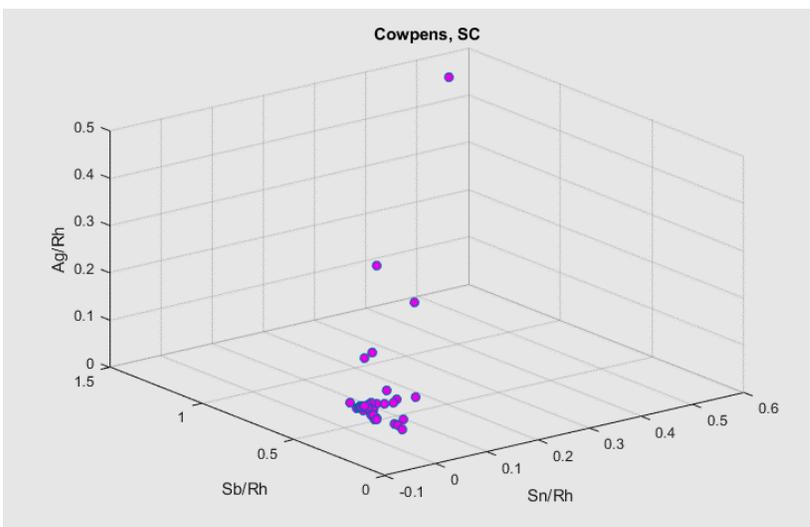


Figure 104. Scatterplot of Silver (Ag), Antimony (Sb) and Tin (Sn) in Cowpens Sample.

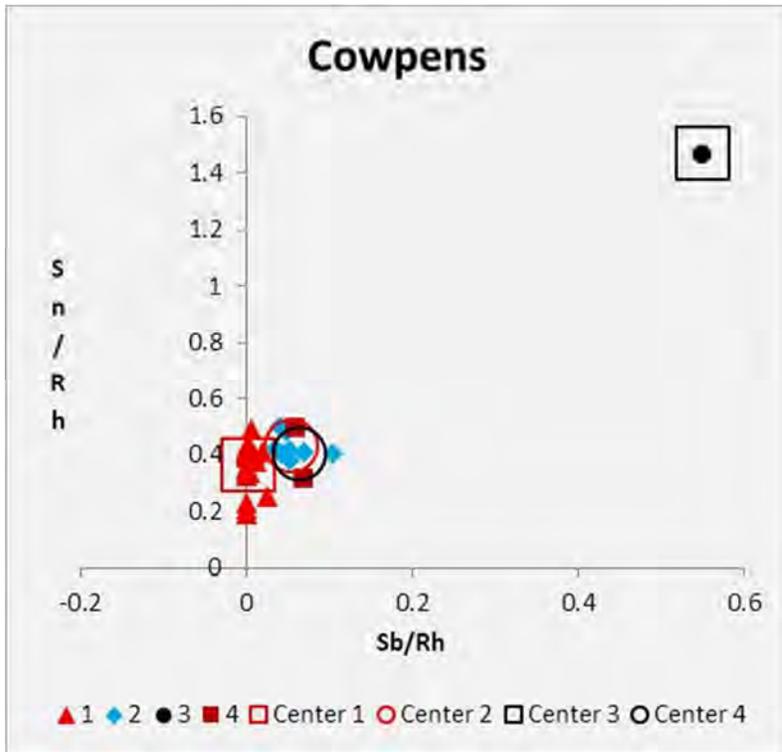


Figure 105. Central Means Chart for Four Clusters, Silver (Ag), Tin (Sn) and Antimony (Sb) Ratios, Cowpens Sample.

### Guilford Courthouse

The Battle of Guilford Courthouse took place on March 15, 1781 in present-day Greensboro, Guilford County, North Carolina. The battlefield is presently maintained as the Guilford Courthouse National Military Park. Seibert analyzed 50 round balls recovered from archaeological work at Guilford Courthouse prior to the 2015 workshop. This sample is included as Group 23 in Appendix 1. Figures 106 and 107 show portions of the spectra for the Guilford Courthouse sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Guilford Courthouse sample. Five clusters were identified (Table 30; Figures 108 and 109). The dominant cluster (Segment 2) contained 20 of 50 items (40% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.40, Tin (Sn)/Rhodium (Rh), 0.40 and Silver (Ag)/Rhodium (Rh), 0.13.

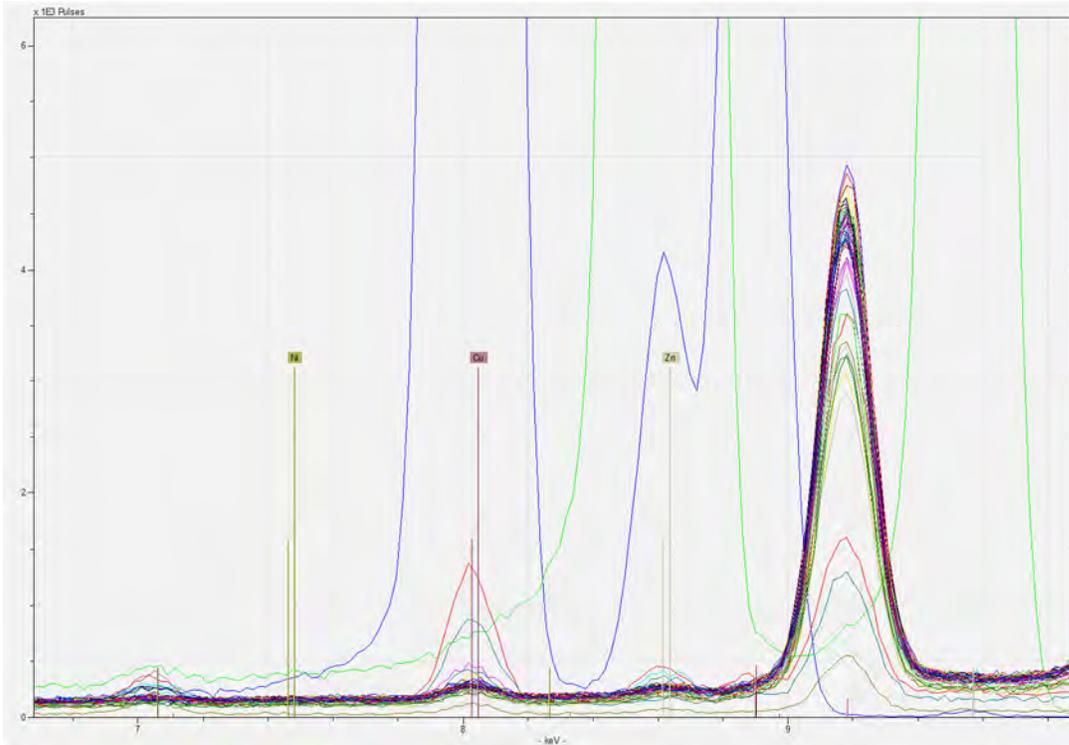


Figure 106. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Guilford Courthouse.

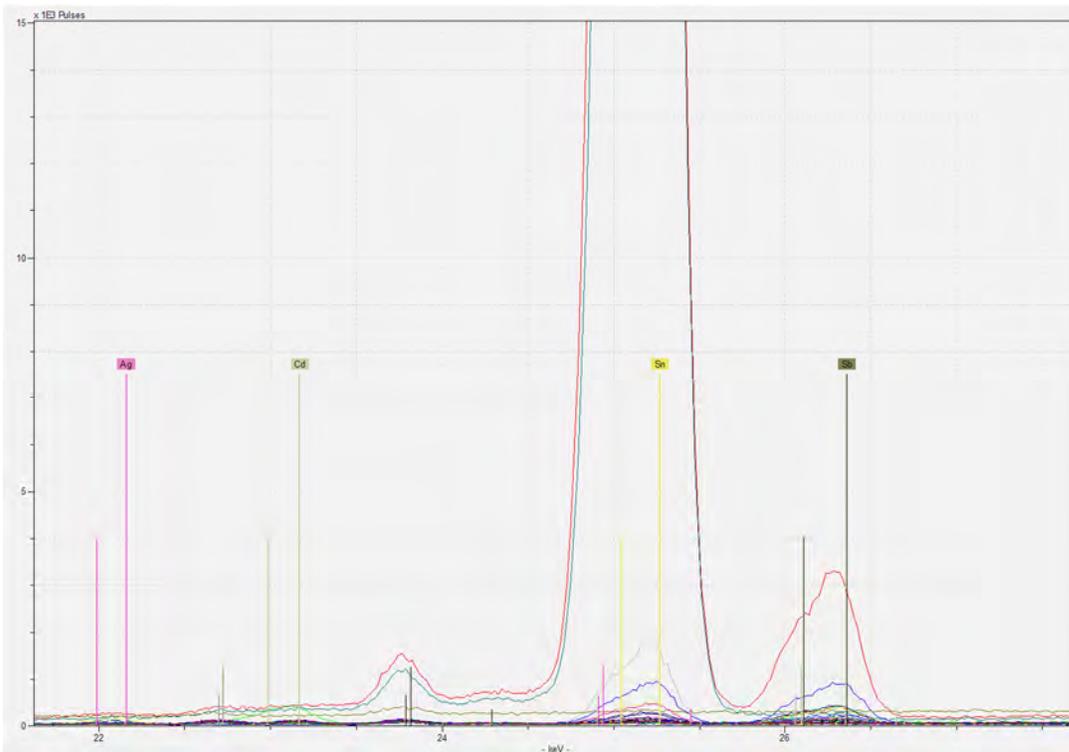


Figure 107. Guilford Courthouse Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Guilford Courthouse Sample.

Table 30. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Guilford Courthouse Sample.

Mean/Centroid	Sb/Rh	Sn/Rh	Ag/Rh	0	0
Segment 1	2.46	2.46	0.22		
Segment 2	0.40	0.40	0.13		
Segment 3	0.11	0.11	0.24		
Segment 4	4.46	4.46	1.29		
Segment 5	23.37	23.37	0.29		
AVERAGE	1.33	1.33	0.26		
Respondents	Number	%	SSE/Segment		
Segment 1	8	16.0%	22.4		
Segment 2	20	40.0%	6.8	SSE Total	39.7
Segment 3	18	36.0%	0.0		
Segment 4	3	6.0%	69.6		
Segment 5	1	2.0%	0.0		
TOTAL	50	100.0%			

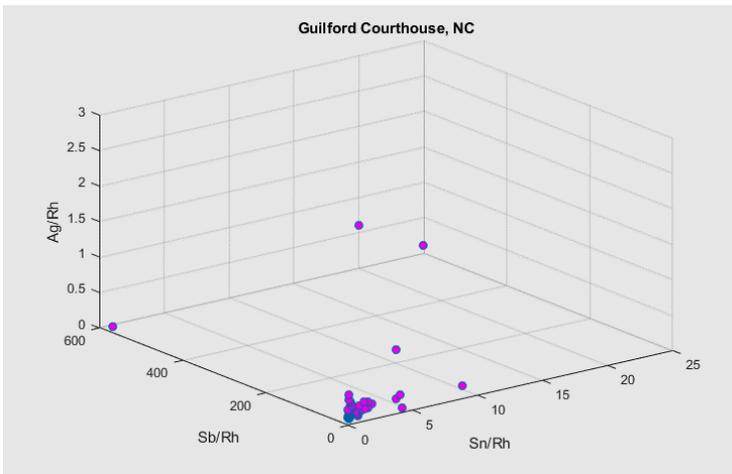


Figure 108. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Guilford Courthouse Sample.

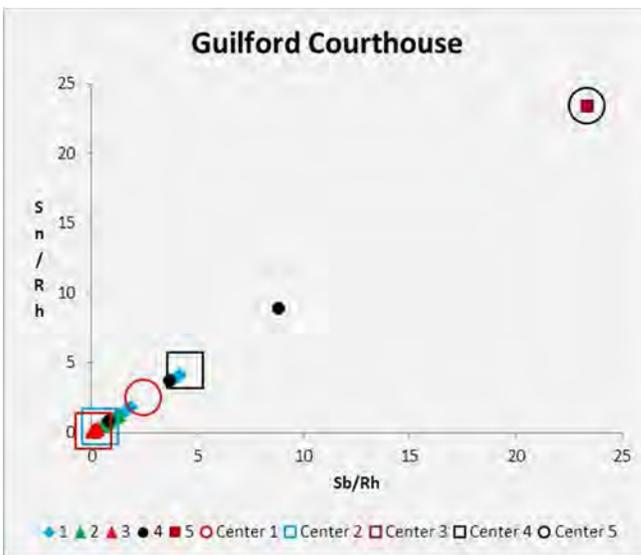


Figure 109. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Guilford Courthouse Sample.

## Fort Motte

Fort Motte was a fortified plantation mansion located in the interior coastal plain of South Carolina. American Continental soldiers lay siege to the British-held position on May 8, 1781 and the siege lasted until May 12. It was an American victory. Archaeological exploration of Fort Motte was undertaken by SCIAA archaeologists (Smith et al. 2007). Smith and Legg provided 11 round balls from Fort Motte for analysis in the 2017 workshop. This sample is included as Group 18 in Appendix 1. Figures 110 and 111 show portions of the spectra for the Fort Motte sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for 11 balls in the Fort Motte sample. Five clusters were identified (Table 31; Figures 112 and 113). The dominant cluster (Segment 1) contained five of 11 specimens (45.5% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.86, Tin (Sn)/Rhodium (Rh), 4.07 and Silver (Ag)/Rhodium (Rh), 0.59.

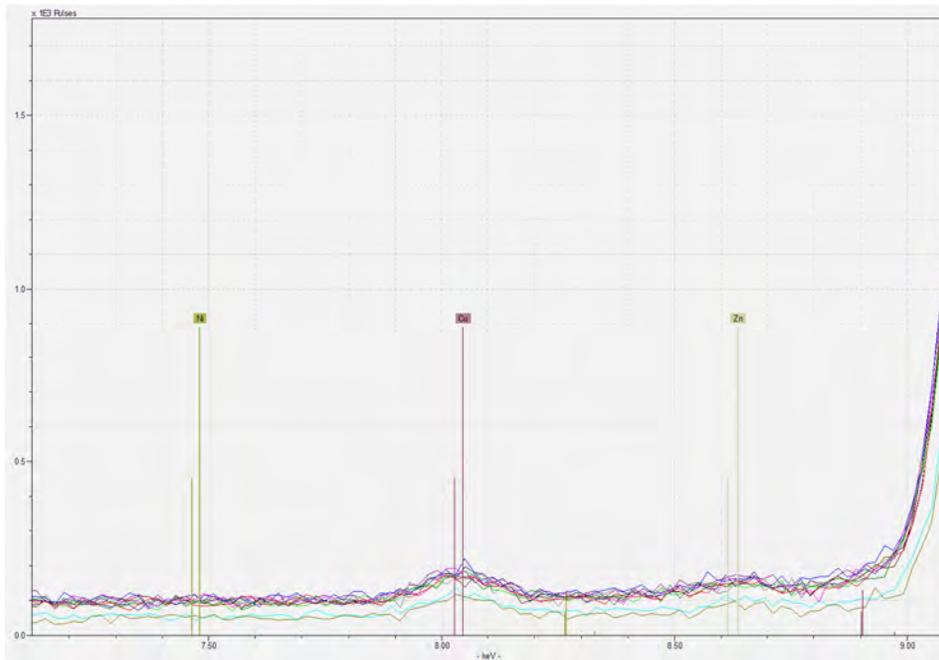


Figure 110. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Fort Motte Sample.

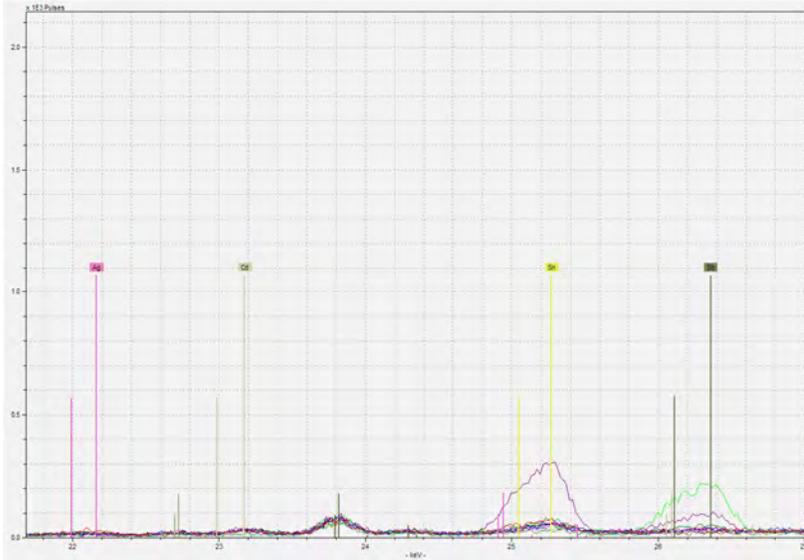


Figure 111. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Motte Sample.

Table 31. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Motte Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	0.86	4.07	0.59		
Segment 2	8.11	31.51	0.80		
Segment 3	4.34	5.20	0.97		
Segment 4	34.06	4.96	1.50		
Segment 5	1.44	5.53	1.47		
AVERAGE	5.01	7.15	0.96		
Respondents	Number	%	SSE/Segment		
Segment 1	5	45.5%	7.3		
Segment 2	1	9.1%	0.0	<b>SSE Total</b>	<b>3.6</b>
Segment 3	1	9.1%	0.0		
Segment 4	1	9.1%	0.0		
Segment 5	3	27.3%	8.2		
TOTAL	11	100.0%			

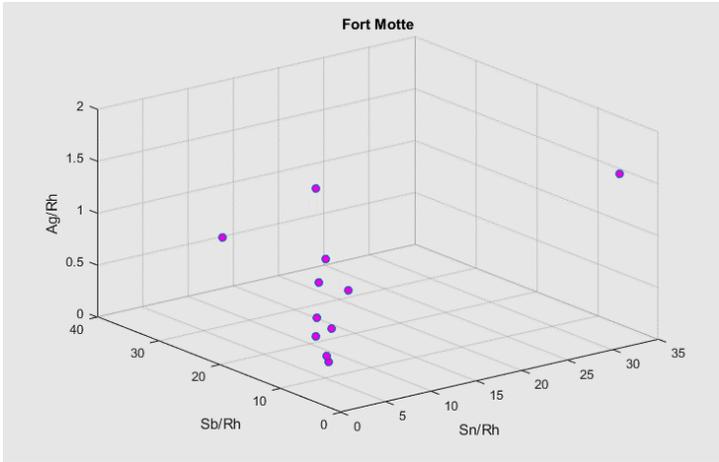


Figure 112. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Motte Sample.

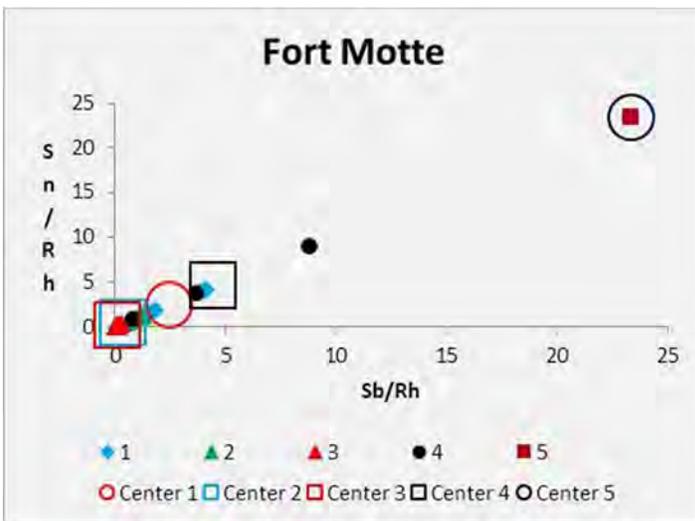


Figure 113. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Motte Sample.

## Fort Watson

Fort Watson is located in the interior coastal plain of present-day Clarendon County, South Carolina. It was the scene of a Revolutionary War siege from April 15-23, 1781. Continental Army forces besieged the British held fort. It was an American victory. Archaeologists with SCIAA have investigated the Fort Watson battlefield. Smith and Legg provided two round balls from Fort Watson for analysis in the 2017 workshop. This sample is included as Group 20 in Appendix 1. Figures 114 and 115 show portions of the spectra for the Fort Watson sample. Copper (Cu), Tin (Sn) and Antimony (Sb) display peaks in these graphs. While the

sample from Fort Watson was very small, the elemental composition of the two specimens are noticeable different. Both contain trace amounts of Copper (Cu). One of the samples contained traces of Tin (Sn), while the other contained traces of Antimony (Sb). Figure 116 shows a scatterplot of the Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for this sample. The Fort Watson sample was too small for any meaningful cluster analysis.

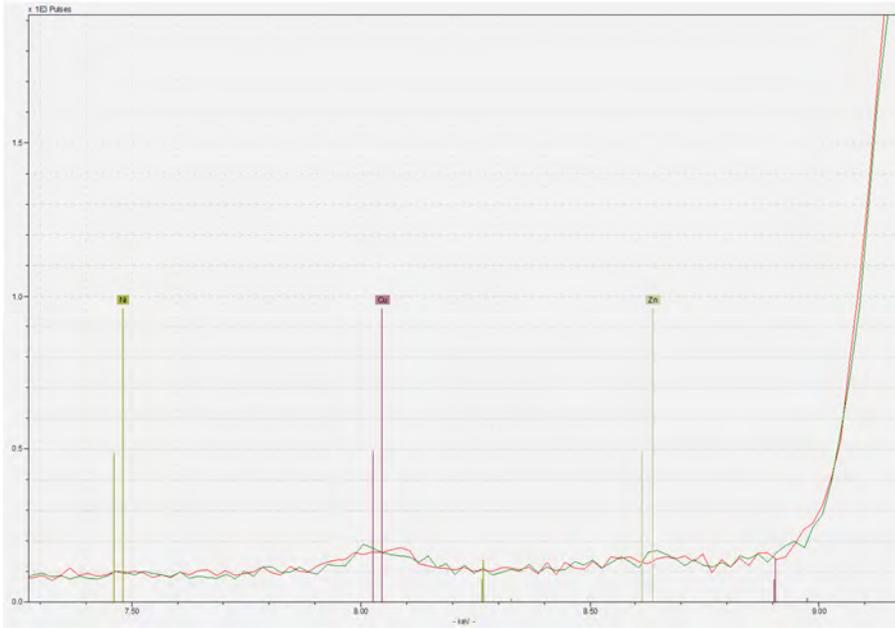


Figure 114. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Fort Watson Sample.

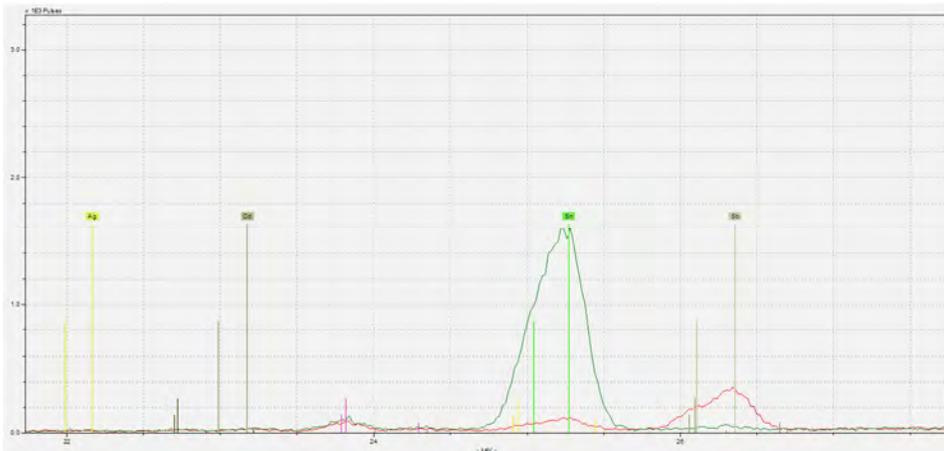


Figure 115. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Watson Sample.

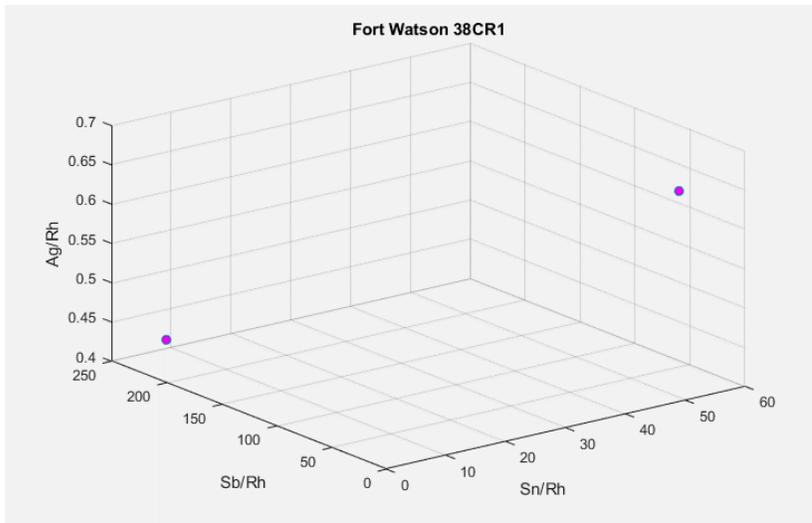


Figure 116. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Watson Sample.

## Ninety-Six

From May 22, to June 18, 1781 the Loyalists who were fortified at Ninety-Six, South Carolina were besieged by Continental troops. The siege was lifted by the Patriots upon the approach of British troops from Charleston. It is considered a loyalist victory. Ninety-Six is presently operated by the National Park Service as the Ninety-Six National Historic Site. Seibert analyzed 29 round balls from Ninety-Six in 2015. This sample is included as Group 32 in Appendix 1. Figures 117 and 118 show portions of the spectra for the Ninety-Six sample. Copper (Cu), Zinc (Zn), Tin (Sn) and Antimony (Sb) display peaks in these graphs. One sample contains markedly higher quantities of Antimony (Sb) and Tin (Sn) than the other samples.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Ninety-Six sample. Five clusters were identified (Table 32; Figures 119 and 120). The dominant cluster (Segment 4) contained 11 of 29 specimens (35.2% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 1.26, Tin (Sn)/Rhodium (Rh), 0.54 and Silver (Ag)/Rhodium (Rh), 0.15.

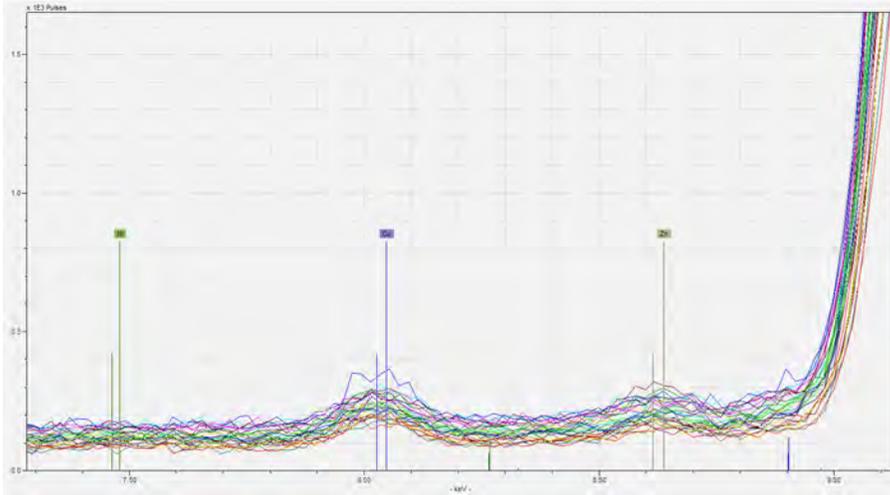


Figure 117. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Ninety-Six Sample.

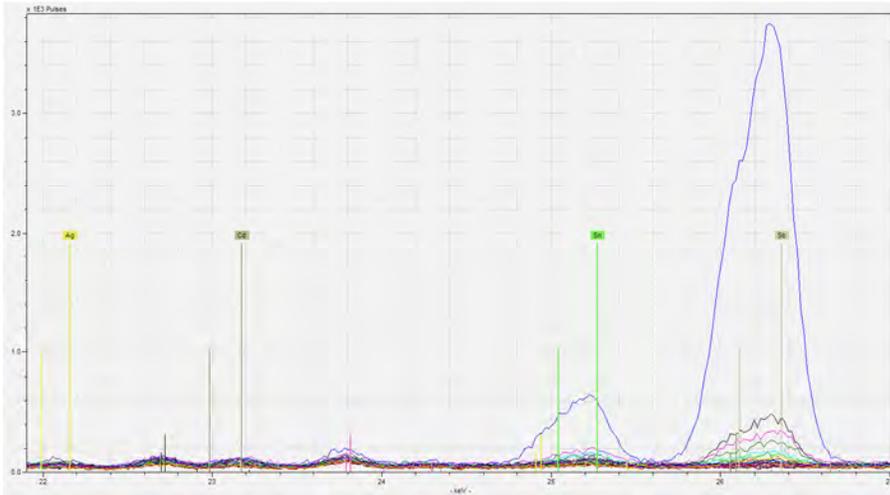


Figure 118. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Ninety-Six Sample.

Table 32. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Ninety-Six Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	36.69	5.27	0.17		
Segment 2	0.55	1.60	0.25		
Segment 3	0.57	0.46	0.26		
Segment 4	1.26	0.54	0.15		
Segment 5	0.27	0.47	0.45		
AVERAGE	2.02	0.74	0.25		
Respondents	Number	%	SSE/Segment		
Segment 1	1	3.4%	0.0		
Segment 2	2	6.9%	0.0		
Segment 3	10	34.5%	0.0		
Segment 4	11	37.9%	35.6		
Segment 5	5	17.2%	0.2		
TOTAL	29	100.0%			
				<b>SSE Total</b>	<b>6.0</b>

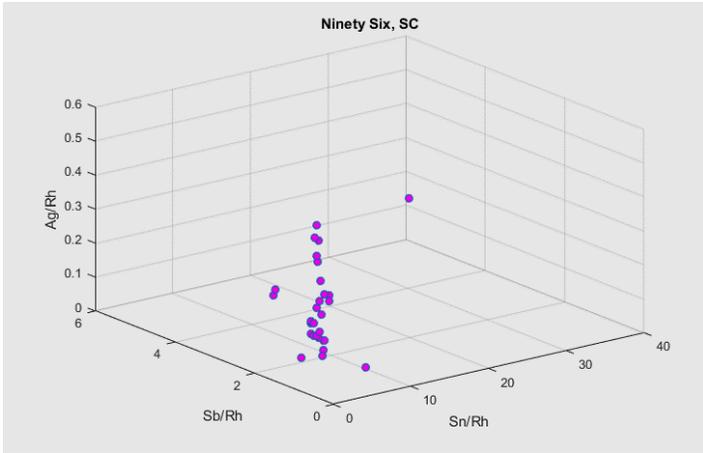


Figure 119. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Ninety-Six Sample.

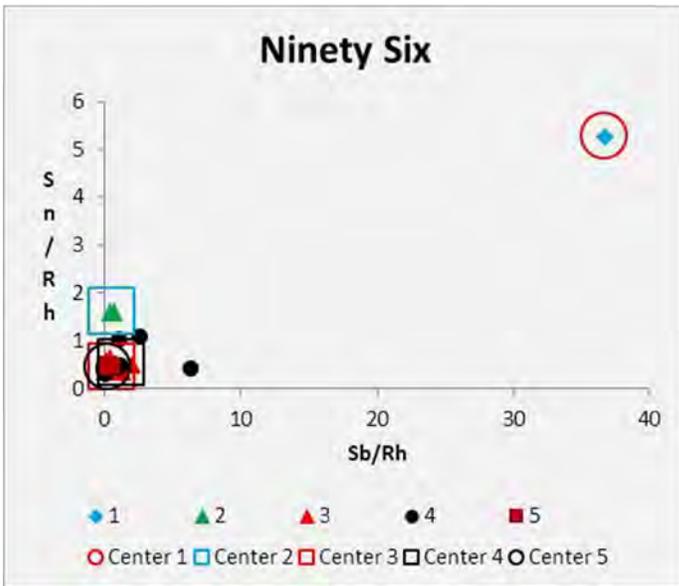


Figure 120. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Ninety-Six Sample.

### Shubrick Plantation

Shubrick Plantation was a plantation where a Revolutionary War skirmish took place in present-day Berkeley County, South Carolina. Allison provided four round balls from the Shubrick Battlefield for analysis in the 2017 workshop. This sample is included as Group 35 in Appendix 1. Figures 121 and 122 show portions of the spectra for the Shubrick sample. Copper (Cu), Silver (Ag), Tin (Sn) and Antimony (Sb) display peaks in these graphs. The Shubrick sample was too small for any meaningful cluster analysis.

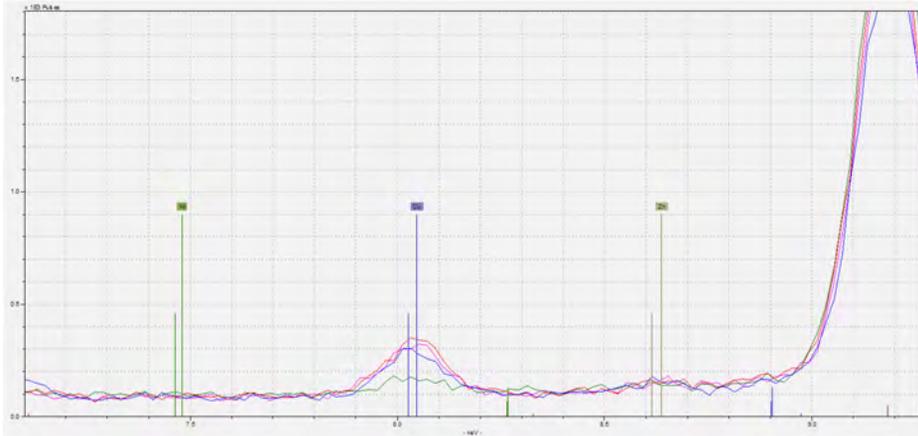


Figure 121. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Shubrick Sample.

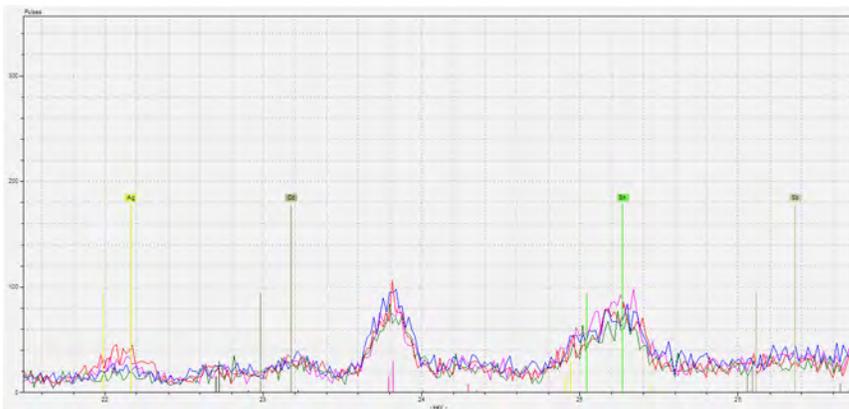


Figure 122. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Shubrick Sample.

## Hanging Rock

Hanging Rock Battlefield is located in Lancaster County in the South Carolina piedmont. Allison provided six round balls from Hanging Rock for analysis in the 2017 workshop. This sample is included as Group 24 in Appendix 1. Figures 123 and 124 show portions of the spectra for the Hanging Rock sample. Hafnium (Hf), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs. The Hanging Rock sample was too small for any meaningful cluster analysis.

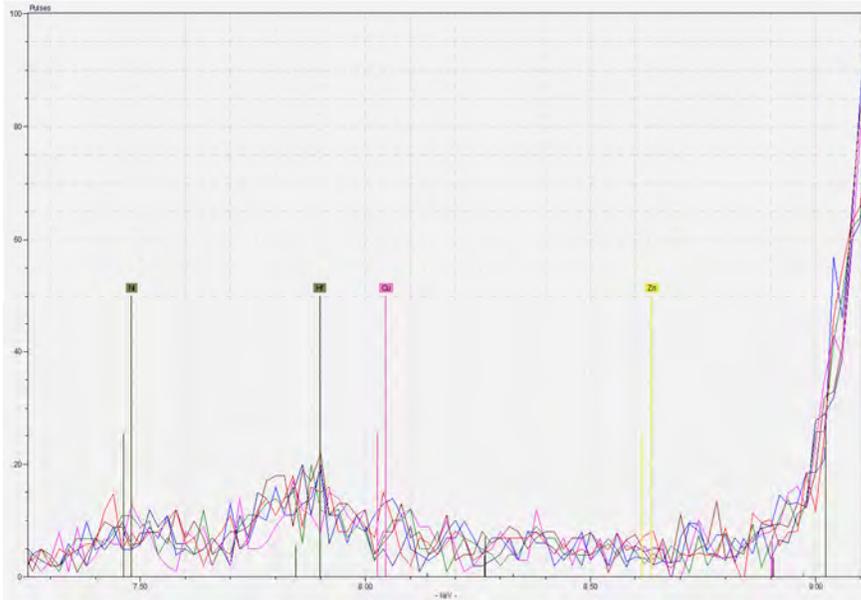


Figure 123. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Hanging Rock Sample.

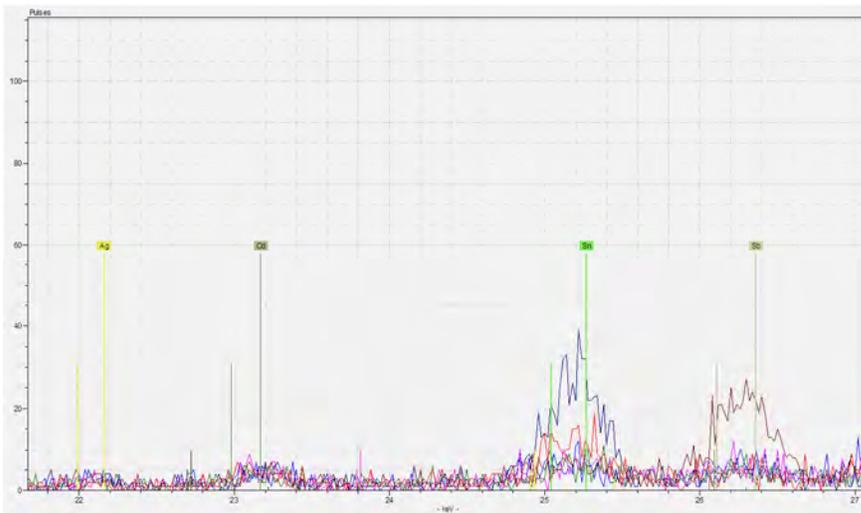


Figure 124. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Hanging Rock Sample.

## Tar Bluff

The battle of Tar Bluff, also known as the Battle of Combahee Ferry, took place on August 25, 1782 in Beaufort County, South Carolina. It pitted Continental troops against British regulars and was a British victory. Archaeologists recently began to explore the Tar Bluff battlefield but no report is available at present. Allison provided six round balls from Tar Bluff for analysis in the 2017 workshop. These

included three intended for use with a British Standard (.75 caliber musket) and three for use in a Charleville (.69 caliber musket). This sample is included as Group 39 in Appendix 1. Figures 125 and 126 show portions of the spectra for the Tar Bluff sample. Hafnium (Hf), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figure 127 shows a scatterplot of the Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios for this sample. The Tar Bluff sample was too small for any meaningful cluster analysis.

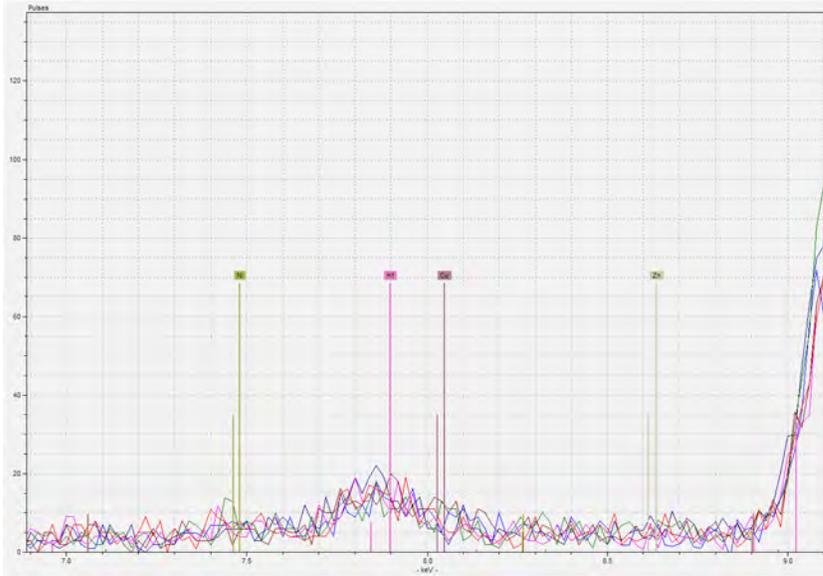


Figure 125. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn) Tar Bluff Sample.

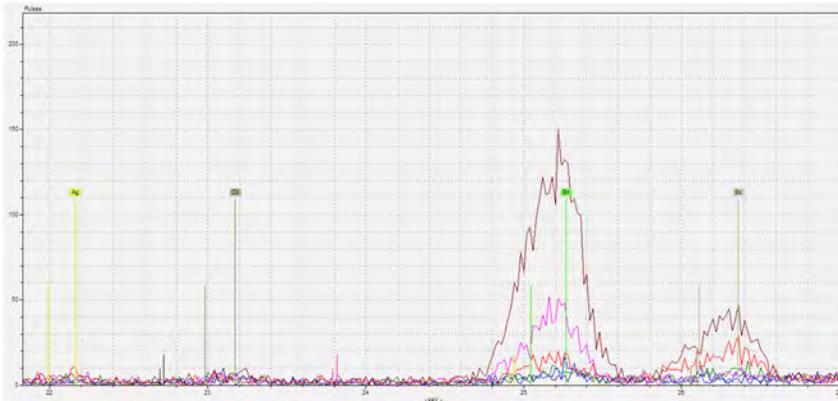


Figure 126. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Tar Bluff Sample.

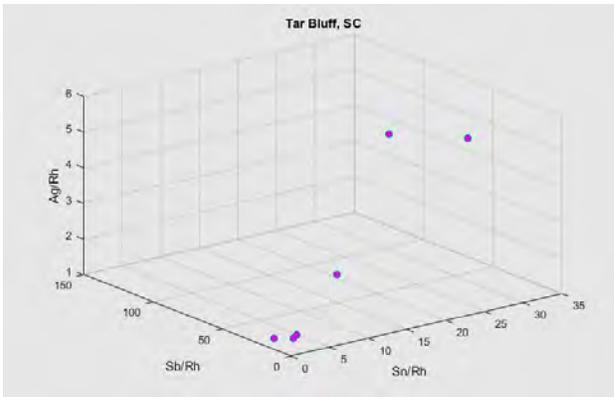


Figure 127. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Tar Bluff Sample.

## Estatoe

Estatoe was a Lower Cherokee town located in the present-day northeastern Georgia Blue Ridge Mountains. The site was excavated by the University of Georgia archaeologists. In 2015 Elliott visited the Laboratory of Archaeology at the University of Georgia, accessed the collection and sampled a small sample of six round balls. This sample is included as Group 12 in Appendix 1. Figures 128 and 129 show portions of the spectra for the Estatoe sample. Copper (Cu), Zinc (Zn), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs. Figure 130 shows a scatterplot of the Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium ratios for this sample. The Estatoe sample was too small for any meaningful cluster analysis.

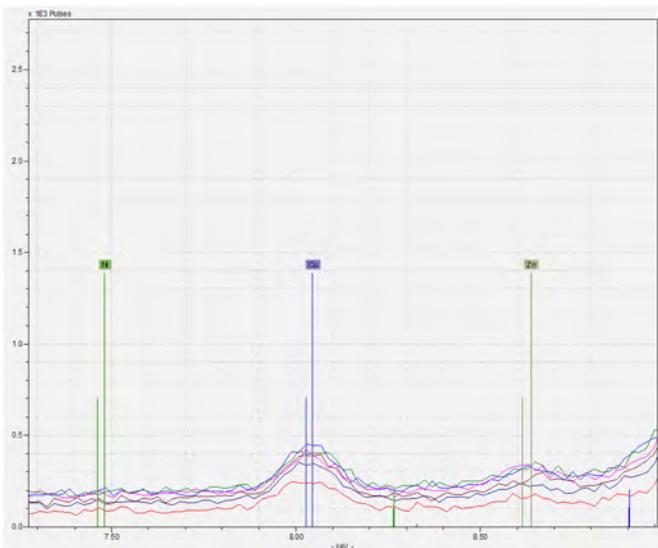


Figure 128. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Estatoe Sample.

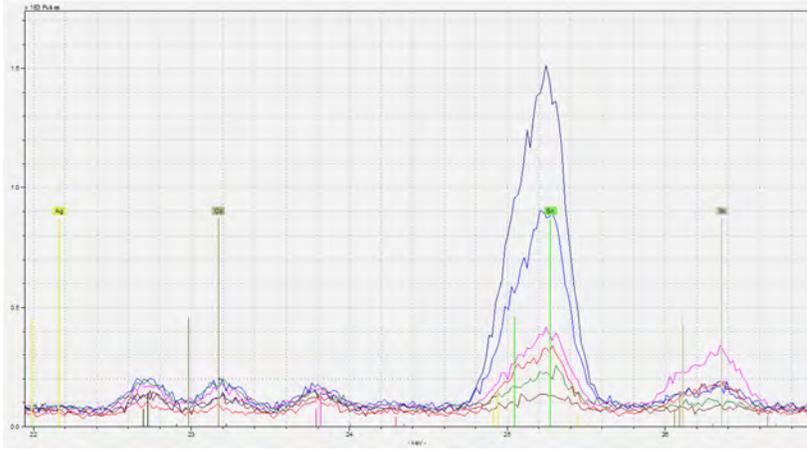


Figure 129. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Estatooe Sample.

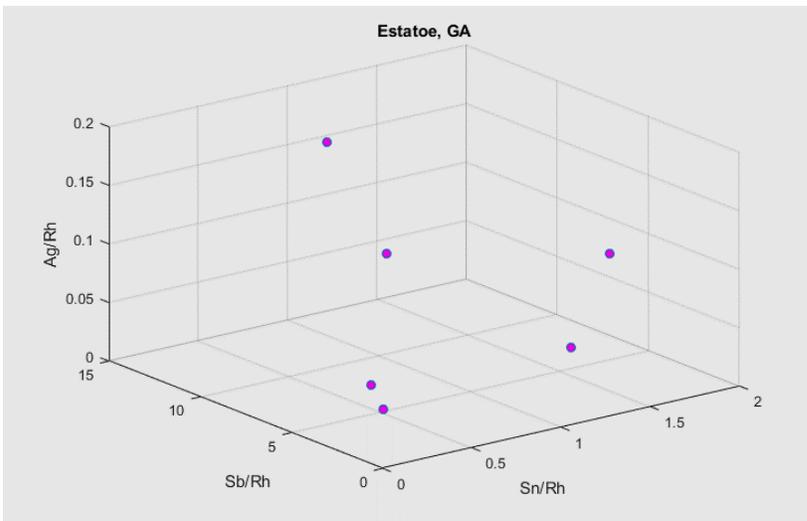


Figure 130. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Estatooe Sample.

## Okfuskenena

Okfuskenena was a Creek village located in the present-day western Georgia piedmont. Also known as the Burnt Village, the village was attacked and burned by Georgia militia in 1793. Okfuskenena (Site 9TP9) was excavated by University of Georgia archaeologists in the 1960s (Williams 2009). In 2015 Elliott visited the Laboratory of Archaeology at the University of Georgia, accessed the collection and sampled 10 round balls. This sample is included as Group 6 in Appendix 1. Figures 131 and 132 show portions of the spectra for the Okfuskenena sample. Copper (Cu), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios in the Okfuskenena sample. Five clusters were identified (Table 33; Figures 133 and 134). The dominant cluster (Segment 4) contained five of 10 specimens (50% of the assemblage). Mean/centroids for this cluster were Antimony (Sb)/Rhodium (Rh), 0.37, Tin (Sn)/Rhodium (Rh), 1.17 and Silver (Ag)/Rhodium (Rh), 0.06.

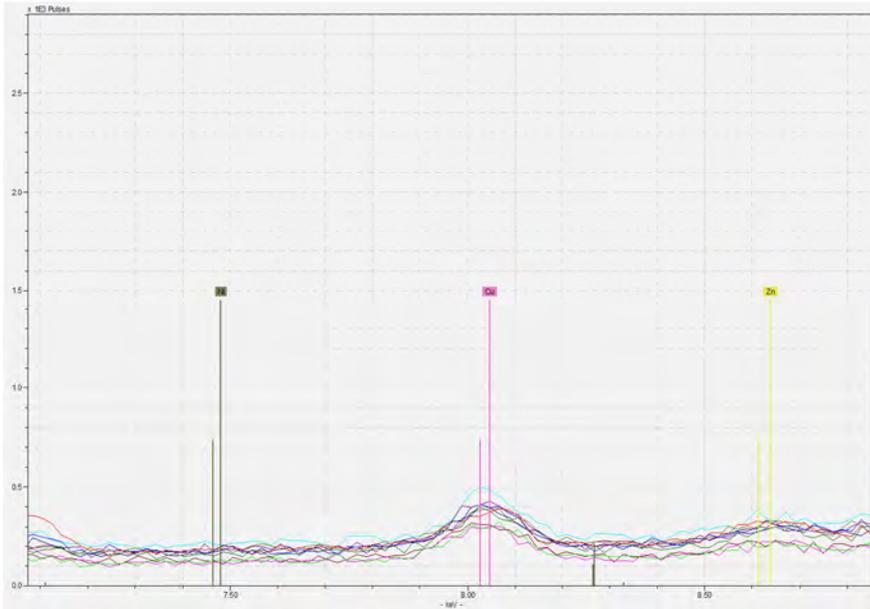


Figure 131. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Okfuskenena Sample.

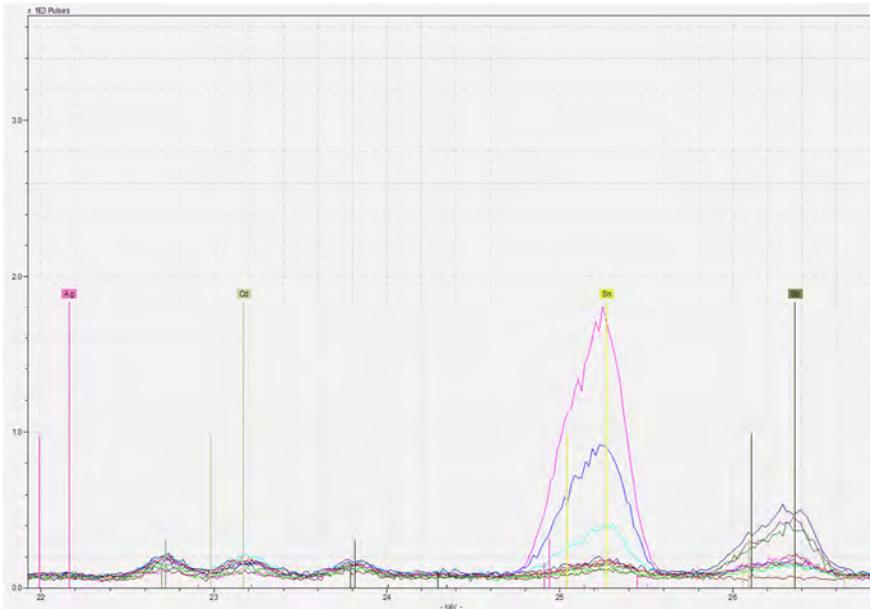


Figure 132. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Okfuskenena Sample.

Table 33. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Okfuskenena Sample.

Mean/Centroid	Sb/Rh	Sn/Rh	Ag/Rh	0	0
Segment 1	1.34	16.58	0.19		
Segment 2	0.06	0.48	0.11		
Segment 3	1.67	0.36	0.06		
Segment 4	0.37	1.17	0.06		
Segment 5	2.13	0.48	0.12		
AVERAGE	0.87	2.41	0.08		
Respondents	Number	%	SSE/Segment		
Segment 1	1	10.0%	0.0		
Segment 2	1	10.0%	0.0		
Segment 3	2	20.0%	0.0		
Segment 4	5	50.0%	8.3		
Segment 5	1	10.0%	0.0		
TOTAL	10	100.0%			
				<b>SSE Total</b>	<b>2.0</b>

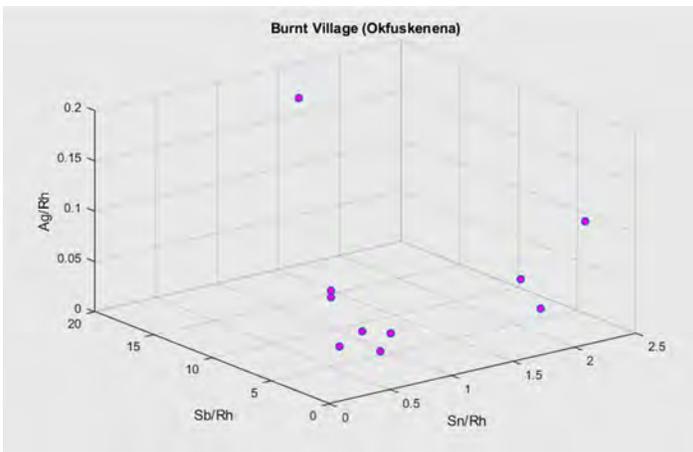


Figure 133. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Okfuskenena Sample.

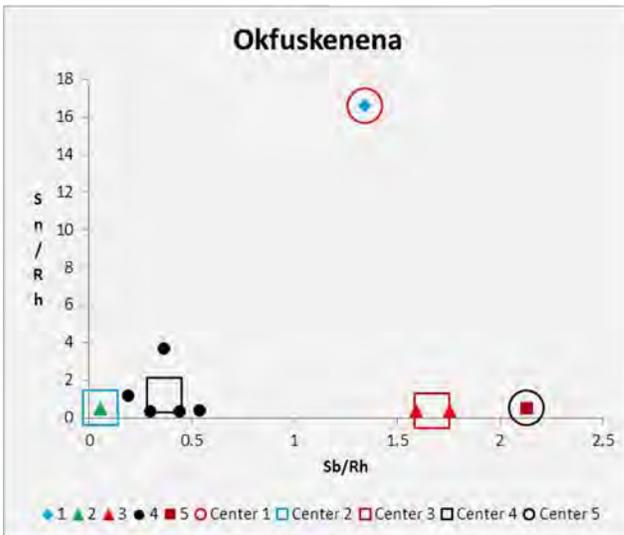


Figure 134. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Okfuskenena Sample.

## Fort Hawkins

Fort Hawkins was a U.S. Army fort in present-day Macon, Bibb County, Georgia. It was never the scene of any military engagement. The archaeological remains of Fort Hawkins is recorded as Site 9BI28. Archaeological excavations at Fort Hawkins began in the 1970s by the University of South Carolina and were followed by more extensive excavations by the LAMAR Institute from 2005-2012 (Elliott 2009a, Elliott et al. 2013). Elliott analyzed the LAMAR Institute's collection of 43 round balls from the site prior to the 2015 workshop and these data are included in this report. This sample is included as Group 21 in Appendix 1. Figure 135 shows a close-up of Nickel (Ni), Copper (Cu) and Zinc (Zn) spectra in the Fort Hawkins assemblage, where some presence of Copper (Cu) and Zinc (Zn) is indicated. Figure 136 shows a close-up of the Fort Hawkins spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb). Tin (Sn) is elevated in numerous specimens in this assemblage, although most contain low levels of Tin (Sn).

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios from the Fort Hawkins sample. Five clusters were identified (Table 34; Figures 137 and 138). The dominant cluster (Segment 4) contained 32 of 43 specimens (74.4%). Its mean/centroid values were Antimony (Sb)/Rhodium (Rh) 0.09, Tin (Sn)/Rhodium (Rh), 1.17 and Silver (Ag)/Rhodium (Rh), 0.08.

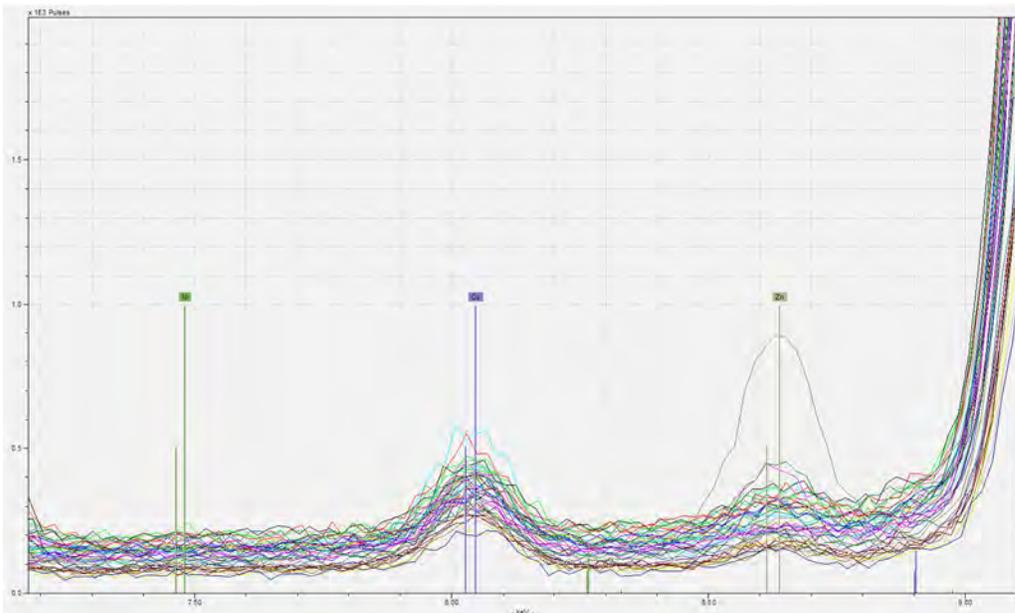


Figure 135. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Fort Hawkins Sample.

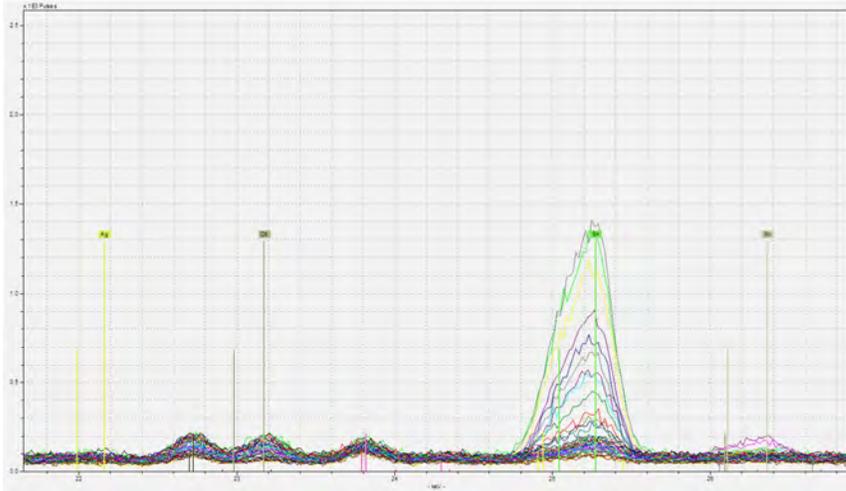


Figure 136. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Hawkins Sample.

Table 34. Output for Five Clusters/Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Hawkins Sample.

Mean/Centroid	<i>Sb/Rh</i>	<i>Sn/Rh</i>	<i>Ag/Rh</i>	0	0
Segment 1	0.09	0.72	0.31		
Segment 2	0.06	0.56	0.22		
Segment 3	0.23	9.40	0.19		
Segment 4	0.09	1.17	0.08		
Segment 5	1.12	4.35	0.20		
AVERAGE	0.15	1.82	0.12		
<b>Respondents</b>	<b>Number</b>	<b>%</b>	<b>SSE/Segment</b>		
Segment 1	4	9.3%	0.1		
Segment 2	2	4.7%	0.0		
Segment 3	3	7.0%	0.0		
Segment 4	32	74.4%	65.6		
Segment 5	2	4.7%	25.5		
<b>TOTAL</b>	<b>43</b>	<b>100.0%</b>			
				<b>SSE Total</b>	<b>48.6</b>

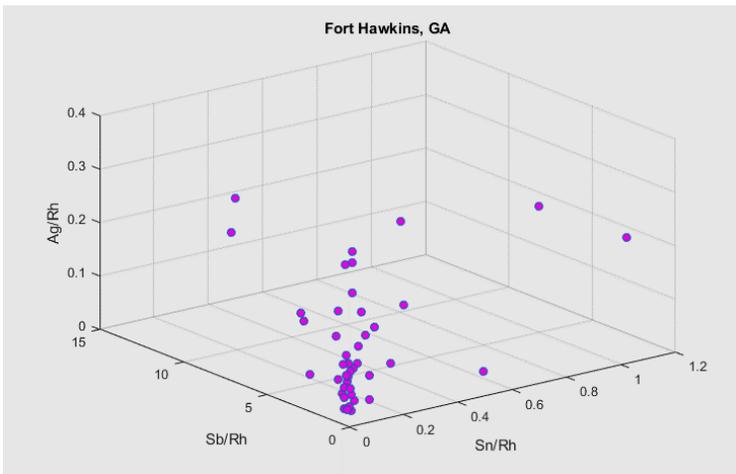


Figure 137. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Hawkins Sample.

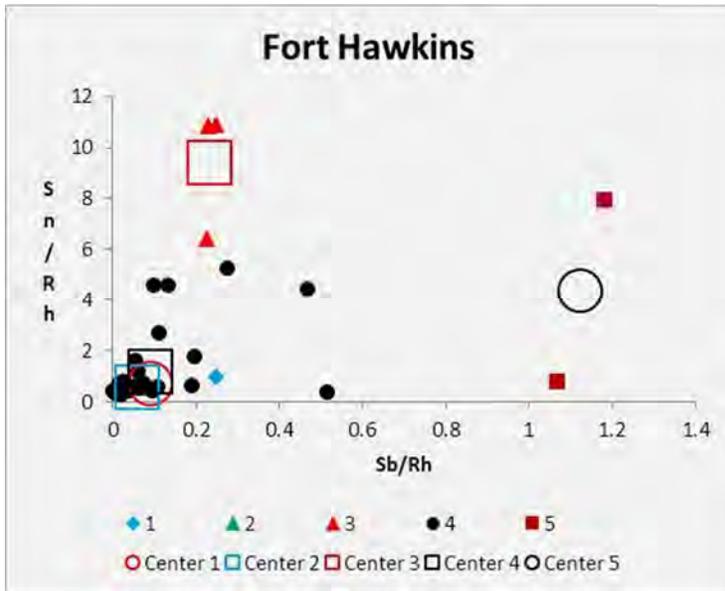
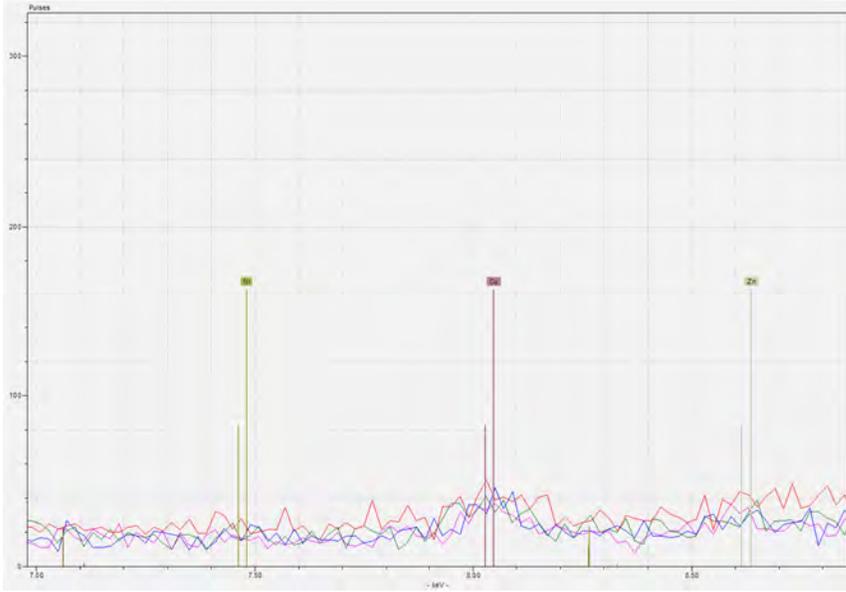


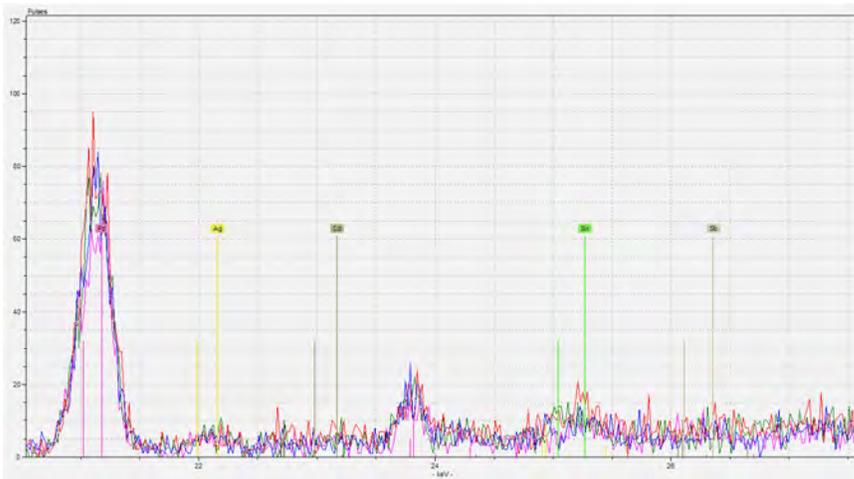
Figure 138. Central Means Chart for Five Segments, Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) Ratios, Fort Hawkins Sample.

### Fort Daniel

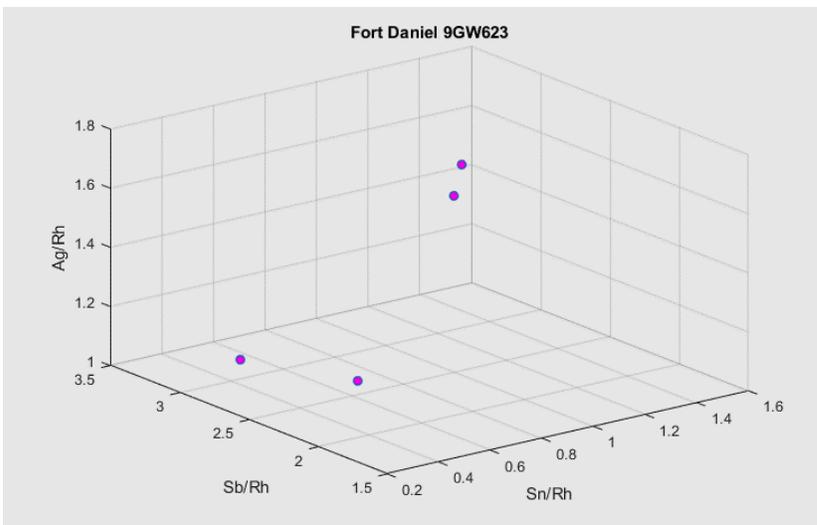
Fort Daniel was a Georgia militia fort located in the piedmont in present-day Gwinnett County, Georgia. It was active in the War of 1812. The archaeological site of Fort Daniel (9GW623) has been studied by D' Angelo. Anthropologist Gregg Beavers provided a sample of four round balls from Fort Daniel for the 2017 workshop. This sample is included as Group 14 in Appendix 1. Figures 139 and 140 show close-ups of the Fort Daniel spectra. Copper (Cu), Silver (Ag) and Tin (Sn) show slight peaks in these graphs. Figure 141 shows a scatterplot of the Antimony (Sb)/Rhodium (Rh), Tin (Sn)/Rhodium (Rh) and Silver (Ag)/Rhodium (Rh) ratios. The Fort Daniel sample was too small for any meaningful cluster analysis.



**Figure 139. Fort Daniel Spectra (Nickel (Ni), Copper (Cu) and Zinc (Zn)).**



**Figure 140. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort Daniel Sample.**



**Figure 141. Scatterplot of Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios, Fort Daniel Sample.**

## Fort King

Fort King was a U.S. Army fort located near present-day Ocala, in Marion County, Florida. It was constructed in 1827, burned in 1836, rebuilt in 1837 and used throughout the Second Seminole War (1835-1842). The fort spans a 15 year period from 1827 to 1842. The archaeological remains of Fort King are recorded as Site 8MR60, as documented in several reports by the Gulf Archaeology Research Institute (GARI). Michelle Sivilich, executive director of GARI provided a sample of 33 round ball ammunition from Fort King for analysis in the 2017 workshop. This sample is included as Group 16 in Appendix 1. Figures 142 and 143 show portions of the spectra for the Fort King sample. Nickel (Ni), Hafnium (Hf), Copper (Cu), Cadmium (Cd), Tin (Sn) and Antimony (Sb) display peaks in these graphs.

Cluster analysis was performed on Silver (Ag)/Rhodium (Rh), Antimony (Sb)/Rhodium (Rh) and Tin (Sn)/Rhodium (Rh) ratios from the Fort King sample. Five clusters were identified (Table 35; Figures 144 and 145). The dominant cluster (Segment 3) contained 12 of 33 specimens (36.4%). Its mean/centroid values were Antimony (Sb)/Rhodium (Rh), 1.06, Tin (Sn)/Rhodium (Rh), 7.84 and Silver (Ag)/Rhodium (Rh), 2.26.

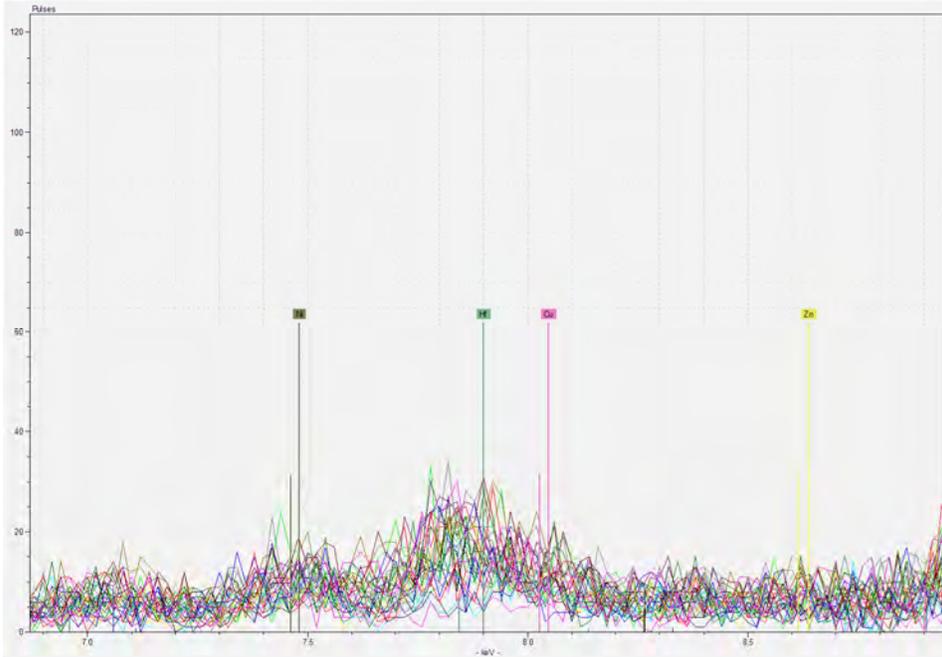


Figure 142. Spectra of Nickel (Ni), Hafnium (Hf), Copper (Cu) and Zinc (Zn), Fort King Sample.

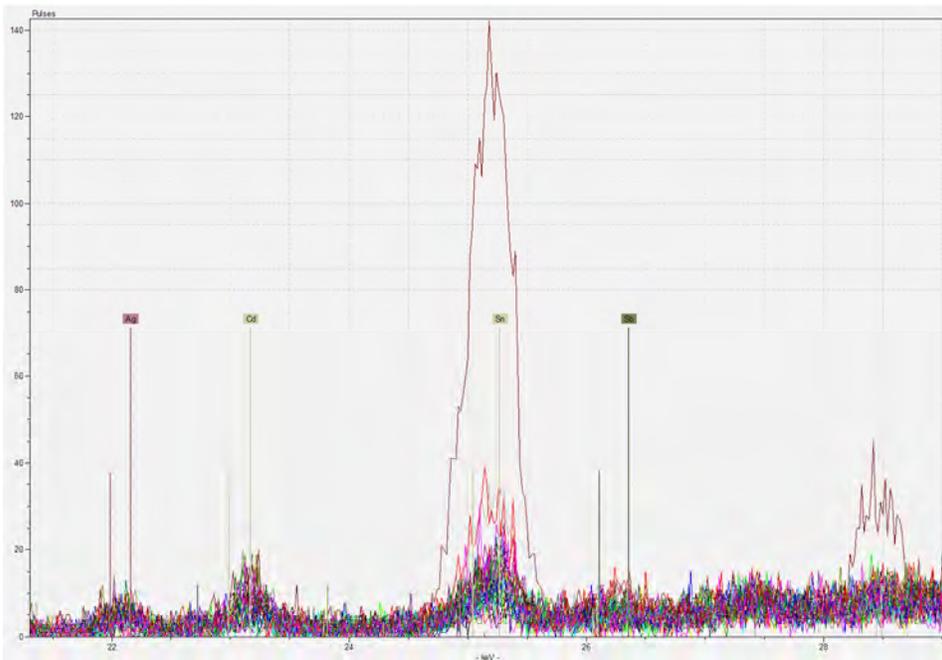


Figure 143. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Fort King Sample.





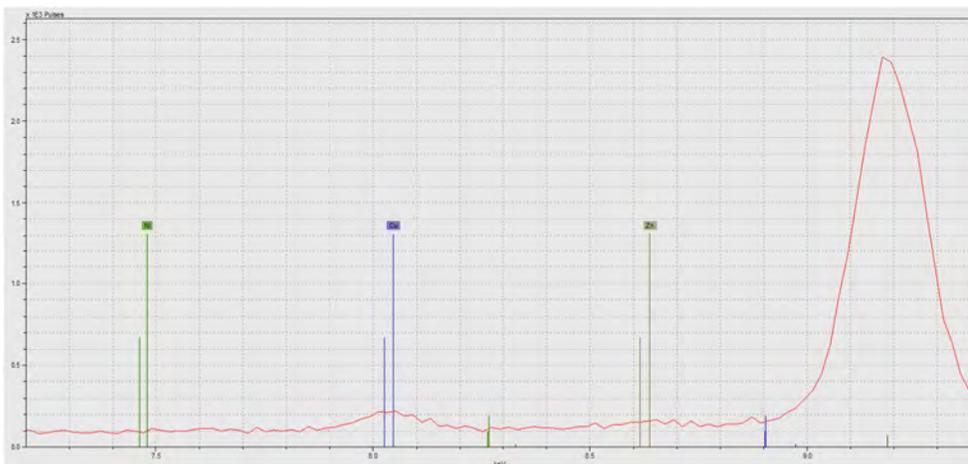


Figure 146. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) British Arsenal Sample.



Figure 147. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) British Arsenal Sample.

## Civil War Examples

Several bullets from the American Civil War period were sampled in the 2017 workshop. While these bullets were not round balls, the elemental information that they provided my prove useful in future studies of later nineteenth-century ammunition. Elliott provided eight Civil War bullets from Purysburg, South Carolina. These include three Enfield bullets, four 3-ringer bullets and one Williams Cleaner bullet. Figures 148 and 149 show portions of the spectra for the Civil War bullets from Purysburg.

McNutt provided three Civil War bullets from the Confederate prison at Camp Lawton (9JS1) in Jenkins County, Georgia and six examples from the Blackshear Confederate prison camp (9PR26) in Pierce County, Georgia. Moreton and

Roberson provided two examples of Civil War bullets from Fort James Jackson, Chatham County, Georgia. One was a 3-ringer minie ball and the other was an Enfield bullet.

Figures 150 and 151 show portions of the spectra for five Enfield bullets from Purysburg, Kettle Creek and Fort James Jackson. Enfield bullets were used in Enfield rifles, which were produced in England and most commonly associated with the Confederate Army. Quantities of Enfield ammunition also were manufactured in England, although quantities also were manufactured in America by the Confederates.

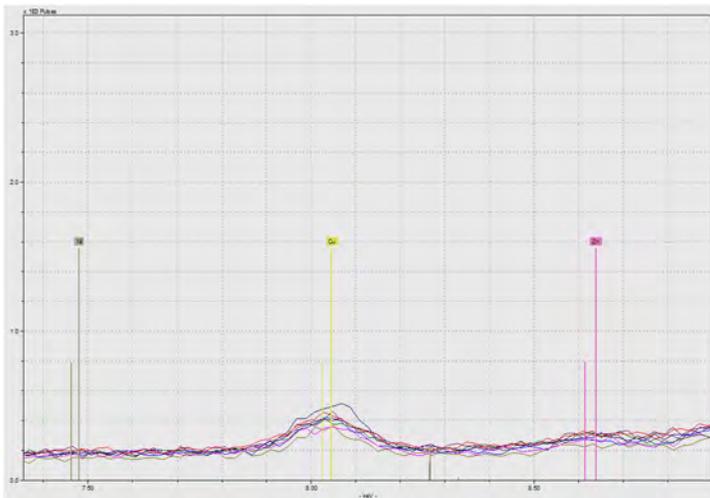


Figure 148. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn) Purysburg Civil War Bullet Sample.

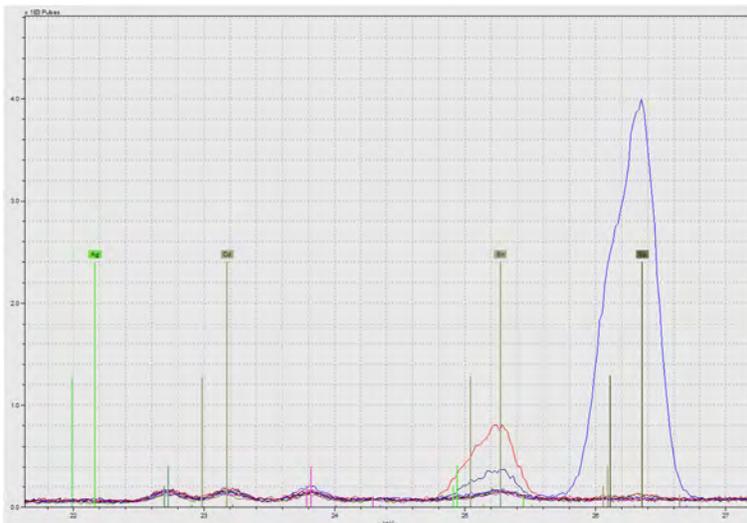
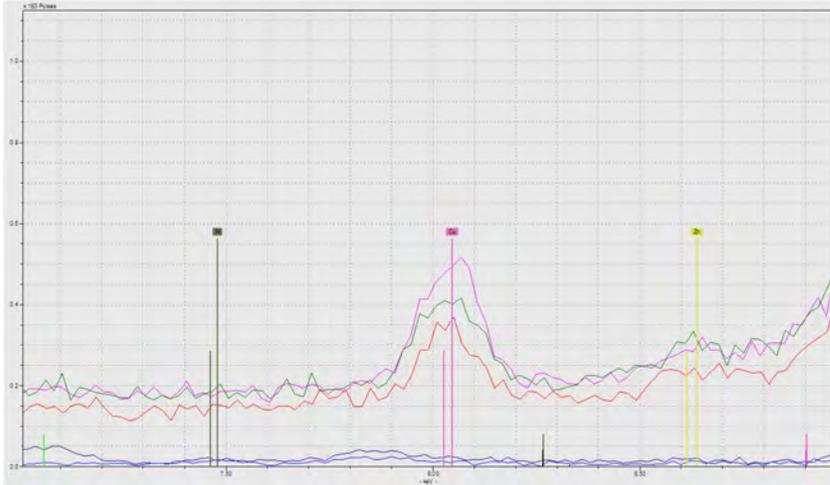
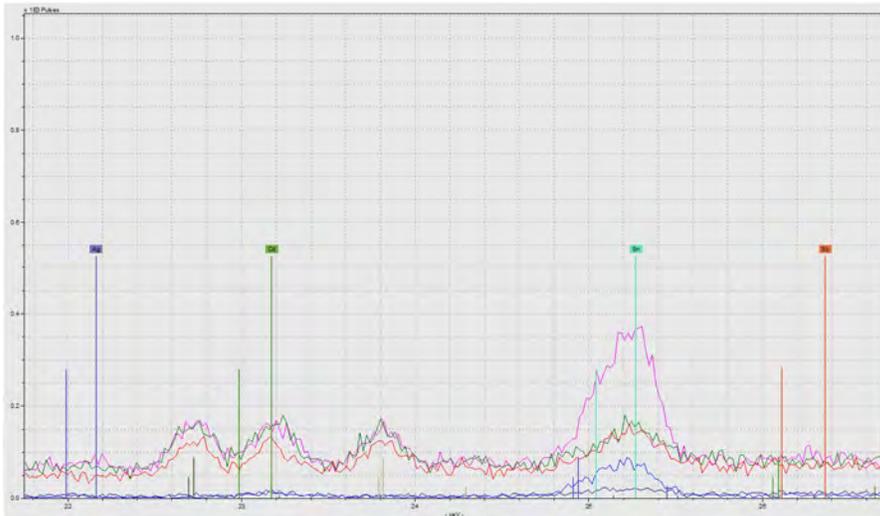


Figure 149. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb) Purysburg Civil War Bullet Sample.



**Figure 150. Spectra of Nickel (Ni), Copper (Cu) and Zinc (Zn), Enfield Bullets from Purysburg, Kettle Creek and Fort James Jackson Samples.**



**Figure 151. Spectra of Silver (Ag), Cadmium (Cd), Tin (Sn) and Antimony (Sb), Enfield Bullets from Purysburg, Kettle Creek and Fort James Jackson Samples.**

## Modern Samples

Participants in the 2017 brought additional samples for analysis in addition to those from historical contexts. Battle brought samples from his recent experimental archaeology project that studied the dynamics of lead case shot fired from artillery.

## V. Interpretations

The current dataset, which comprises 933 samples, contains information on several elements that are important elements in the differentiation of the elemental characterization of round ball ammunition. Each is discussed in the following.

### Antimony

Antimony (Sb) is a silvery white, brittle metalloid with the atomic number 51 (Butterman and Carlin 2004; Royal Society of Chemistry 2017). It occurs with lead ores. Antimony has a high melting point (1170°F) compared to lead. It has a value of 3 on Mohs hardness scale. In early America, Antimony was a key minor ingredient in the alloy pewter. It served to harden and strengthen the pewter.

Figure 152 shows a graph of the Antimony (Sb) values by weapon type. Figure 153 shows a graph of Antimony (Sb) values for Guilford Courthouse, Kings Mountain, Moores Creek and Ninety-Six. A graph showing higher Antimony (Sb) values (>5,000 Photons) in Fusil and Rifle samples are shown in Figure 154. These include Fusil balls from Brier Creek, Carr's Fort, Mount Pleasant and Purysburg. This graph includes Rifle balls from Brier Creek, Carrs Fort, Mount Pleasant and Purysburg.

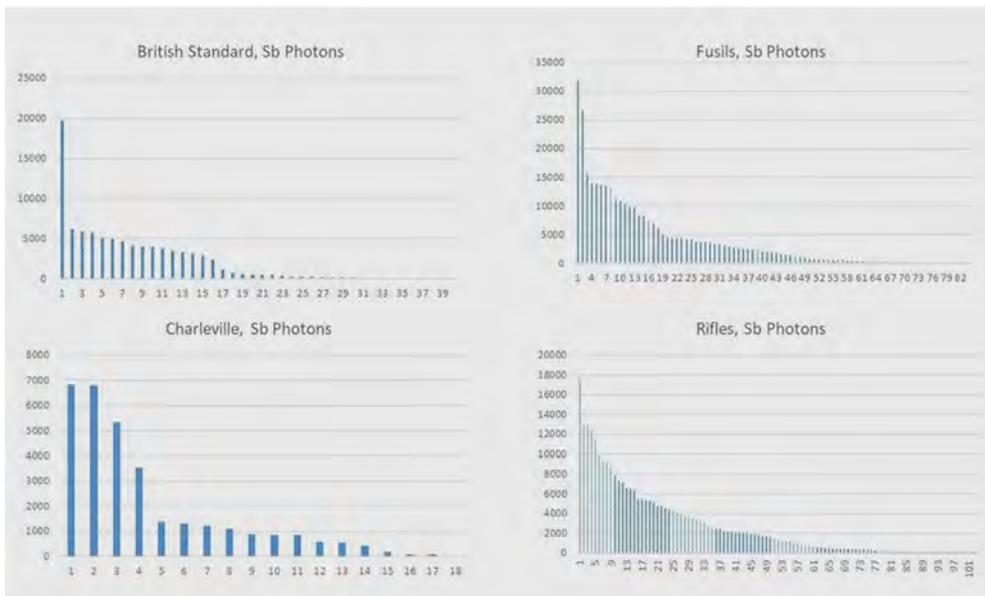


Figure 152. Antimony (Sb) in British Standard, Charleville, Fusils and Rifles (Method 2).

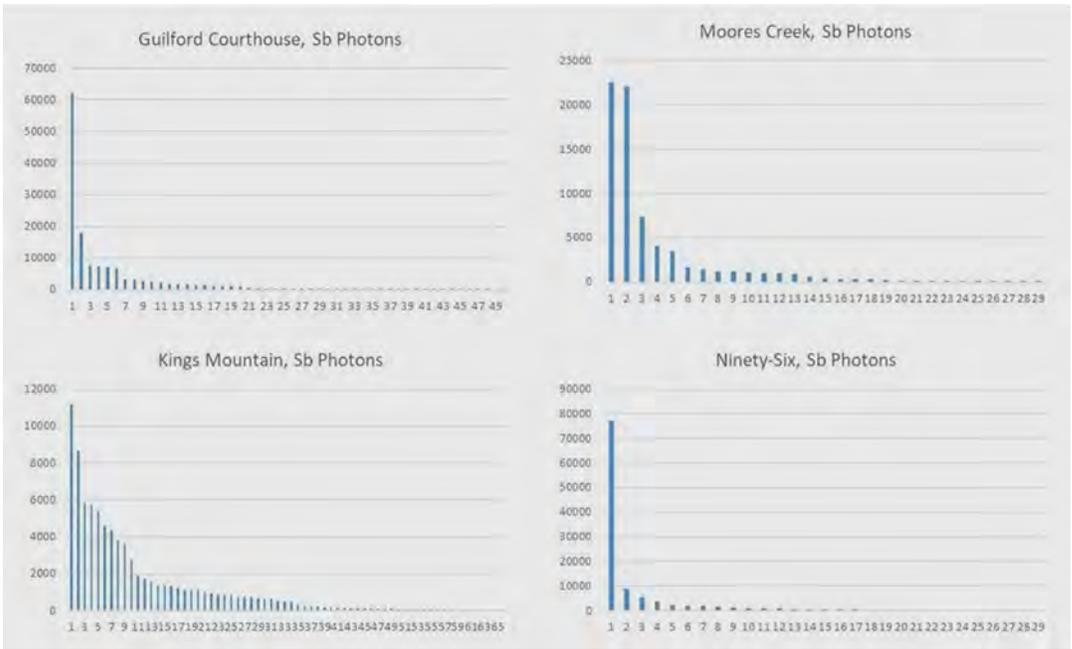


Figure 153. Antimony (Sb) Photons in Guilford Courthouse, Kings Mountain, Moores Creek and Ninety-Six Samples.

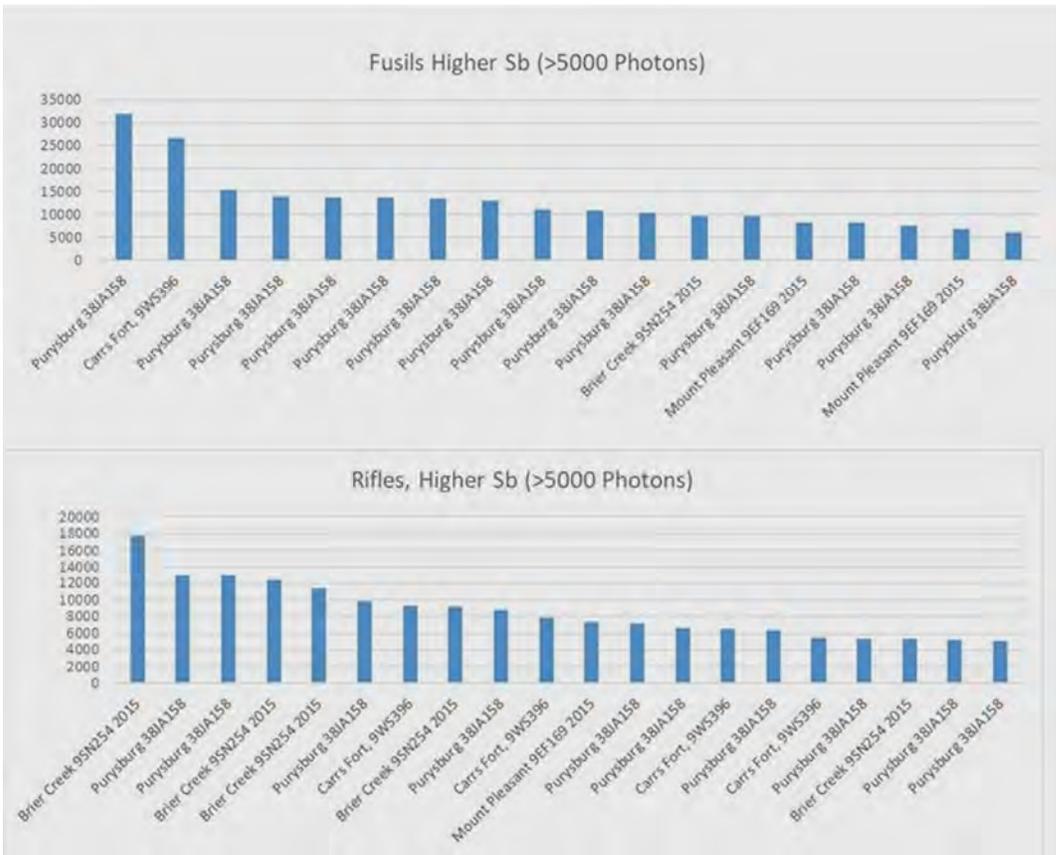


Figure 154. Higher Antimony (Sb) Photon Values in Fusils and Rifles (Method 2).

Antimony (Sb)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 22 (42%), Charleville, 23 (82%), Fusil, 55 (49%), and Rifles, 80 (50%).

### Cadmium

Cadmium (Cd) is a soft, ductile metal with the atomic number 48 (Butterman and Plachy 2004; International Cadmium Association 2017). Cadmium occurs as an impurity in lead ores. Cadmium has a melting point of 610°F, which is slightly lower than that of lead. It has a value of 2 on Mohs hardness scale.

Cadmium (Cd) amounts vary considerably in the round ball collections, although its importance and meaning remains unclear. A total of 783 of 933 samples (84%) emitted 100 photons or higher and 297 (26%) emitted 1000 photons or higher of this element. Cadmium (Cd)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 11 (21%), Charleville, 9 (32%), Fusil, 28 (25%), and Rifles, 56 (35%). While Cadmium is present in low frequencies, the distribution of balls with Cadmium (Cd)/Rhodium (Rh) ratio values of five or greater reveals some patterning (Figure 155). Balls in this category were identified at the Battle of Beaufort, Brier Creek, Fort Frederica, Fort King, Galphins, Guilford Courthouse, Kettle Creek, Mount Pleasant and the New Jersey Sites.

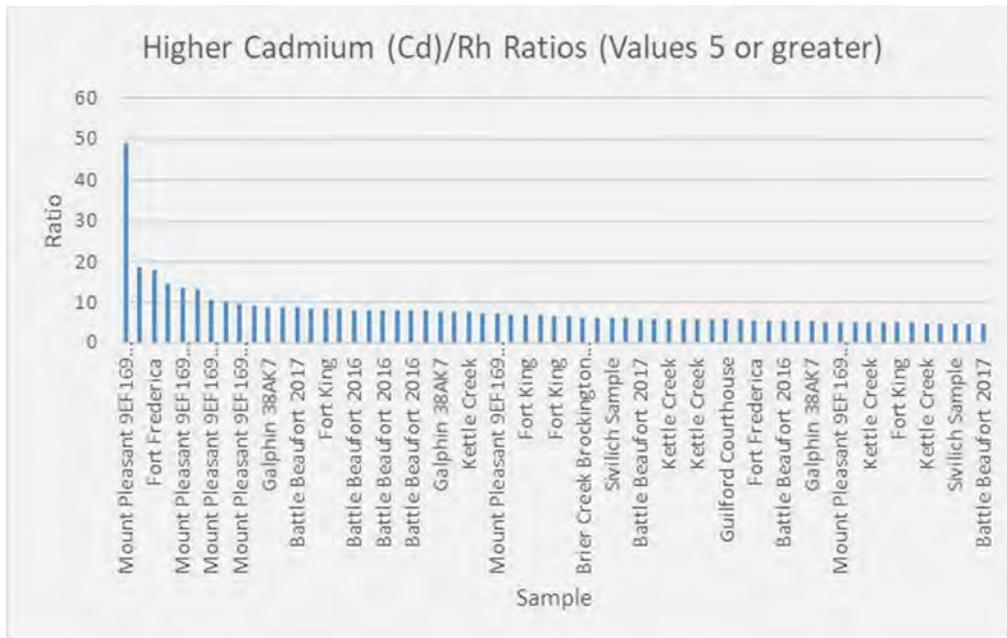


Figure 155. Samples with Higher Cadmium to Rhodium (Cd)/Rh Ratios.

## Copper

Copper (Cu) is a malleable reddish-gold metal with the atomic number 29 (Doebrich 2009:1-4). It occurs with lead ores. Copper has a very high melting point (1984°F) compared to lead. It has a value of 3 on Mohs hardness scale.

Copper was identified in many of the round balls that were sampled. A total of 922 of 933 samples (99%) emitted 100 photons or higher and 512 (55%) emitted 1000 photons or higher of this element. Five specimens in the study, including Moores Creek (MOCR 1021), Minute Man (FS29, FS29B and 77=6685) and Guilford Courthouse (GUCO 10672) have markedly higher amounts of copper (390,000 photons or higher) compared to all of the other specimens in the study. Thirty-one other specimens in the study have Cu photon values of 10,000 or higher. Copper (Cu)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 14 (27%), Charleville, 9 (32%), Fusil, 33 (30%), and Rifles, 85 (54%).

## Hafnium

Hafnium (Hf) is a lustrous, silvery gray, transition metal with the atomic number 72. It was not discovered until 1923. Hafnium has a melting point of 4051°F. It has a value of 5.5 on Mohs hardness scale (Greenwood and Earnshaw 1997).

Hafnium was identified in the spectra of only a few samples and confirmation of its presence remains tentative. It was recognized in the Beaufort (2016), Fort Frederica, Fort King, Galphins, Hanging Rock, Kettle Creek and Tar Bluff samples.

## Nickel

Nickel (Ni) is a silvery-white lustrous metal with the atomic number 28 (Nickel Institute 2017). Nickel has a very high melting point (2646°F) compared to lead. It has a value of 4.0 on Mohs hardness scale.

Nickel was not observed in significant amounts in most of the samples. Nickel displayed recognizable peaks in the spectra for the Battle of Beaufort (2016 and 2017 samples), Brier Creek (2017 sample), Cowpens, Fort Frederica, Fort Moore, Galphins and the King George Statue samples. A total of 439 of 933 samples (47%) emitted 100 photons or greater but only 41 (4%) emitted 10,000 photons or greater. Nickel (Ni)/Rhodium (Rh) ratio values were sorted. Ten samples had values of 10 or greater. These were from Beaufort, Brier Creek, Kettle Creek, Mount Pleasant.

A total of 276 (30%) had ratios greater than one. Nickel (Ni)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 11 (21%), Charleville, 9 (32%), Fusil, 28 (25%), and Rifles, 56 (35%).

## Silver

Silver (Ag) is a precious silver metal with the atomic number 47 (Butterman and Hilliard 2004). Silver has a high melting point (1761°F) compared to lead. It has a value of 2.5 on Mohs hardness scale. It commonly occurs with lead ores.

Silver is evidenced in many of the round ball samples in this study. Its importance and meaning in their identification remains unclear. Figure 156 shows the distribution of Silver photons by weapon type. Silver (Ag)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 12 (23%), Charleville, 9 (32%), Fusil, 25 (22%), and Rifles, 53 (33%).

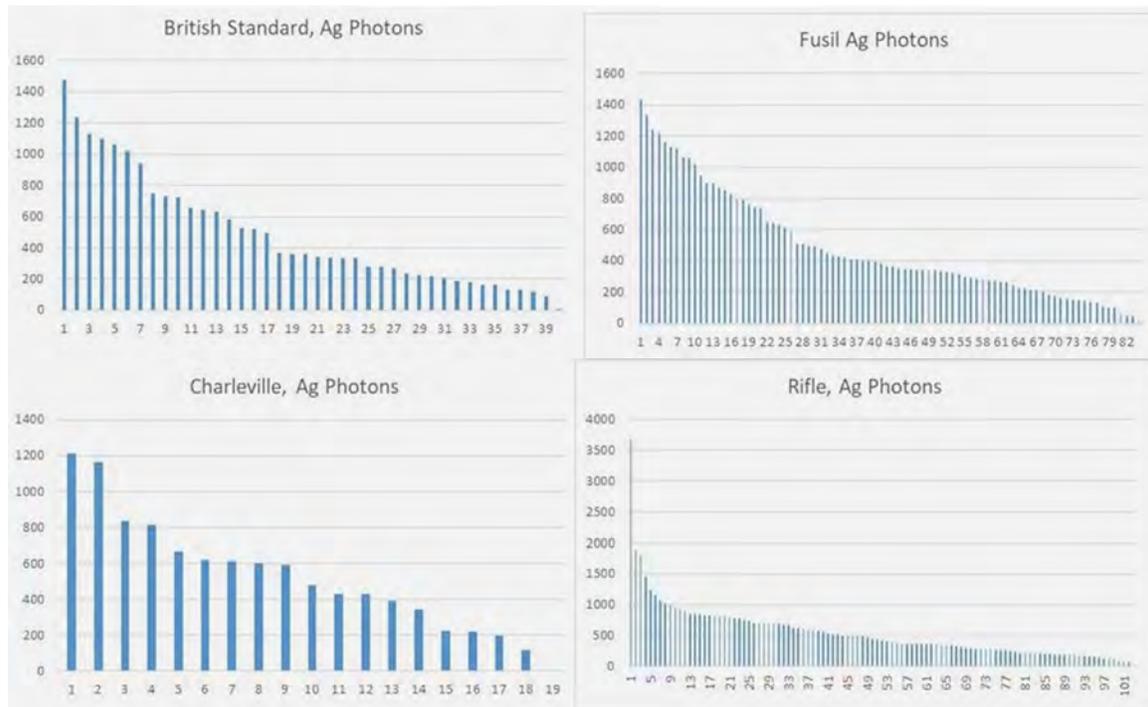


Figure 156. Silver (Ag) Photons by Weapon Type (Method 2).

## Tin

Tin (Sn) is a soft, white metal with the atomic number 50 (Calvert 2002). It occurs with lead ores. Tin has a melting point of 449°F, which is lower than that of lead. It has a value of 1.5 on Mohs hardness scale. Tin is a major component of pewter alloy.

Figure 157 shows the distribution of Silver photons by weapon type. Figure 158 shows the distribution of Silver for Guilford Courthouse, Kings Mountain, Moores Creek and Ninety-Six. Higher Tin (Sn) photon values (> 10,000 Photons) and Antimony (Sb) (>5,000 Photons) in Fusil and Rifle samples are shown in Figure 159. For Tin (Sn), these include Fusil balls from Carrs Fort, Estatoe, Mount Pleasant, Purysburg (and Black Swamp). It includes Rifle balls from Brier Creek, Carrs Fort, Fort Hawkins, Okfuskenena and Purysburg. For Antimony (Sb), these include Fusil balls from Brier Creek, Carr's Fort, Mount Pleasant and Purysburg. It includes Rifle balls from Brier Creek, Carrs Fort, Mount Pleasant and Purysburg. Tin (Sn)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 15 (29%), Charleville, 11 (39%), Fusil, 55 (49%), and Rifles, 115 (72%).

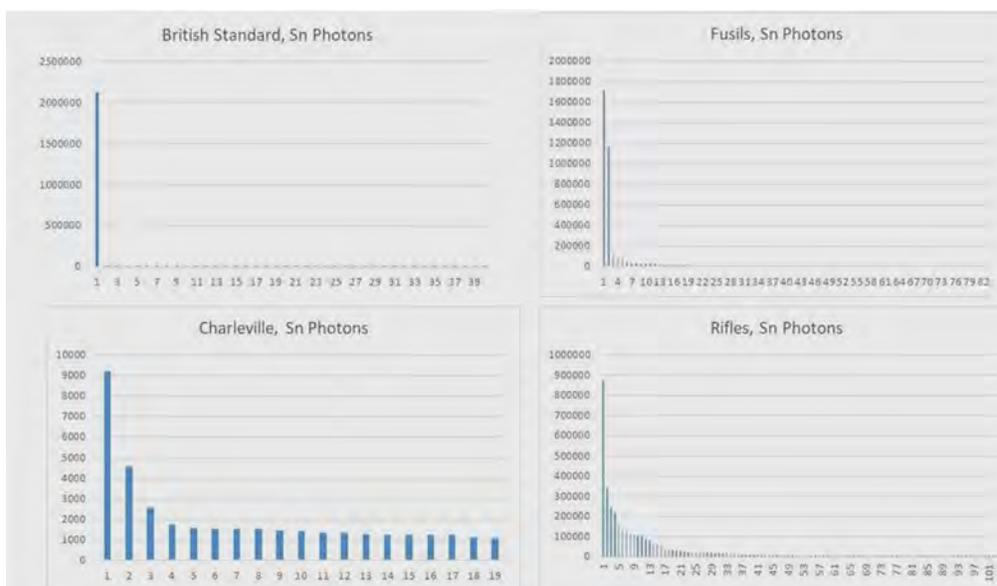


Figure 157. Tin (Sn) in British Standard, Charleville, Fusils and Rifles (Method 2).

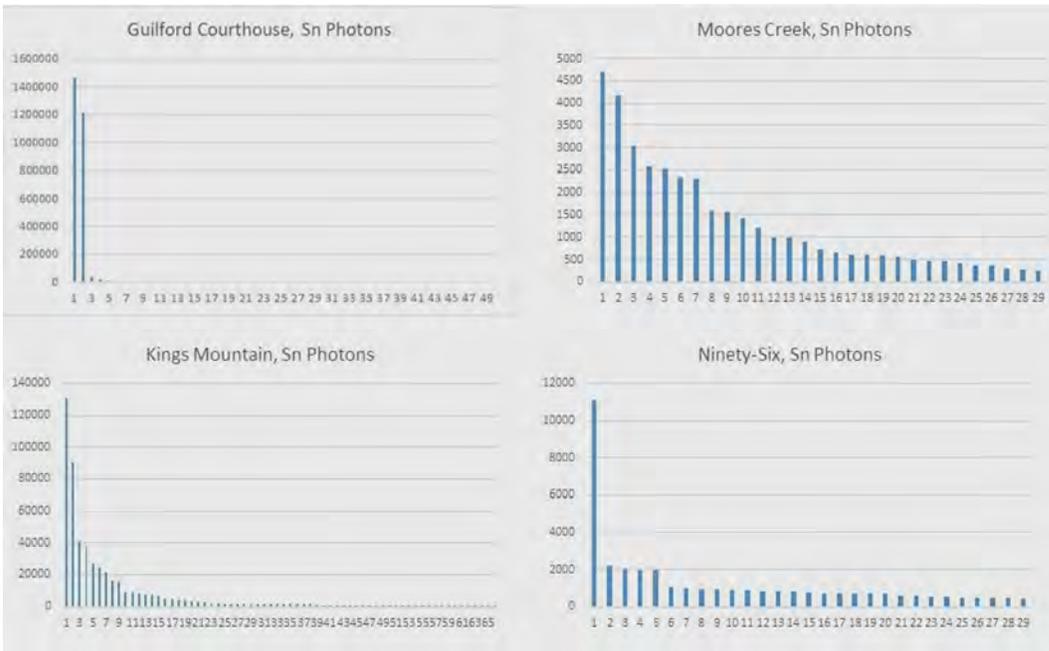


Figure 158. Tin (Sn) Photons in Guilford Courthouse, Kings Mountain, Moores Creek and Ninety-Six Samples.

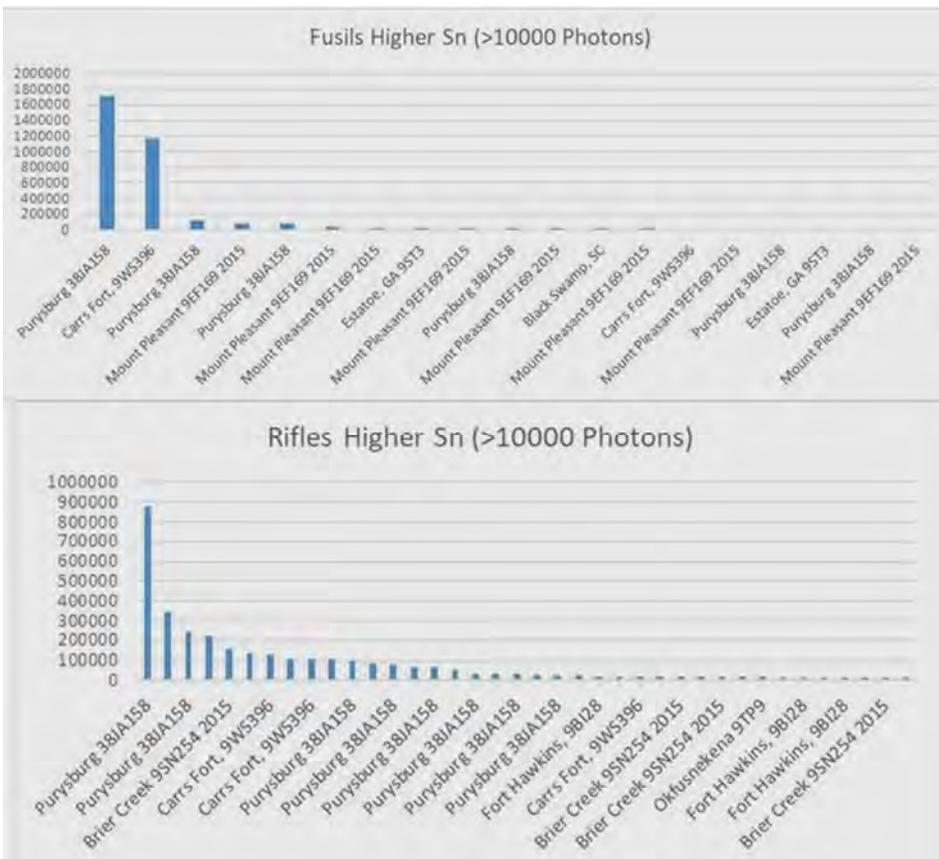


Figure 159. Higher Tin (Sn) Photon Values in Fusils and Rifles (Method 2).

## Zinc

Zinc (Zn) is a lustrous metal with the atomic number 30 (Bleiwas and diFrancesco 2010; International Zinc Association 2017). It is found with lead ores. Zinc has a high melting point (787°F). Zinc has a value of 2.5-3 on Mohs hardness scale.

Zinc (Zn)/Rhodium (Rh) ratio values were sorted by weapon type. We tallied the number of specimens for weapon type with values of one or greater. The results were: British Standard balls, 6 (12%), Charleville, 1 (4%), Fusil, 9 (8%), and Rifles, 22 (14%). While Zinc (Zn) in Rifle balls shows the highest percentage this distribution does not appear to have statistical validity.

## Casting Sprue

Archaeological evidence for metal casting of round balls was observed at three sites in the study-- Brier Creek, Mount Pleasant and Purysburg. Examples of gang mold sprue from each of these three sites were analyzed. Tin (Sn) and Antimony (Sb) photon values for these gang mold sprue samples are shown in Figure 160.

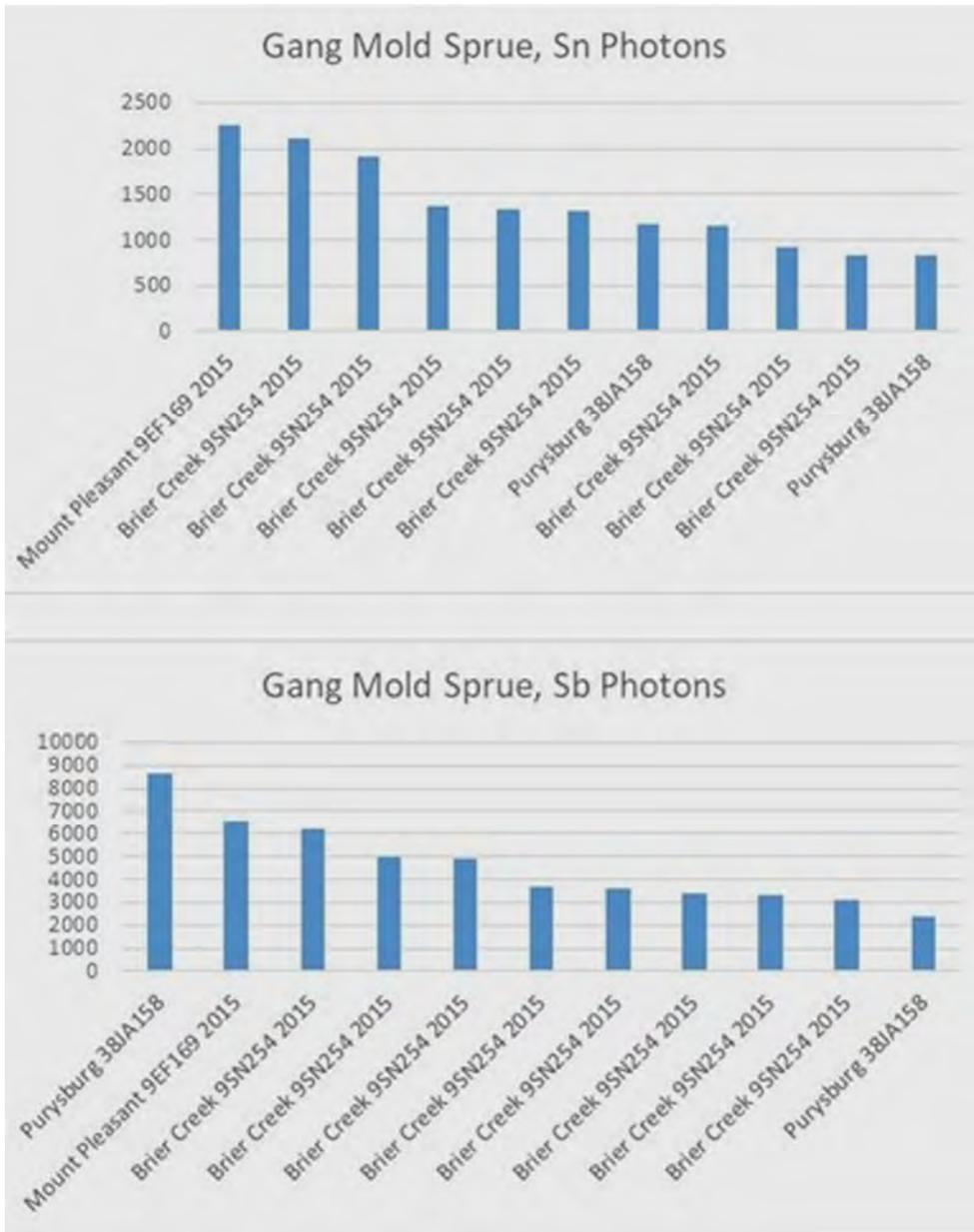


Figure 160. Tin (Sn) and Antimony (Sb) Photons, Gang Mold Sprue from Brier Creek, Mount Pleasant and Purysburg Samples.

## VI. Summary

This report contains a wide range of information about the elemental composition of metallic round balls recovered from many eighteenth and early nineteenth century sites in the United States. It also includes information on a few examples from other places and later time periods. Bruker's Tracer series machines generated these data, which were processed using Bruker's Artax software. The purpose of this project was to explore the feasibility of these techniques in characterizing round balls in culturally meaningful ways. The project team endeavored to develop standardized methods for data collection. This report includes data collect by numerous methods over a several year period, culminating in the 2017 Get the Lead Out! Workshop, which was sponsored by the National Center for Preservation Technology and Training, National Park Service.

This report explores many of the elements that were identified in the samples. We looked for relationships between elements, or clusters of elements, by weapon type and by archaeological site. The elements Tin (Sn), Antimony (Sb) and Silver (Ag) appear to be important additives to the Lead (Pb) balls. Other elements, including Nickel (Ni), Copper (Cu), Zinc (Zn) and Cadmium (Cd) also may be important, but more study is needed to establish their relevance. This research has established the utility of this technology for identifying patterning in the data. The task of interpreting these patterns remains to be fully completed. Hopefully, the data and interpretations provided in this report represent a sound basis for future studies on this topic.

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# Appendix 1. Data Spreadsheet

Group Dataset	Method	Weapon	Sample	Ag K12	Cd K12	Cu K12	Fe K12	Ni K12	Pb L1	Pb M1	Pd K12	Rh K12	Sb K12	Sn K12	Zn K12	Sb/Sn	Ag/Sn	Zn/Pb	Cu/Pb	Sb/Rh	Sn/Rh	Ag/Rh	Cd/Rh	Cd/Sn	Pd/Rh	Sn/Sb	Ni/Rh	Cu/Rh	Zn/Rh	Sn/Pb
1 Battle Beaufort 2016	4		BFFS95	81	164	405	384	182	104624	376	55	20	530	302	6	1.755	0.268	0.000	0.004	26.500	15.100	4.050	8.200	0.543	2.750	0.570	9.100	20.250	0.300	0.003
1 Battle Beaufort 2016	4		BFFS77	131	135	370	336	206	93567	453	92	31	55	299	19	0.184	0.438	0.000	0.004	1.774	9.645	4.226	4.355	0.452	2.968	5.436	6.645	11.395	0.613	0.003
1 Battle Beaufort 2016	4		BFFS89	206	256	507	448	202	110235	449	79	31	661	338	14	1.956	0.609	0.000	0.005	21.233	10.903	6.645	8.258	0.757	2.548	0.511	6.516	16.355	0.452	0.003
1 Battle Beaufort 2016	4		BFFS25a	160	126	300	174	7704	346	28	25	128	1336	24	0.096	0.240	0.000	0.004	4.414	4.345	5.517	0.666	10.441	6.000	10.039	6.000	10.039	0.017	0.001	
1 Battle Beaufort 2016	4		BFFS83	216	110	378	393	160	87559	238	77	29	32	305	50	0.105	0.708	0.001	0.004	1.103	10.517	7.448	3.793	0.361	2.655	9.531	5.517	13.034	1.724	0.003
1 Battle Beaufort 2016	4		BFFS74	102	150	464	303	175	85612	282	49	36	1034	243	4	4.255	0.420	0.000	0.005	28.722	6.750	2.833	4.167	0.617	1.361	0.235	4.861	12.889	0.111	0.003
1 Battle Beaufort 2016	4		BFFS100a	324	144	420	457	170	94798	423	77	35	3421	323	66	10.591	1.103	0.001	0.004	97.743	9.229	9.257	4.114	0.446	2.200	0.094	4.857	12.200	1.886	0.003
1 Battle Beaufort 2016	4		BFFS84	327	169	458	527	175	98488	371	38	37	27	294	9	0.092	1.102	0.000	0.005	0.730	7.946	8.838	4.568	0.575	1.027	10.899	4.730	12.738	0.243	0.003
1 Battle Beaufort 2016	4		BFFS86	234	176	421	390	173	104416	409	85	37	188	441	31	0.436	0.543	0.000	0.004	5.081	11.649	6.324	4.757	0.408	2.297	2.293	4.676	11.738	0.838	0.004
1 Battle Beaufort 2016	4		BFFS92	277	189	432	452	171	95887	383	86	40	61	242	16	0.262	1.145	0.000	0.005	1.525	6.050	6.925	4.725	0.781	2.150	3.967	4.275	10.800	0.400	0.003
1 Battle Beaufort 2016	4		BFFS96	255	109	374	352	152	80514	261	56	40	730	264	37	2.765	0.966	0.000	0.005	18.250	6.600	6.375	2.725	0.413	1.400	0.362	3.800	9.350	0.925	0.003
1 Battle Beaufort 2016	4		BFFS93	220	55	329	463	131	81702	305	50	36	393	292	14	1.346	0.753	0.000	0.004	10.917	8.111	6.111	1.528	0.188	1.389	0.743	3.639	9.139	0.389	0.004
1 Battle Beaufort 2016	4		BFFS87	182	73	357	371	166	66012	234	30	46	112	194	32	0.577	0.938	0.000	0.005	2.435	4.217	3.957	1.587	0.376	0.652	1.732	3.609	7.761	0.696	0.003
1 Battle Beaufort 2016	4		BFFS75	160	178	437	323	141	96692	429	57	40	317	344	20	0.922	0.465	0.000	0.005	7.925	8.600	4.000	4.450	0.517	1.425	1.085	3.525	10.925	5.000	0.004
1 Battle Beaufort 2016	4		BFFS99	181	132	325	420	170	88573	411	90	49	2228	229	24	9.729	0.790	0.000	0.004	45.469	4.673	6.694	2.694	0.576	3.837	1.013	3.469	6.633	0.490	0.003
1 Battle Beaufort 2016	4		BFFS82	142	120	521	434	156	96281	506	68	47	632	296	32	2.135	0.480	0.000	0.005	13.447	6.298	3.021	2.553	0.405	1.447	0.468	3.319	11.085	0.681	0.003
1 Battle Beaufort 2016	4		BFFS85b	154	141	398	367	150	90782	418	28	48	411	4212	1	0.098	0.037	0.000	0.004	8.563	87.750	3.208	2.938	0.033	0.583	10.248	3.125	8.292	0.021	0.046
1 Battle Beaufort 2016	4		BFFS94	238	218	399	339	165	108147	757	102	59	282	339	18	0.832	0.702	0.000	0.004	4.780	5.746	4.034	3.695	0.643	1.729	1.202	2.797	7.763	0.305	0.003
1 Battle Beaufort 2016	4		BFFS90	208	196	420	410	151	106607	664	81	56	132	292	12	0.452	0.712	0.000	0.004	2.357	5.214	3.714	3.500	0.671	1.446	2.212	2.696	7.500	0.214	0.003
1 Battle Beaufort 2016	4		BFFS100b	252	190	461	290	116	96597	460	57	60	134	298	65	0.450	0.846	0.001	0.005	2.680	5.960	5.040	3.800	0.638	1.140	2.224	2.320	9.220	1.300	0.003
1 Battle Beaufort 2016	4		BFFS76	77	91	356	836	150	68985	181	52	67	334	273	26	1.223	0.282	0.000	0.005	4.985	4.075	1.149	1.358	0.333	0.776	0.817	2.239	5.313	0.388	0.004
1 Battle Beaufort 2016	4	Case shot	BFFS81	180	221	439	382	180	107457	647	43	27	50	999	11	0.050	0.180	0.000	0.004	1.852	37.000	6.667	8.185	0.221	1.593	19.980	6.667	16.259	0.407	0.009
1 Battle Beaufort 2016	4	Case shot	BFFS88b	148	173	506	458	133	103045	425	75	21	227	828	58	0.274	0.179	0.001	0.005	10.810	39.429	7.048	8.238	0.209	3.571	3.648	6.333	24.095	2.762	0.008
1 Battle Beaufort 2016	4	Case shot	BFFS79	135	168	381	321	180	102678	627	85	30	26	456	24	0.057	0.296	0.000	0.004	0.867	15.200	4.500	5.600	0.368	2.833	17.538	6.000	12.700	0.800	0.004
1 Battle Beaufort 2016	4	Case shot	BFFS91	342	152	533	437	151	101144	315	65	33	144	333	-11	0.432	1.027	0.000	0.005	4.364	10.091	10.364	4.606	0.456	1.970	2.313	4.576	16.162	-0.333	0.003
1 Battle Beaufort 2016	4	Case shot	BFFS88a	144	139	315	429	123	84265	292	43	36	105	345	3	0.304	0.417	0.000	0.004	2.917	9.583	4.000	3.861	0.403	1.194	3.286	3.417	8.750	0.083	0.004
1 Battle Beaufort 2016	4	Case shot	BFFS80	253	123	348	482	109	74861	214	62	76	71	335	12	0.212	0.755	0.000	0.005	0.934	4.408	3.329	1.618	0.367	0.816	4.718	1.434	4.579	0.158	0.004
2 Battle Beaufort 2017	7		BB MB3	7	105	161	197	209	48983	242	38	12	268	320	24	0.838	0.022	0.000	0.003	22.333	26.667	0.583	8.750	0.328	3.167	1.174	17.417	13.417	2.000	0.007
2 Battle Beaufort 2017	7		BBM82	70	86	153	156	238	44251	227	58	14	16	284	7	0.056	0.246	0.000	0.003	1.143	20.286	5.000	6.143	0.303	4.143	17.500	17.000	10.929	0.500	0.006
2 Battle Beaufort 2017	7		BB023	89	88	257	246	217	47726	142	69	20	811	284	-1	2.856	0.313	0.000	0.005	40.550	14.200	4.450	4.400	0.310	3.450	0.350	10.850	12.850	-0.050	0.006
2 Battle Beaufort 2017	7		BB 176a	51	105	130	114	203	44396	193	51	20	883	251	18	3.518	0.203	0.000	0.003	45.150	12.550	2.550	4.418	2.550	0.284	10.150	6.500	0.900	0.006	0.006
2 Battle Beaufort 2017	7		BB137	30	118	174	208	243	49975	385	46	25	150	300	24	0.500	1.000	0.000	0.003	6.000	12.000	1.200	4.720	0.393	1.840	2.000	9.720	6.960	0.960	0.006
2 Battle Beaufort 2017	7		BB 173	80	113	208	173	251	48158	259	68	26	56	323	43	0.173	0.248	0.001	0.004	2.154	12.423	3.077	4.346	0.350	2.615	5.768	6.654	8.000	1.654	0.007
2 Battle Beaufort 2017	7		BB 124	42	123	226	181	210	47212	190	68	22	1191	735	1	1.620	0.057	0.000	0.005	54.136	33.409	1.909	5.591	0.167	3.091	0.617	9.545	10.273	0.045	0.016
2 Battle Beaufort 2017	7		BB152	127	112	126	178	235	44199	154	65	25	87	341	19	0.255	0.372	0.000	0.003	4.480	13.640	5.080	4.480	0.328	2.600	3.920	9.400	5.040	0.760	0.008
2 Battle Beaufort 2017	7		BB147	83	112	181	115	251	49645	269	38	32	7	465	9	0.015	0.178	0.000	0.004	0.219	14.531	2.594	3.500	0.241	1.188	66.429	7.844	5.656	0.281	0.009
2 Battle Beaufort 2017	7		BB139	77	83	154	185	249	42281	194	31	33	131	284	15	0.461	0.271	0.000	0.004	3.970	8.606	2.333	2.515	0.292	0.939	2.168	7.545	6.667	0.455	0.007
2 Battle Beaufort 2017	7		BB146	101	48	173	156	203	33526	174	62	27	46	364	21	0.126	0.277	0.001	0.005	1.704	13.481	3.741	1.778	0.132	1.704	7.913	7.519	6.400	0.778	0.011
2 Battle Beaufort 2017	7		BB 168	96	126	186	175	179	49857	174	46	25	75	313	15	0.240	0.307	0.000	0.004	3.000	12.520	3.840	5.040	0.403	2.480	4.173	7.160	7.440	0.600	0.006
2 Battle Beaufort 2017	7		BB 171	114	133	169	282	218	48352	193	48	31	13	325	17	0.040	0.351	0.000	0.004	0.419	10.484	3.677	4.290	0.409	1.548	25.000	7.032	5.452	0.548	0.007
2 Battle Beaufort 2017	7		BB309	199	202	399	202	238	49789	252	41	35	1334	281	14	4.996	0.252	0.000	0.004	38.114	7.629	2.000	3.286	0.431	1.171	0.200	6.800	5.686	0.544	0.005
2 Battle Beaufort 2017	7		BB 134	115	94	171	95	251	43176	202	56	38	86	403	11	0.213	0.285	0.000	0.004	2.263	10.605	3.026	2.474	0.233	1.474	4.686	6.505	4.000	0.289	0.009
2 Battle Beaufort 2017	7		BB 176b	58	87	190</																								

3	Brier Creek 95N254 2015	2	British Standard	bc293	337	1386	1974	13007	25	1284276	3941	9307	5289	45	1547	485	0.029	0.218	0.000	0.002	0.009	0.292	0.064	0.262	0.896	1.760	34.378	0.005	0.373	0.092	0.001	
3	Brier Creek 95N254 2015	2	British Standard	bc378	86	1456	2131	6536	110	1196327	4444	7943	4284	34	1631	428	0.021	0.053	0.000	0.002	0.008	0.381	0.020	0.340	0.893	1.854	47.971	0.026	0.497	0.100	0.001	
3	Brier Creek 95N254 2015	2	British Standard	bc299	227	1483	1818	8459	54	1301632	4218	8278	4617	32	1646	330	0.019	0.138	0.000	0.001	0.007	0.357	0.049	0.321	0.901	1.793	51.438	0.012	0.394	0.071	0.001	
3	Brier Creek 95N254 2015	2	British Standard	bc286	1060	1785	2205	5343	27	1120593	5905	8643	4569	1234	2099	375	0.073	0.123	0.000	0.002	0.004	0.472	0.218	0.397	0.874	1.778	47.511	0.008	0.358	0.064	0.001	
3	Brier Creek 95N254 2015	2	Charleville	bc590	200	966	2188	10148	52	1003464	3324	8089	2329	6211	1235	342	5.523	0.162	0.000	0.002	2.929	0.530	0.086	0.415	0.782	3.473	0.181	0.022	0.939	0.147	0.001	
3	Brier Creek 95N254 2015	2	Charleville	bc485	119	808	2054	3617	39	879703	4074	7421	2114	6341	1085	344	3.257	0.110	0.000	0.002	1.618	0.497	0.504	0.370	0.745	3.398	0.307	0.018	0.940	0.158	0.001	
3	Brier Creek 95N254 2015	2	Charleville	bc2	615	1202	1938	2373	1	1142643	6551	7786	2690	-11	1550	368	-0.007	0.397	0.000	0.002	-0.004	0.576	0.229	0.447	0.775	2.894	-140.909	0.000	0.720	0.137	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc42	275	1120	2421	21224	78	1083286	2000	10969	5625	1725	483	8.569	0.159	0.000	0.002	1.799	0.318	0.051	0.206	0.649	2.022	0.177	0.014	0.446	0.089	0.002		
3	Brier Creek 95N254 2015	2	Fusil	bc457	288	1069	2037	6072	-3	1102661	2574	7678	2453	3346	1208	386	2.770	0.238	0.000	0.002	1.364	0.492	0.117	0.436	0.885	3.130	0.361	-0.001	0.830	0.157	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc422	133	675	1795	8736	4	898072	1650	2185	2900	1140	313	2.544	0.117	0.000	0.002	1.327	0.522	0.061	0.309	0.592	3.482	0.393	0.002	0.822	0.143	0.001		
3	Brier Creek 95N254 2015	2	Fusil	bc426	180	1309	2265	5343	-2	1120593	5905	8643	4569	1234	2099	375	0.073	0.123	0.000	0.002	1.393	0.472	0.218	0.397	0.874	1.778	47.511	0.008	0.358	0.064	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc491	142	784	3238	16423	73	926708	986	9412	3293	3782	1256	324	3.011	0.113	0.000	0.003	1.148	0.381	0.043	0.238	0.624	2.858	0.332	0.022	0.983	0.098	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc451	154	1022	2977	7819	45	1107466	2884	8205	4250	4467	1255	397	3.559	0.123	0.000	0.003	1.051	0.295	0.036	0.283	0.958	1.931	0.281	0.011	0.700	0.093	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc474	214	1783	2514	4592	162	1357363	4391	8845	5197	4581	1907	773	2.402	0.112	0.001	0.002	0.881	0.367	0.041	0.343	0.935	1.702	0.416	0.031	0.484	0.149	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc434	278	1543	2260	11389	98	1269077	2925	8725	4788	3772	1580	314	2.387	0.176	0.000	0.002	0.788	0.330	0.058	0.322	0.977	1.822	0.019	0.020	0.472	0.066	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc408	504	942	1609	9511	24	1034196	2883	7543	2658	652	1254	451	0.520	0.402	0.000	0.002	0.245	0.472	0.190	0.354	0.751	2.838	1.923	0.009	0.605	0.170	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc9	640	1322	5162	7281	70	1128157	4841	8385	3881	549	3224	433	1.170	0.199	0.000	0.004	0.141	0.831	0.165	0.341	0.410	2.161	5.872	0.018	1.330	0.112	0.003	
3	Brier Creek 95N254 2015	2	Fusil	bc308	404	664	1555	4022	16	893309	697	11212	4450	350	1556	548	0.237	0.260	0.001	0.002	0.083	0.350	0.091	0.149	0.427	2.500	4.228	0.010	0.349	0.123	0.002	
3	Brier Creek 95N254 2015	2	Fusil	bc7	381	944	1914	3951	49	992427	4713	7412	2300	165	1270	425	0.130	0.300	0.000	0.002	0.072	0.552	0.166	0.410	0.743	3.223	7.697	0.021	0.832	0.185	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc35	896	853	1888	4495	114	1030489	5785	7628	2552	118	1276	430	0.092	0.702	0.000	0.002	0.046	0.500	0.351	0.334	0.668	2.989	10.804	0.045	0.740	0.168	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc23	792	1550	2130	2503	61	1352820	6469	8409	4805	162	1784	395	0.091	0.444	0.000	0.002	0.034	0.371	0.165	0.323	0.869	1.750	11.012	0.013	0.443	0.082	0.001	
3	Brier Creek 95N254 2015	2	Fusil	bc24	1161	1579	1912	1047	197	1310206	7584	8384	4576	88	1535	475	0.057	0.756	0.000	0.001	0.019	0.335	0.254	0.345	1.029	1.832	17.443	0.043	0.418	0.104	0.001	
3	Brier Creek 95N254 2015	2	Rifle	bc43	700	425	1844	2249	122	729372	5005	7010	1979	9192	673	428	13.668	1.040	0.001	0.003	5.475	0.401	0.417	0.253	0.632	4.175	0.073	0.073	0.908	0.255	0.001	
3	Brier Creek 95N254 2015	2	Rifle	bc51	744	631	3479	28825	29	1149429	3909	13521	5194	17788	9546	1074	1.863	0.078	0.001	0.004	3.425	1.838	0.143	0.121	0.066	2.603	0.537	0.006	0.670	0.207	0.012	
3	Brier Creek 95N254 2015	2	Rifle	bc10	632	1170	3804	6242	115	1194942	3909	13521	5194	17788	9546	1074	0.092	0.005	0.000	0.003	2.771	30.169	0.041	0.261	0.009	0.009	3.565	10.886	0.026	0.671	0.110	0.113
3	Brier Creek 95N254 2015	2	Rifle	bc28	1902	320	2465	26728	74	781720	1088	9371	4260	1171	1541	301	0.071	0.110	0.000	0.002	1.399	0.401	0.110	0.239	0.603	22.772	0.004	0.110	0.022	0.684	0.197	0.001
3	Brier Creek 95N254 2015	2	Rifle	bc113	175	909	2555	28028	1	810622	3717	25554	2470	5243	343067	497	0.016	0.001	0.001	0.003	2.314	148.514	0.076	0.394	0.003	1.062	64.173	0.000	1.106	0.215	0.413	0.001
3	Brier Creek 95N254 2015	2	Rifle	bc571	1234	771	2035	6473	27	861169	3515	12779	2109	3659	104498	248	0.035	0.012	0.000	0.002	1.735	49.549	0.585	0.366	0.007	6.059	28.559	0.013	0.965	0.118	0.121	
3	Brier Creek 95N254 2015	2	Rifle	bc631	1451	420	1855	24176	26	627453	1302	13756	3851	3756	21243	413	0.177	0.068	0.001	0.003	0.975	5.516	0.377	0.109	0.020	3.572	6.566	0.007	0.482	0.107	0.034	
3	Brier Creek 95N254 2015	2	Rifle	bc32	571	660	2906	8597	65	757572	2668	18695	1278	2147	221424	555	0.010	0.003	0.001	0.004	0.942	97.201	0.251	0.290	0.003	8.207	103.132	0.029	1.276	0.244	0.292	
3	Brier Creek 95N254 2015	2	Rifle	bc425	823	669	1934	4390	63	817888	4271	7372	2276	1646	10657	593	0.154	0.077	0.001	0.002	0.855	5.533	0.427	0.347	0.063	3.828	6.474	0.033	1.004	0.308	0.013	
3	Brier Creek 95N254 2015	2	Rifle	bc601	593	680	2239	12694	98	895720	2451	11655	3799	3081	19398	422	0.159	0.031	0.001	0.003	1.516	6.266	0.179	0.260	0.196	2.792	6.296	0.026	0.589	0.111	0.022	
3	Brier Creek 95N254 2015	2	Rifle	bc36	519	787	1809	3265	104	1380708	6380	8385	4351	1171	1672	494	0.043	0.036	0.000	0.003	0.736	7.804	0.202	0.306	0.039	1.749	23.315	0.000	0.459	0.084	0.021	
3	Brier Creek 95N254 2015	2	Rifle	bc6	667	2293	2428	2668	194	1586870	7480	10375	6229	4420	17048	348	0.259	0.039	0.000	0.001	0.710	2.737	0.107	0.368	1.356	3.857	0.031	0.377	0.056	0.011		
3	Brier Creek 95N254 2015	2	Rifle	bc633	925	1108	1901	10697	77	1158083	3324	8137	3358	2045	1554	444	1.316	0.595	0.000	0.002	0.609	0.463	0.275	0.330	0.713	2.423	0.760	0.023	0.566	0.132	0.001	
3	Brier Creek 95N254 2015	2	Rifle	bc579	282	593	1703	52635	98	1773224	5078	6822	1854	1003	958	383	1.047	0.294	0.000	0.002	0.541	0.517	0.152	0.320	0.619	3.680	0.955	0.053	0.919	0.207	0.001	
3	Brier Creek 95N254 2015	2	Rifle	bc41	526	421	1655	11870	65	704587	3545	7811	1992	432	2664	448	0.162	0.197	0.001	0.002	0.217	1.337	0.264	0.211	1.588	3.921	6.167	0.033	0.831	0.245	0.004	
3	Brier Creek 95N254 2015	2	Rifle	bc405	834	474	1645	28059	1	733297	695	7564	2172	385	913	649	0.422	0.913	0.001	0.002	0.177	0.420	0.384	0.218	0.519	3.483	2.371	0.000	0.757	0.299	0.001	
3	Brier Creek 95N254 2015	2	Rifle	bc320	290	724	2521	10210	21	923893	2211	9780	3980	311	20090	667	0.015	0.014	0.001	0.003	0.078	5.048	0.073	0.182	0.603	2.457	64.598	0.005	0.633	0.168	0.022	
3	Brier Creek 95N254 2015	2	Rifle	bc79	62	1627	2124	6527	7	1380708	6380	8385	4351	1171	1672	494	0.043	0.036	0.000	0.003	0.074	0.334	0.012	0.306	0.918	2.749	23.315	0.000	0.459	0.084	0.021	
3	Brier Creek																															

6 Okfusnekena 9TP9	2	Lead patch	bv17544	153	564	1560	1668	109	816725	3981	6987	2847	1536	1072	301	1.433	0.143	0.000	0.002	0.540	0.377	0.054	0.198	0.526	2.454	0.698	0.038	0.548	0.106	0.001
7 Camden, SC	8	Charleville	Camden mb 5 charleville Allison	27	67	157	183	92	35867	199	34	23	263	115	8	2.287	0.235	0.000	0.004	11.435	5.000	1.174	2.913	0.473	1.478	0.437	4.000	6.826	0.348	0.003
7 Camden, SC	8	Charleville	Camden mb 5 charleville Allison	63	49	169	148	82	34674	269	42	35	24	103	16	2.233	0.632	0.000	0.005	0.686	2.943	1.800	1.400	0.476	1.200	4.292	2.343	4.829	0.457	0.003
7 Camden, SC	8	Charleville	Camden mb 5 Allison shot 2 Allisc	48	157	142	87	71	4374	269	42	35	24	103	16	0.199	0.324	0.000	0.000	4.000	9.250	3.000	4.878	0.527	2.938	4.238	5.338	6.826	0.348	0.003
7 Camden, SC	8	Charleville	Camden mb 2 Allison	31	76	158	145	87	35427	245	29	32	42	140	53	0.300	0.221	0.001	0.004	1.313	4.375	0.969	1.375	0.543	0.906	3.333	2.719	4.938	1.656	0.004
7 Camden, SC	8	Charleville	Camden mb 4 Allison	47	68	159	135	80	34951	253	34	35	46	146	14	0.315	0.322	0.000	0.005	1.314	4.171	1.343	1.943	0.466	0.971	1.174	2.866	4.543	1.600	0.004
7 Camden, SC	8	Charleville	Camden mb Allison	49	71	121	183	45	34433	169	44	38	330	90	19	3.667	0.544	0.001	0.004	8.684	2.368	1.289	1.868	0.789	1.158	0.273	1.184	3.184	0.500	0.003
7 Camden, SC	9		Camden 79-004 180sec	69	279	593	520	113	541571	3918	5630	144	199	692	100	0.288	1.000	0.000	0.001	1.382	4.806	0.479	1.938	0.403	39.097	3.477	0.785	4.118	0.694	0.001
7 Camden, SC	9		Camden 83-001 180sec	213	275	600	574	67	557330	3981	6294	151	174	626	242	0.282	0.034	0.000	0.001	11.682	41.497	1.411	1.821	0.044	41.682	3.552	4.440	5.770	1.603	0.011
7 Camden, SC	9		Camden Garrison 333 180sec	78	208	816	840	34	528801	3261	5341	139	393	585	169	0.072	0.133	0.000	0.002	2.827	4.209	0.561	1.496	0.356	38.424	1.489	0.245	4.871	1.216	0.001
7 Camden, SC	8	Case shot	Camden 17 9 Allison shot Allison	43	47	151	142	87	41578	269	42	35	24	103	16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 Camden, SC	8	Case shot	Camden 17 020 case shot 2 Allisc	59	62	121	129	54	35979	280	37	31	403	614	21	0.656	0.096	0.001	0.003	13.000	19.806	1.903	2.000	1.01	1.194	1.524	1.742	3.903	0.677	0.017
8 Carrs Fort, 9WS396	2	Fusil	17c558	350	1160	4587	45931	35	344518	2852	69829	2852	2668	1174787	696	0.023	0.000	0.002	0.013	9.357	411.917	1.123	0.407	0.001	24.844	44.021	0.162	1.068	0.244	3.410
8 Carrs Fort, 9WS396	2	Fusil	16c563	97	643	1966	8889	126	836955	3721	8101	3269	1376	18054	408	0.076	0.005	0.000	0.002	0.421	5.523	0.300	0.197	0.036	2.478	13.121	0.039	0.601	0.125	0.022
8 Carrs Fort, 9WS396	2	Fusil	18c309	897	1042	1853	68523	33	924737	1319	8706	4073	245	1369	722	0.179	0.655	0.001	0.002	0.060	0.336	0.220	0.256	0.761	2.137	5.888	0.008	4.655	0.177	0.001
8 Carrs Fort, 9WS396	2	Rifle	2c2726	816	927	13041	9846	252	1031636	2923	15197	3883	9281	130670	614	0.071	0.006	0.001	0.013	2.390	33.652	0.120	0.239	0.007	3.914	14.079	0.065	3.368	0.158	0.127
8 Carrs Fort, 9WS396	2	Rifle	3c5275	684	784	2554	24597	34	993474	5292	12310	3849	6532	87536	583	0.075	0.008	0.001	0.003	1.697	22.743	0.178	0.204	0.009	3.918	13.401	0.009	0.664	0.152	0.088
8 Carrs Fort, 9WS396	2	Rifle	11c5555	576	1195	2030	23301	316	1146761	3957	9902	4906	7831	20115	432	0.309	0.029	0.000	0.002	1.598	4.104	0.118	0.242	0.059	2.000	2.569	0.024	0.410	0.088	0.016
8 Carrs Fort, 9WS396	2	Rifle	9c297	613	1279	2706	70641	59	1139404	1952	9689	5091	5469	15765	778	0.347	0.039	0.001	0.002	1.074	3.097	0.120	0.251	0.081	1.903	2.883	0.012	0.532	0.153	0.014
8 Carrs Fort, 9WS396	2	Rifle	8c299	1011	1439	2151	68625	43	1287911	3105	9227	5027	2430	6121	777	0.397	0.165	0.001	0.002	0.483	1.218	0.201	0.286	0.235	1.835	2.519	0.009	0.428	0.155	0.004
8 Carrs Fort, 9WS396	2	Rifle	7c567	694	626	1608	44683	53	799567	1931	8122	3004	1338	3545	472	0.377	0.196	0.001	0.002	0.445	1.180	0.231	0.208	0.177	2.704	2.649	0.018	0.535	0.157	0.004
8 Carrs Fort, 9WS396	2	Rifle	13c555	937	1349	1934	47112	278	1307134	3104	9024	5262	2018	8578	565	0.235	0.109	0.000	0.001	0.384	1.630	0.178	0.256	0.157	1.728	4.251	0.053	0.368	0.107	0.007
8 Carrs Fort, 9WS396	2	Rifle	15c311	600	157311	2975	26787	71	1250188	9000	14720	4970	1758	105232	384	0.015	0.006	0.001	0.002	0.318	21.173	0.121	0.317	0.015	2.962	66.687	0.014	5.958	0.175	0.084
8 Carrs Fort, 9WS396	2	Rifle	3c546	439	1494	2020	19086	21	1332287	6054	8193	4687	1255	1957	358	0.641	0.224	0.000	0.002	0.258	0.402	0.090	0.307	0.763	1.683	1.559	0.004	0.415	0.073	0.001
8 Carrs Fort, 9WS396	2	Rifle	12c558	195	955	1462	14054	1	1043488	5254	7511	2554	131	1743	466	0.075	0.112	0.000	0.001	0.051	0.682	0.076	0.104	0.060	2.941	13.305	0.000	0.572	0.182	0.002
8 Carrs Fort, 9WS396	2	Rifle	14c551	235	1447	2021	1824	78	1305794	2952	8802	5041	235	1813	111	0.130	0.138	0.000	0.002	0.047	0.360	0.105	0.287	0.788	1.922	3.716	0.398	0.868	0.247	0.001
8 Carrs Fort, 9WS396	2	Rifle	630	895	1552	15343	18	967005	3264	7535	3921	442	1233	402	0.115	0.111	0.000	0.002	0.036	0.314	0.161	0.228	0.726	1.924	1.682	0.883	0.005	0.396	0.103	0.001
8 Carrs Fort, 9WS396	2	Rifle	4c578	340	1830	2128	16108	15	1432192	6631	8628	5295	178	2502	381	0.071	0.136	0.000	0.001	0.034	0.473	0.064	0.346	0.731	1.629	14.056	0.003	0.402	0.072	0.002
8 Carrs Fort, 9WS396	2	Rifle	1c562	666	1087	2365	46042	203	1052079	1984	14772	4793	5905	99718	723	0.059	0.007	0.001	0.002	1.232	20.805	0.139	0.227	0.011	3.082	16.887	0.042	4.993	0.151	0.095
8 Carrs Fort, 9WS396	2	Rifle	6c286	703	676	2433	23631	81	807072	2622	17249	3470	2724	175220	481	0.033	0.004	0.001	0.003	1.527	46.738	0.188	0.180	0.004	4.601	30.611	0.022	6.649	0.128	0.217
8 Carrs Fort, 9WS396	2	Rifle	c724	419	1513	2119	23326	35	1316434	6059	9268	4969	5850	15686	371	0.182	0.027	0.000	0.002	0.575	3.163	0.084	0.305	0.096	1.869	5.504	0.007	0.427	0.075	0.012
9 Charlesfort/Santa Elena 38	6		388U162R Prov 158	44	177	442	327	103	123096	387	1988	39	44	152	113	0.289	1.164	0.001	0.001	1.128	3.897	0.188	1.128	0.289	33.282	4.455	2.641	4.662	2.897	0.001
9 Charlesfort/Santa Elena 38	6		388U162R Prov 52	206	24	182	52	50	105721	1815	1052	1052	1052	1052	1052	0.002	0.019	0.000	0.002	0.000	538.600	16.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9 Charlesfort/Santa Elena 38	6		388U162R Prov 52 sprue	0	0	198	523	33	72366	366	1385	24	27	4342	128	0.006	0.017	0.002	0.003	1.125	180.917	1.042	0.000	0.000	57.708	160.815	1.375	2.500	5.333	0.060
9 Charlesfort/Santa Elena 38	6		388U162D Prov 102	21	80	191	272	35	147893	1113	1269	28	53	118	45	0.449	0.178	0.000	0.001	1.893	4.214	0.750	2.857	0.678	45.321	2.226	1.250	6.821	1.607	0.001
9 Charlesfort/Santa Elena 38	6		388U162N Prov 66	42	25	217	255	56	85287	466	1113	54	127	109	94	1.165	0.385	0.001	0.003	2.352	2.019	0.778	0.463	0.229	20.611	0.858	1.037	4.019	1.741	0.001
9 Charlesfort/Santa Elena 38	6		388U162R Prov 159	89	29	230	465	26	126987	648	1311	28	242	136	97	1.779	0.654	0.001	0.002	8.643	4.857	1.379	1.036	0.213	46.821	0.562	0.929	8.214	3.464	0.001
9 Charlesfort/Santa Elena 38	6		388U162I Prov 130	190	31	172	209	11	85558	567	1150	14	27	78	61	0.346	0.436	0.001	0.002	1.929	5.517	13.771	2.214	0.397	82.143	2.889	0.786	12.286	4.357	0.001
9 Charlesfort/Santa Elena 38	6		388U162D Prov 50	163	37	193	658	26	135813	908	1360	62	81	158	44	0.513	0.032	0.000	0.001	1.306	2.548	1.629	0.597	0.234	21.995	1.951	0.419	5.113	0.710	0.001
9 Charlesfort/Santa Elena 38	6		388U162M Prov 284	810	37	242	155	13	145294	982	1301	504	35	127	94	0.617	0.378	0.001	0.002	1.395	3.242	0.316	0.291	0.386	28.237	3.396	0.848	2.876	0.284	0.001
9 Charlesfort/Santa Elena 38	6		388U162R Prov 61 strip	48	14	170	335	8	76137	417	1103	32	46	103	64	0.447	0.466	0.001	0.002	1.438	3.219	1.500	0.438	1.136	34.969	2.239	0.250	5.313	2.063	0.001
9 Charlesfort/Santa Elena 38	6		388U162R Prov 61 sprue	54	48	193	383	1	140642	727	1329	34	43	149	51	0.289	0.362	0.000	0.001	1.265	4.382	1.588	1.							

15 Fort Frederica 9GNI177	8	FOFR 1118 Seibert	36	58	143	181	67	31551	150	39	21	722	157	17	4.599	0.229	0.001	0.005	34.381	7.476	1.714	2.762	0.369	1.857	0.217	3.190	6.810	0.810	0.005	
15 Fort Frederica 9GNI177	8	FOFR 2094 handle Seibert	61	452	137	109	62	13842	293	32	25	11	88525	21	0.000	0.000	0.001	0.002	0.010	0.440	3541.000	2.440	18.080	0.005	1.280	8047.727	2.480	5.480	0.840	6.395
15 Fort Frederica 9GNI177	8	FOFR 139 Seibert	38	67	121	134	53	34306	251	29	22	20	97	4	0.206	0.392	0.000	0.004	0.909	4.409	1.727	3.045	6.911	1.318	4.850	2.409	5.700	0.182	0.003	
15 Fort Frederica 9GNI177	8	FOFR 25459 Seibert	31	36	174	155	59	25624	103	29	25	50	1735	26	0.029	0.018	0.001	0.007	2.000	69.800	1.240	1.440	0.021	1.160	34.700	2.360	6.960	1.040	0.068	
15 Fort Frederica 9GNI177	8	FOFR 25454 Seibert	46	78	130	160	79	34937	207	36	35	84	190	26	0.442	0.242	0.001	0.004	2.400	5.429	1.314	2.229	0.411	1.029	2.262	2.257	3.714	0.743	0.006	
15 Fort Frederica 9GNI177	8	FOFR 1479 sinker Seibert	39	56	873	189	78	28221	139	33	36	22	163	469	0.135	0.239	0.017	0.031	0.611	4.528	1.083	1.556	0.344	0.917	7.409	2.167	24.250	13.028	0.006	
15 Fort Frederica 9GNI177	8	FOFR 137 Seibert	52	71	174	153	61	33870	213	31	30	154	91	30	1.692	0.571	0.001	0.005	5.133	3.033	1.733	2.367	0.780	1.033	0.591	2.033	5.800	1.000	0.003	
15 Fort Frederica 9GNI177	8	FOFR 2251 sinker Seibert	55	86	130	222	58	31764	192	48	34	236	1074	12	0.220	0.051	0.000	0.004	6.941	31.588	1.618	2.529	0.080	1.412	4.551	1.706	3.824	0.353	0.034	
15 Fort Frederica 9GNI177	8	FOFR 25458 Seibert	36	57	129	172	62	29418	153	24	37	26	290	46	0.090	0.124	0.002	0.004	3.703	7.838	0.973	1.541	0.197	0.649	11.154	1.676	3.486	1.243	0.010	
15 Fort Frederica 9GNI177	8	FOFR 2250 sinker Seibert	56	85	115	270	30	33132	155	30	31	103	105	8	0.981	0.533	0.000	0.003	0.723	3.387	1.806	2.742	0.810	0.968	1.019	0.968	3.710	0.258	0.003	
15 Fort Frederica 9GNI177	8	FOFR 6527 007 Michelle	32	68	164	176	79	25441	233	21	8	1	108	24	0.009	0.206	0.000	0.005	0.125	13.500	4.000	4.500	0.030	3.975	108.000	9.500	26.900	1.000	0.003	
16 Fort King 8MR60	8	FS455.004 Michelle	29	78	147	183	68	35232	262	40	11	34	98	10	0.347	0.296	0.000	0.004	3.091	8.909	1.636	7.091	0.796	3.636	2.882	6.182	13.364	0.909	0.003	
16 Fort King 8MR60	8	FK567.004	43	76	88	110	61	36217	287	20	10	34	204	19	0.167	0.211	0.001	0.002	3.400	20.400	4.300	7.600	0.373	2.000	6.000	6.100	1.900	0.006	0.006	
16 Fort King 8MR60	8	FK488.006	63	62	127	231	105	33024	176	53	20	23	119	24	0.193	0.529	0.001	0.004	1.150	5.950	1.350	3.100	0.521	2.650	5.174	5.250	6.350	1.200	0.004	
16 Fort King 8MR60	8	FK499.007	49	136	227	257	175	58926	338	78	34	-1	244	37	-0.004	0.201	0.001	0.004	-0.029	7.176	1.441	4.000	0.557	2.294	-244.000	5.147	6.676	1.088	0.004	
16 Fort King 8MR60	8	FK284.011	79	169	223	285	138	55466	227	75	29	29	236	17	0.123	0.335	0.000	0.004	1.000	8.138	2.724	5.828	0.716	2.586	8.138	4.759	7.690	0.586	0.004	
16 Fort King 8MR60	8	FK589.007	48	107	140	240	103	46726	187	47	24	17	155	9	0.110	0.310	0.000	0.003	0.708	6.458	1.200	4.458	0.690	1.958	9.118	4.292	5.833	0.375	0.003	
16 Fort King 8MR60	8	FK78.006	65	79	103	213	87	35453	189	36	21	39	169	8	0.231	0.385	0.000	0.003	1.857	8.048	3.095	3.762	0.467	1.714	4.333	4.143	4.905	0.381	0.005	
16 Fort King 8MR60	8	FK308.007	70	114	197	271	111	43331	261	42	27	27	206	35	0.131	0.340	0.001	0.005	1.000	7.630	2.593	4.222	0.553	1.556	7.630	4.111	7.996	1.296	0.005	
16 Fort King 8MR60	8	FO95.006	58	37	97	220	74	20152	106	15	18	25	123	35	0.203	0.472	0.002	0.005	1.389	6.833	3.222	2.056	0.301	0.833	4.920	4.111	5.389	1.944	0.006	
16 Fort King 8MR60	8	TU324 FS562.011 Michelle	28	38	143	179	31	34446	236	39	27	56	124	5	0.452	0.226	0.000	0.004	2.074	4.599	1.037	3.111	0.677	1.444	2.214	3.741	5.295	0.295	0.004	
16 Fort King 8MR60	8	FK313.023	102	119	168	495	84	44442	166	58	23	27	202	21	0.134	0.505	0.000	0.004	1.174	8.783	4.435	5.174	0.589	2.522	7.481	3.652	7.304	0.913	0.005	
16 Fort King 8MR60	8	FK8.028	81	49	125	220	77	26085	62	39	22	188	630	20	0.298	0.129	0.001	0.005	8.545	28.636	3.682	2.227	0.078	1.773	3.351	3.500	5.682	0.909	0.024	
16 Fort King 8MR60	8	FK275.022	53	107	170	347	80	42060	97	35	23	23	210	35	0.110	0.252	0.001	0.004	1.000	9.130	2.304	4.652	0.510	1.522	9.130	3.478	7.911	1.522	0.005	
16 Fort King 8MR60	8	FK197.009	76	175	204	425	88	56694	179	78	26	38	263	8	0.144	0.289	0.000	0.004	1.462	10.115	2.923	6.731	0.665	3.000	6.921	3.385	7.846	0.308	0.005	
16 Fort King 8MR60	8	FK432.016	77	149	223	367	116	52204	186	63	35	75	366	-10	0.205	0.210	0.000	0.004	2.143	10.457	2.200	4.257	0.407	1.800	4.880	3.314	6.710	-0.286	0.007	
16 Fort King 8MR60	8	FK236.007	64	54	172	313	128	34867	93	43	39	38	183	34	0.208	0.350	0.001	0.005	0.974	4.692	1.641	1.385	0.295	1.103	4.816	3.282	4.410	0.872	0.005	
16 Fort King 8MR60	8	FK305.004 Michelle	60	83	117	188	45	37917	243	20	16	124	24	9	0.112	0.293	0.000	0.003	1.271	11.500	4.286	5.710	0.327	1.599	3.330	6.544	1.187	0.347	0.004	
16 Fort King 8MR60	8	FK164.004	69	187	228	520	120	44992	131	58	38	284	31	0.028	0.204	0.001	0.004	2.105	74.316	1.816	4.921	0.066	1.526	35.300	3.158	6.000	0.816	0.051		
16 Fort King 8MR60	8	FK194.007	99	224	216	514	123	59216	180	85	42	22	271	23	0.081	0.365	0.000	0.004	0.524	6.452	2.357	5.333	0.827	2.024	12.318	2.929	5.143	0.548	0.005	
16 Fort King 8MR60	8	FK276.042	86	154	221	617	113	49778	68	52	39	6	261	29	0.023	0.300	0.001	0.004	0.154	6.692	2.205	3.949	0.590	1.333	43.500	2.897	5.667	0.744	0.005	
16 Fort King 8MR60	8	FK777.013	27	163	183	396	101	57213	227	70	37	20	261	14	0.077	0.103	0.000	0.003	0.541	7.054	0.730	4.405	0.625	1.892	13.050	2.730	4.946	0.378	0.005	
16 Fort King 8MR60	8	FK283.009	45	95	216	450	85	49334	140	32	36	21	231	32	0.091	0.195	0.001	0.004	0.583	6.417	1.250	2.639	0.411	0.889	11.000	2.361	6.000	0.889	0.005	
16 Fort King 8MR60	8	FK211.006	57	36	134	123	68	27230	153	51	29	18	124	25	0.145	0.460	0.001	0.005	0.621	4.276	1.966	1.241	0.290	1.759	6.889	2.345	4.621	0.862	0.005	
16 Fort King 8MR60	8	FK228.003	61	120	151	256	99	47691	182	66	46	14	198	13	0.071	0.380	0.000	0.003	0.304	4.304	1.326	2.609	0.606	1.453	14.143	2.152	3.283	0.283	0.004	
16 Fort King 8MR60	8	FK284.010	59	19	70	157	63	14653	60	26	30	59	411	21	0.144	0.144	0.001	0.005	1.967	13.700	1.967	0.633	0.046	0.867	6.966	2.100	2.333	0.700	0.028	
16 Fort King 8MR60	8	FK215.011	60	188	228	323	91	58846	199	106	46	86	282	5	0.305	0.213	0.000	0.004	1.870	6.130	1.304	4.087	0.667	2.304	3.279	1.978	4.597	0.109	0.005	
16 Fort King 8MR60	8	FS297.010 Michelle	25	70	123	311	47	33578	145	41	28	-4	102	-4	-0.039	0.245	0.000	0.004	-0.143	3.643	0.893	2.500	0.686	1.464	-25.000	1.679	4.393	-0.143	0.003	
16 Fort King 8MR60	8	FK57.009	52	152	155	294	61	54452	239	75	45	-4	239	9	0.172	0.218	0.000	0.003	0.913	5.311	1.156	3.378	0.636	1.667	5.829	1.356	4.444	0.200	0.004	
16 Fort King 8MR60	8	FK228.004	120	99	162	218	48	37851	221	70	45	39	190	44	0.205	0.632	0.001	0.004	0.867	4.222	2.667	2.200	0.521	1.556	4.872	1.067	3.600	0.978	0.005	
16 Fort King 8MR60	8	FK573.005 Michelle	38	83	135	198	45	37917	243	20	16	124	24	9	0.112	0.293	0.000	0.003	1.271	11.500	4.286	5.710	0.327	1.599	3.330	6.544	1.187	0.347	0.004	
16 Fort King 8MR60	8	FK573.005	118	72	104	178	32	32482	85	52	52	69	586	11	0.118	0.201	0.000	0.003	1.327	11.269	2.269	1.385	1.123	1.000	8.493	0.615	2.200	0.212	0.018	
17 Fort Moore 38A4	10	GOOD_38A4_53C1-02263-Spec	1202	9017	7129	4623	5060	1343123	16191	3865	3734	1050	35584	397	0.030	0.034	0.000	0.005	0.281	9.530	0.322	2.415	0.253	1.035	33.890	1.355	1.900	0.106	0.026	
17 Fort Moore 38A4	10	GOOD_38A4_53D2-02265-Spec	1805	8440	1283	3415	4961	1327171	16087	3861	3794	72	17008	501	0.004	0.106	0.000	0.001	0.019											

21 Fort Hawkins, 98I28	2	Rifle	fh553	419	976	1906	4381	102	1025585	5535	7020	3443	106	2504	434	0.042	0.167	0.000	0.002	0.031	0.727	0.122	0.283	0.390	2.039	23.623	0.030	0.554	0.126	0.002
21 Fort Hawkins, 98I28	2	Rifle	fh580e	289	747	2072	14663	83	979155	1869	8533	4666	120	3510	1072	0.034	0.082	0.001	0.002	0.026	0.752	0.062	0.160	0.213	1.829	29.250	0.018	0.444	0.230	0.004
21 Fort Hawkins, 98I28	2	Rifle	fh619	86	755	4012	6888	47	973926	4323	7268	2996	21	1301	1426	0.016	0.066	0.001	0.004	0.007	0.434	0.029	0.252	0.580	2.426	61.952	0.016	1.399	0.476	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh614	637	781	3515	395	95239	6924	7953	1030	1576	262	1076	262	0.076	0.104	0.000	0.003	0.052	0.690	0.315	0.390	0.923	3.458	93.265	0.009	0.316	0.085	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh414	509	968	2158	7471	169	982938	3891	8902	2471	566	26845	6192	0.021	0.109	0.006	0.002	0.229	10.864	0.206	0.392	0.036	3.603	47.429	0.068	0.873	2.506	0.027
21 Fort Hawkins, 98I28	2	Springfield	fh580d	253	1006	1758	8827	111	1023900	3687	7479	2611	127	1506	836	0.084	0.168	0.001	0.002	0.049	0.577	0.097	0.385	0.668	2.864	11.858	0.043	0.733	3.320	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh735	792	1730	2371	16378	187	1319135	3697	10207	5444	549	24885	560	0.022	0.032	0.000	0.002	0.101	4.571	0.145	0.318	0.070	1.875	45.328	0.034	0.436	1.013	0.019
21 Fort Hawkins, 98I28	2	Springfield	fh633	520	1724	1943	5553	133	1343487	8627	8677	5621	38	1880	916	0.020	0.277	0.001	0.001	0.007	0.334	0.093	0.307	0.917	1.544	49.474	0.024	0.346	0.163	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh580a	266	1222	2050	11383	95	1096838	2138	8809	4150	259	4902	960	0.053	0.054	0.001	0.002	0.062	1.181	0.064	0.294	0.249	21.23	18.927	0.023	0.494	0.231	0.004
21 Fort Hawkins, 98I28	2	Springfield	fh581	573	791	1913	5142	41	847326	3905	6925	1937	37	1101	519	0.034	0.020	0.001	0.002	0.019	0.568	0.296	0.408	0.718	3.575	29.757	0.021	0.988	0.268	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh315	206	1472	1711	844	95239	6924	7953	1030	1576	262	1076	262	0.076	0.104	0.000	0.003	0.052	0.690	0.315	0.390	0.923	3.458	93.265	0.009	0.316	0.085	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh321	396	1131	1850	15683	67	1124070	2909	8307	4447	68	1473	565	0.046	0.269	0.001	0.002	0.015	0.331	0.089	0.254	0.768	1.868	21.662	0.015	0.416	1.127	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh703a	162	1517	2486	29858	61	1320083	4998	8597	5030	111	1927	596	0.058	0.084	0.000	0.002	0.022	0.383	0.032	0.302	0.787	1.769	17.360	0.012	0.494	1.118	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh580b	279	944	1986	12190	47	1041900	2041	7873	6030	121	1537	1930	0.079	0.182	0.002	0.002	0.024	0.306	0.055	0.188	0.614	1.565	12.702	0.009	0.395	0.384	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh580	588	1599	2041	10263	47	1375432	4694	8847	6015	133	2085	801	0.064	0.282	0.001	0.001	0.022	0.347	0.098	0.266	0.767	1.471	15.677	0.008	0.339	0.133	0.002
21 Fort Hawkins, 98I28	2	Springfield	fh743	246	1402	1812	6346	15	1313644	4226	8616	4667	79	3383	675	0.023	0.073	0.001	0.001	0.017	0.725	0.053	0.300	0.414	1.846	42.823	0.003	0.388	0.145	0.003
21 Fort Hawkins, 98I28	2	Springfield	fh703	158	1085	2366	47761	14	1076446	2367	5053	5498	58	1651	1094	0.035	0.096	0.001	0.002	0.011	0.300	0.029	0.197	0.657	1.647	28.466	0.003	0.430	0.199	0.002
21 Fort Hawkins, 98I28	2	Springfield	fh735	313	1292	2301	20512	126	1197413	4355	8400	4837	125	1756	599	0.078	0.178	0.001	0.002	0.026	0.353	0.065	0.265	0.730	1.737	14.048	0.000	0.476	0.124	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh703c	133	659	1856	9558	116	847371	3021	7945	3297	1702	1239	537	0.174	0.107	0.001	0.002	0.516	0.376	0.040	0.200	0.532	2.410	0.728	0.035	0.563	0.163	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh94	123	1056	1956	3621	68	1065839	6598	7327	2586	30	1324	352	0.023	0.093	0.000	0.002	0.012	0.512	0.048	0.408	0.798	2.833	44.133	0.026	0.756	0.136	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh313a	316	590	1527	2108	1	810870	5761	6728	2015	178	1017	273	0.175	0.311	0.000	0.002	0.088	0.505	0.157	0.293	0.580	3.339	5.713	0.000	0.758	0.135	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh397	523	1555	2036	7126	1	1303009	5455	7881	4646	2	1888	553	0.001	0.277	0.000	0.002	0.000	0.406	0.113	0.335	0.824	1.696	944.000	0.000	0.438	0.119	0.001
21 Fort Hawkins, 98I28	2	Springfield	fh580g	298	276	2261	5838	341	545124	2403	6204	1356	1449	1054	500	0.175	0.283	0.001	0.004	1.069	0.777	0.220	0.204	0.262	4.575	0.727	0.251	1.667	0.369	0.002
21 Fort Hawkins, 98I28	2	Buckshot	fh386b	125	292	1493	1992	25	549308	3563	5940	1384	264	893	276	0.296	0.140	0.001	0.003	0.191	0.645	0.090	0.211	0.327	4.292	3.383	0.028	1.079	0.199	0.002
21 Fort Hawkins, 98I28	2	Buckshot	fh703f	53	242	1722	4523	27	569236	3122	6144	1626	179	943	498	0.190	0.056	0.001	0.003	0.110	0.580	0.033	0.149	0.257	3.739	5.268	0.017	1.059	0.306	0.002
21 Fort Hawkins, 98I28	2	Buckshot	fh580j	138	196	1021	3301	2	571649	3666	6243	1823	178	738	277	0.241	0.169	0.000	0.003	0.098	0.405	0.081	0.157	0.343	0.926	0.144	0.000	0.971	0.140	0.001
21 Fort Hawkins, 98I28	2	Lead patch	fh703d	346	693	1642	9223	63	794886	2180	8043	3054	61	1202	595	0.051	0.288	0.001	0.002	0.020	0.394	0.113	0.227	0.577	2.634	19.705	0.021	0.558	0.195	0.002
22 Galpin 38A7	8		38A7-393b	57	144	181	297	87	52237	236	64	14	115	211	17	0.545	0.270	0.000	0.003	8.214	15.071	4.071	10.286	0.682	4.571	1.835	6.214	1.929	1.214	0.004
22 Galpin 38A7	8		38A7-79x16	53	159	168	202	109	49404	261	61	18	156	651	6	0.240	0.081	0.000	0.003	8.667	36.167	2.944	8.833	0.244	3.389	4.173	6.056	9.333	0.333	0.013
22 Galpin 38A7	8		38A7-388csmall	84	93	168	221	79	42033	212	64	15	91	1104	63	0.082	0.076	0.001	0.004	6.067	73.600	5.600	6.200	0.084	4.267	12.132	5.267	11.200	4.200	0.026
22 Galpin 38A7	8		38A7-388b	61	204	218	427	117	58819	254	73	26	33	282	31	0.117	0.216	0.001	0.004	1.269	10.846	2.366	7.846	0.723	2.808	8.545	5.600	8.385	1.192	0.005
22 Galpin 38A7	8		38A7-381a	119	98	115	195	92	34872	125	52	22	299	1343	52	0.223	0.089	0.002	0.003	13.591	61.045	5.409	4.425	0.267	2.364	4.492	4.122	2.264	0.040	0.029
22 Galpin 38A7	8		38A7-395b	198	196	203	187	69	29563	121	47	177	677	253	39	0.267	0.249	0.000	0.003	0.098	0.412	0.173	0.349	1.270	3.719	6.373	3.018	2.703	0.005	0.024
22 Galpin 38A7	8		38A7-387c	69	191	206	277	109	49416	245	57	35	51	279	21	0.183	0.247	0.000	0.004	1.457	7.971	1.971	5.457	0.685	1.029	5.471	4.114	5.866	6.000	0.005
22 Galpin 38A7	8		38A7-79x11	68	179	216	436	110	56696	227	92	36	224	258	31	0.868	0.264	0.001	0.004	6.222	7.167	1.889	4.972	0.694	2.556	1.152	3.056	6.000	0.861	0.005
22 Galpin 38A7	8		38A7-381c	84	106	150	430	102	48590	180	69	37	200	1741	8	0.115	0.048	0.000	0.003	5.405	47.054	2.270	2.865	0.061	1.865	8.705	2.757	4.054	0.216	0.036
22 Galpin 38A7	8		38A7-395a	35	188	234	495	100	57807	201	89	37	27	291	12	0.093	0.120	0.000	0.004	0.730	7.865	0.946	5.081	0.646	2.405	10.778	2.703	6.324	0.324	0.005
22 Galpin 38A7	8		38A7-388c	47	151	202	322	100	52844	193	95	43	1433	188	29	0.622	0.250	0.001	0.004	33.326	4.372	1.093	3.512	0.803	2.209	0.131	2.326	4.694	0.674	0.004
22 Galpin 38A7	8		38A7-395cshaved	77	118	196	448	88	41858	185	37	41	209	1230	9	0.170	0.063	0.000	0.005	5.098	30.000	1.878	2.878	0.096	0.902	5.885	2.146	4.780	0.220	0.029
22 Galpin 38A7	8		38A7-79x2b	63	139	189	3307	69	29563	121	47	177	677	253	39	0.267	0.249	0.000	0.003	0.098	0.412	0.173	0.349	1.270	3.719	6.373	3.018	2.703	0.005	0.024
22 Galpin 38A7	8		38A7-380b	71	79	162	300	62	44778	187	55	40	54	185	21	0.292	0.384	0.000	0.004	1.350	4.625	1.775	1.975	4.277	3.735	3.426	1.550	4.050	0.525	0.004
22 Galpin 38A7	8		38A7-393bsmall	76	95	96	271	44	34486	134	36	29	227	2287	10	0.099	0.033	0.000	0.003	7.828	78.862	2.621	3.276	0.422	1.241					

24 Hanging Rock, SC	8		Hanging Rock 01-025 Allison	33	47	133	122	84	34263	233	45	36	41	102	1	0.402	0.324	0.000	0.004	1.139	2.833	0.917	1.306	0.461	1.250	2.488	2.333	3.694	0.028	0.003	
24 Hanging Rock, SC	8		Hanging Rock 01-025 Allison	35	79	146	143	69	37128	310	51	33	92	113	27	0.814	0.310	0.001	0.004	2.788	3.424	1.061	2.394	0.699	1.545	1.228	2.091	4.424	0.818	0.003	
24 Hanging Rock, SC	8		Hanging Rock 01-057 Allison	36	65	138	125	71	33167	225	36	40	44	559	10	0.079	0.064	0.000	0.004	1.100	13.975	0.900	1.625	0.116	0.900	12.705	1.775	4.550	0.250	0.017	
25 Kettle Creek, 9WS370	4	British Standard		136	377	868	854	367	44717	367	44	33	202	44905	39	0.084	0.175	0.000	0.004	3.404	13.485	2.366	4.121	0.306	1.121	5.227	4.405	14.241	0.005	0.005	
25 Kettle Creek, 9WS370	4	Charleville		154	152	195	355	591	167	102256	613	98	54	433	4808	38	0.090	0.032	0.000	0.003	8.019	89.037	2.815	3.611	0.041	1.815	11.104	3.093	6.574	0.704	0.047
25 Kettle Creek, 9WS370	4	Fusil		216	119	366	855	157	82444	193	61	25	3146	336	39	9.363	0.643	0.000	0.004	125.840	13.440	8.640	4.760	0.354	2.440	0.107	6.280	14.640	1.560	0.004	
25 Kettle Creek, 9WS370	4	Fusil		309	173	157	364	570	219	92312	450	59	30	1654	2812	72	0.588	0.062	0.001	0.004	55.133	93.733	5.767	5.233	0.056	1.967	1.700	7.300	12.133	2.400	0.030
25 Kettle Creek, 9WS370	4	Fusil		104	269	137	472	954	183	98599	246	59	72	1069	3775	12	0.283	0.071	0.000	0.005	14.847	52.431	3.736	1.903	0.036	0.819	3.531	25.536	0.167	0.038	
25 Kettle Creek, 9WS370	4	Fusil		109	94	52	261	1810	135	69962	306	29	33	294	3029	10	0.097	0.031	0.000	0.004	8.909	91.788	2.848	1.576	0.017	0.879	10.303	4.091	7.909	0.303	0.043
25 Kettle Creek, 9WS370	4	Fusil		250	107	138	330	784	155	89905	497	88	50	217	2094	4	0.104	0.051	0.000	0.004	4.340	41.880	2.140	2.760	0.066	1.760	9.650	3.100	6.600	0.080	0.023
25 Kettle Creek, 9WS370	4	Fusil		148	112	337	868	132	95147	267	44	71	202	44905	39	0.084	0.175	0.000	0.004	3.404	13.485	2.366	4.121	0.306	1.121	5.227	4.405	14.241	0.005	0.005	
25 Kettle Creek, 9WS370	4	Fusil		522	185	156	354	1573	122	87233	183	66	56	50	298	58	0.168	0.021	0.001	0.004	0.893	5.321	3.304	2.786	0.523	1.179	5.960	2.179	6.321	1.036	0.003
25 Kettle Creek, 9WS370	4	Fusil		529	355	145	547	1060	178	91773	262	45	49	23	312	78	0.074	0.138	0.001	0.006	0.469	6.367	7.245	2.959	0.465	0.918	13.565	3.633	11.163	1.592	0.003
25 Kettle Creek, 9WS370	4	Rifle		86	206	107	353	961	158	78870	312	55	24	1869	251	31	7.446	0.821	0.000	0.004	77.875	10.458	8.583	4.458	0.426	2.292	0.134	6.583	11.708	1.292	0.003
25 Kettle Creek, 9WS370	4	Rifle		152	124	204	401	600	177	101591	556	49	34	2265	243	32	9.321	0.510	0.000	0.004	66.618	7.147	3.647	6.000	0.840	1.441	0.107	5.206	11.794	0.941	0.002
25 Kettle Creek, 9WS370	4	Rifle		37	258	170	406	869	155	94851	380	60	50	2146	3233	17	0.664	0.080	0.000	0.004	42.920	64.660	5.160	3.400	0.053	1.200	1.507	3.100	8.120	0.340	0.034
25 Kettle Creek, 9WS370	4	Rifle		44	82	89	208	207	161	76605	615	42	33	1370	208	34	6.587	0.394	0.000	0.003	41.515	6.303	2.485	2.697	0.428	1.273	0.152	4.879	6.303	1.030	0.003
25 Kettle Creek, 9WS370	4	Rifle		40	97	107	216	364	139	84708	558	51	53	1657	198	26	8.369	0.490	0.000	0.003	31.244	3.736	1.830	2.019	0.540	1.151	0.119	2.523	4.075	0.491	0.002
25 Kettle Creek, 9WS370	4	Rifle		510	107	116	364	306	155	88038	588	72	33	879	287	30	3.063	0.373	0.000	0.004	26.636	8.697	3.242	3.515	0.404	2.182	0.327	4.697	11.030	0.909	0.003
25 Kettle Creek, 9WS370	4	Rifle		504	201	171	334	825	150	99855	330	92	56	810	248	22	3.266	0.810	0.000	0.003	14.464	4.429	3.589	3.054	0.690	1.643	0.306	2.679	5.964	0.393	0.002
25 Kettle Creek, 9WS370	4	Rifle		534	123	148	332	694	169	84101	292	63	32	458	1824	77	0.251	0.067	0.001	0.004	14.313	57.000	3.844	4.625	0.081	1.969	3.983	5.281	10.375	2.406	0.022
25 Kettle Creek, 9WS370	4	Rifle		110	119	140	394	579	184	92196	556	59	37	382	241	51	1.585	0.494	0.001	0.004	10.324	6.514	3.216	3.784	0.581	1.595	0.631	4.973	10.649	1.378	0.003
25 Kettle Creek, 9WS370	4	Rifle		532	68	147	304	925	149	85457	212	52	25	248	2027	34	0.122	0.034	0.000	0.004	9.920	81.080	2.720	5.880	0.073	2.080	8.173	5.960	12.160	1.360	0.024
25 Kettle Creek, 9WS370	4	Rifle		38	57	153	307	321	172	85181	479	54	20	177	1814	40	0.098	0.031	0.000	0.004	8.850	90.700	2.850	7.650	0.084	2.700	10.249	8.600	15.350	2.000	0.021
25 Kettle Creek, 9WS370	4	Rifle		259	67	162	312	3088	138	88631	238	40	54	340	854	-5	0.398	0.102	0.000	0.003	6.296	15.815	1.611	3.000	0.190	0.907	2.512	2.556	5.778	-0.093	0.010
25 Kettle Creek, 9WS370	4	Rifle		106	126	108	68	338	1106	376	97033	314	63	37	202	61	0.260	0.049	0.000	0.004	6.211	13.827	3.264	4.121	0.306	1.212	5.093	4.203	11.482	1.909	0.003
25 Kettle Creek, 9WS370	4	Rifle	MD#4	125	105	158	310	1325	149	77539	177	55	32	194	1418	73	0.137	0.088	0.001	0.004	6.063	44.313	3.968	4.938	0.111	1.719	7.309	4.656	9.888	2.281	0.018
25 Kettle Creek, 9WS370	4	Rifle		310	98	133	335	557	197	80755	356	54	54	284	6452	37	0.044	0.015	0.000	0.004	5.259	119.481	1.815	2.463	0.021	1.000	22.718	3.648	6.204	0.685	0.080
25 Kettle Creek, 9WS370	4	Rifle		523	175	205	411	1191	180	94612	275	50	47	232	4746	-10	0.049	0.037	0.000	0.004	4.936	100.979	3.723	4.362	0.043	1.064	20.457	3.830	7.455	-0.213	0.050
25 Kettle Creek, 9WS370	4	Rifle		36	274	155	407	1600	148	91316	180	66	58	283	291	67	0.973	0.942	0.001	0.004	4.879	5.017	4.274	2.672	0.533	1.138	1.028	2.552	7.017	1.155	0.003
25 Kettle Creek, 9WS370	4	Rifle		313	49	199	435	1112	149	107518	441	76	38	180	344	18	0.523	0.142	0.000	0.004	4.737	9.053	1.289	5.237	0.578	2.000	1.911	3.321	11.447	0.474	0.003
25 Kettle Creek, 9WS370	4	Rifle		142	112	180	354	513	197	113327	714	104	50	232	389	-1	0.596	0.288	0.000	0.003	4.640	7.780	2.400	3.600	0.280	1.800	1.677	3.940	7.050	-0.020	0.000
25 Kettle Creek, 9WS370	4	Rifle		530	320	141	320	681	122	99121	259	63	27	202	44905	39	0.271	0.051	0.000	0.003	4.257	27.159	3.827	3.458	0.107	0.818	11.211	4.568	14.821	0.909	0.009
25 Kettle Creek, 9WS370	4	Rifle		502	160	163	335	2640	136	87269	288	33	37	139	1274	56	0.109	0.133	0.001	0.004	3.757	34.432	4.568	4.405	0.128	0.892	9.165	3.676	9.054	1.514	0.015
25 Kettle Creek, 9WS370	4	Rifle		254	94	205	274	715	145	81868	439	43	60	206	3562	14	0.006	0.003	0.000	0.003	3.433	594.367	1.567	3.417	0.006	0.717	173.117	2.417	4.567	0.233	0.436
25 Kettle Creek, 9WS370	4	Rifle		257	117	178	358	360	145	83706	464	53	42	143	15148	76	0.009	0.008	0.001	0.004	3.405	360.667	2.786	4.238	0.012	1.262	105.930	3.452	8.524	1.810	0.181
25 Kettle Creek, 9WS370	4	Rifle		506	245	184	445	945	184	98870	313	94	58	188	295	0	0.637	0.831	0.000	0.005	3.241	5.086	4.224	3.172	0.624	1.621	1.569	3.172	7.672	0.000	0.003
25 Kettle Creek, 9WS370	4	Rifle		247	60	124	398	1857	154	79853	355	58	57	172	337	78	0.510	0.178	0.001	0.005	3.018	5.912	1.053	2.175	0.368	1.018	1.959	2.702	6.982	1.368	0.004
25 Kettle Creek, 9WS370	4	Rifle		255	68	163	395	693	150	102037	539	76	11	30	248	43	0.121	0.274	0.000	0.004	2.727	22.545	6.182	14.818	0.055	6.909	8.267	13.636	35.909	3.909	0.002
25 Kettle Creek, 9WS370	4	Rifle		537	160	169	333	1106	376	97033	314	63	37	202	61	0.260	0.049	0.000	0.003	4.257	13.827	3.264	4.121	0.306	1.212	5.093	4.203	11.482	1.909	0.003	
25 Kettle Creek, 9WS370	4	Rifle		519	172	135	373	903	113	94497	378	45	46	111	247	30	0.045	0.069	0.000	0.004	2.413	53.848	3.739	2.935	0.055	0.798	22.315	2.457	8.109	0.652	0.026
25 Kettle Creek, 9WS370	4	Rifle		248	81	121	276	1349	125	90148	354	67	29	69	292	45	0.236	0.277	0.000	0.003	2.379	10.069	2.793	4.172	0.414	2.310	4.232	4.310	9.517	1.552	0.003
25 Kettle Creek, 9WS370	4	Rifle		509	114	155	381	933	160																						

26 Kings Mountain, SC	2	KIMO 2583	546	606	1091	1026	87	845211	5709	6766	1633	44	801	411	0.055	0.682	0.000	0.001	0.027	0.491	0.334	0.371	0.757	4.143	18.205	0.053	0.668	0.252	0.001
26 Kings Mountain, SC	2	KIMO 2978	309	786	880	8966	93	879920	4191	6759	1746	51	948	241	0.054	0.326	0.000	0.001	0.029	0.543	0.177	0.450	0.829	3.871	17.588	0.053	0.504	0.138	0.001
26 Kings Mountain, SC	2	KIMO 2684	229	663	841	999	88	876908	7027	6430	1741	76	751	353	0.101	0.305	0.000	0.001	0.044	0.439	0.134	0.387	0.883	3.758	9.882	0.051	0.492	0.206	0.001
26 Kings Mountain, SC	2	KIMO 3003	256	498	876	2015	81	775961	5595	6155	1575	32	848	387	0.038	0.302	0.000	0.001	0.020	0.538	0.163	0.316	0.587	3.908	26.500	0.051	0.596	0.246	0.001
26 Kings Mountain, SC	2	KIMO 3171	410	329	972	3870	61	573247	3207	7099	1239	737	24523	288	0.030	0.107	0.001	0.002	0.600	19.954	0.334	0.268	0.013	5.776	33.274	0.050	0.791	0.234	0.043
26 Kings Mountain, SC	2	KIMO 2707	387	766	969	1383	94	974064	7088	6688	1921	134	1181	414	0.113	0.328	0.000	0.001	0.070	0.615	0.201	0.399	0.649	3.482	8.813	0.049	0.504	0.216	0.001
26 Kings Mountain, SC	2	KIMO 3130	861	586	1507	1458	69	758315	5762	7715	1474	983	37845	190	0.026	0.023	0.000	0.002	0.667	25.675	0.584	0.398	0.015	5.234	38.499	0.047	1.022	0.129	0.050
26 Kings Mountain, SC	2	KIMO 2956	215	910	923	2870	95	1054116	7172	7193	2048	183	945	695	0.194	0.228	0.000	0.001	0.089	0.461	0.105	0.444	0.963	3.512	5.164	0.046	0.451	0.339	0.001
26 Kings Mountain, SC	2	KIMO 2804	111	741	838	1388	87	993974	7215	6844	1890	93	1029	332	0.090	0.108	0.000	0.001	0.049	0.544	0.059	0.392	0.720	3.621	11.065	0.046	0.443	0.176	0.001
26 Kings Mountain, SC	2	KIMO 3047	291	877	947	1718	91	998913	7004	7609	1988	299	8703	663	0.034	0.033	0.001	0.001	0.150	4.378	0.146	0.441	0.101	3.827	29.107	0.046	0.476	0.334	0.009
26 Kings Mountain, SC	2	KIMO 2864	403	311	937	2215	53	591714	3919	5902	1278	652	4628	319	0.141	0.087	0.001	0.002	0.510	3.621	0.315	0.243	0.067	4.618	7.098	0.041	0.733	0.250	0.008
26 Kings Mountain, SC	2	KIMO 3057	193	583	821	1370	80	869596	6414	6790	1985	34	811	366	0.042	0.238	0.000	0.001	0.017	0.409	0.097	0.294	0.719	3.421	23.853	0.040	0.414	0.184	0.001
26 Kings Mountain, SC	2	KIMO 3055	175	837	1099	3919	83	982341	5316	7492	2146	1390	2724	310	0.010	0.064	0.000	0.001	0.648	1.269	0.092	0.390	0.307	3.491	1.960	0.039	0.512	0.144	0.003
26 Kings Mountain, SC	2	KIMO 2775	204	750	1045	2111	72	916646	6716	6946	1865	3807	1034	486	0.354	0.196	0.001	0.001	2.041	0.559	0.109	0.402	0.720	3.724	0.274	0.039	0.560	0.261	0.001
26 Kings Mountain, SC	2	KIMO 2869	209	317	1001	1226	44	628845	4656	5671	1521	1302	436	589	2.986	0.479	0.001	0.002	1.041	0.349	0.167	0.253	0.727	4.533	0.335	0.035	0.800	0.471	0.001
26 Kings Mountain, SC	2	KIMO 2685	787	672	3704	10389	64	882722	3026	7708	1953	630	2002	401	0.315	0.393	0.000	0.004	0.323	1.025	0.403	0.344	0.336	3.947	3.178	0.033	1.897	0.205	0.002
26 Kings Mountain, SC	2	KIMO 2747	175	756	1106	1513	60	958802	7522	6696	1981	549	1011	253	0.543	0.173	0.000	0.001	0.277	0.510	0.088	0.382	0.748	3.380	1.842	0.030	0.558	0.128	0.001
26 Kings Mountain, SC	2	KIMO 3147	577	651	1099	5108	57	931072	6137	7637	1886	464	7388	112	0.625	0.078	0.001	0.001	2.446	3.917	0.306	0.345	0.088	4.049	1.601	0.030	0.583	0.383	0.008
26 Kings Mountain, SC	2	KIMO 2962	686	1047	935	3413	56	1048380	6807	7734	2161	3625	1225	199	2.959	0.560	0.000	0.001	1.677	0.567	0.317	0.484	0.855	3.579	0.338	0.026	0.433	0.092	0.001
26 Kings Mountain, SC	2	KIMO 2871	437	644	905	1610	44	923454	6613	7603	1802	2759	15391	439	0.179	0.028	0.000	0.001	1.531	8.541	0.243	0.357	0.042	4.219	5.578	0.024	5.024	0.244	0.017
26 Kings Mountain, SC	2	KIMO 3015	668	647	837	3367	40	901353	6134	6915	1813	1353	976	291	1.386	0.684	0.000	0.001	0.749	0.538	0.368	0.357	0.663	3.814	0.721	0.022	0.462	0.161	0.001
26 Kings Mountain, SC	2	KIMO 2966	734	898	1495	1519	45	1047900	7436	8885	2059	1719	27320	301	0.016	0.027	0.000	0.001	0.839	13.327	0.358	0.438	0.033	4.334	15.893	0.022	0.729	0.148	0.026
26 Kings Mountain, SC	2	KIMO 2963	280	520	2384	3097	31	869095	2128	2346	1024	198	386	208	0.218	0.051	0.000	0.001	0.244	0.483	0.156	0.289	0.685	4.577	0.287	0.001	0.483	0.267	0.001
26 Kings Mountain, SC	2	KIMO 3043	490	419	809	1130	32	795065	6290	6054	1706	81	1306	328	0.062	0.375	0.000	0.001	0.047	0.766	0.287	0.246	0.321	3.549	16.123	0.019	0.474	0.192	0.002
26 Kings Mountain, SC	2	KIMO 2673	442	707	835	6951	30	850381	4044	6945	1767	122	1139	251	0.107	0.388	0.000	0.001	0.069	0.647	0.251	0.401	0.621	3.944	9.336	0.017	0.474	0.143	0.001
26 Kings Mountain, SC	2	KIMO 2999	239	931	941	1136	24	1024924	7453	7325	1967	868	3330	370	0.261	0.072	0.000	0.001	0.441	1.693	0.122	0.473	0.280	3.724	3.836	0.012	0.478	0.188	0.003
26 Kings Mountain, SC	2	KIMO 3000	428	675	752	2911	13	819324	5101	6062	1585	82	817	264	0.100	0.524	0.000	0.001	0.052	0.515	0.270	0.426	0.826	4.102	0.963	0.008	0.474	0.167	0.001
26 Kings Mountain, SC	2	KIMO 2806	313	829	796	773	11	941362	7138	6905	2012	60	947	248	0.063	0.331	0.000	0.001	0.030	0.471	0.156	0.412	0.875	3.432	15.783	0.005	0.396	0.123	0.001
26 Kings Mountain, SC	2	KIMO 3048	202	538	1003	1375	7	775593	5408	7679	1679	189	21389	425	0.009	0.009	0.001	0.001	0.113	12.739	0.120	0.320	0.025	4.412	113.169	0.004	0.597	0.253	0.028
26 Kings Mountain, SC	2	KIMO 3170	293	622	713	1337	2	867583	7013	6459	1810	55	833	366	0.066	0.352	0.000	0.001	0.030	0.460	0.162	0.344	0.747	3.569	15.145	0.001	0.394	0.202	0.001
26 Kings Mountain, SC	2	KIMO 2963	218	575	644	945661	1	945661	6456	6456	1152	3938	290	0.000	0.000	0.000	0.000	0.000	1.207	0.096	0.122	0.327	0.026	4.575	0.000	0.000	0.000	0.000	0.000
26 Kings Mountain, SC	2	KIMO 2796	251	616	911	588	1	853424	7114	6501	1818	135	1076	596	0.125	0.233	0.001	0.001	0.074	0.592	0.138	0.339	0.572	3.576	7.970	0.001	0.501	0.328	0.001
26 Kings Mountain, SC	2	KIMO 2769	666	632	1156	2195	1	938854	6951	8347	1914	11151	16509	177	0.684	0.041	0.000	0.001	5.826	8.521	0.348	0.330	0.039	4.361	1.463	0.001	0.604	0.092	0.017
26 Kings Mountain, SC	2	KIMO 2646	1209	799	1514	12685	0	946539	3475	8075	1966	8654	1446	391	5.985	0.836	0.000	0.002	4.402	0.736	0.615	0.406	0.553	4.107	0.167	0.000	0.700	0.199	0.002
27 Madison Square, 9CH1221	2	m956	401	996	1919	3363	192	1123709	6378	10562	3640	1371	56015	231	0.024	0.007	0.000	0.002	0.377	15.389	0.110	0.274	0.018	2.902	40.857	0.053	0.527	0.063	0.050
27 Madison Square, 9CH1221	2	m71	329	806	1932	5920	83	921313	4020	5646	2161	3264	55374	450	0.059	0.006	0.000	0.002	1.510	25.624	0.152	0.373	0.015	4.611	16.965	0.038	0.894	0.208	0.060
27 Madison Square, 9CH1221	2	m79	336	1779	2131	5963	179	1389568	6370	8103	4855	52	1729	584	0.030	0.194	0.000	0.002	0.011	0.356	0.069	0.366	1.029	1.669	33.250	0.037	0.439	0.120	0.001
27 Madison Square, 9CH1221	2	m74	454	1407	2051	3497	106	845009	7165	7165	1152	3938	290	0.000	0.000	0.000	0.000	0.000	1.207	0.096	0.122	0.327	0.026	4.575	0.000	0.000	0.000	0.000	0.000
27 Madison Square, 9CH1221	2	m75	274	1150	1689	3907	89	1081995	5757	7246	2546	25	1395	329	0.018	0.196	0.000	0.002	0.010	0.548	0.108	0.452	0.824	2.846	55.800	0.035	0.663	0.129	0.001
27 Madison Square, 9CH1221	2	m122	326	717	1768	4276	107	872219	3712	10743	3364	621	23899	521	0.026	0.014	0.001	0.002	0.185	7.104	0.097	0.213	0.303	1.394	38.485	0.032	0.526	0.155	0.027
27 Madison Square, 9CH1221	2	m030	158	1452	1719	1556	100	1220919	6856	7419	3220	117	1600	387	0.073	0.099	0.000	0.001	0.036	0.497	0.049	0.451	0.908	2.304	13.675	0.031	0.534	0.120	0.001
27 Madison Square, 9CH1221	2	m28	123	2034	2106	1507	150	1450313	8031	8572	5066	2066	1978	609	1.044	0.062	0.000	0.001	0.408	0.390	0.204	0.402	1.028	1.692	0.957	0.030	0.416	0.120	0.001
27 Madison Square, 9CH1221	2	m89	234	1629	2031	2636	94	1312183	5578	8941	4278	7065	1612	413	4.383	1.145	0.000	0.002	1.651	0.377	0.025	0.381	1.011	2.090	0.228</				

29	Moores Creek, NC	2		MOCR 1258	1392	34	1146	2131	23	377792	1878	3786	860	313	289	242	1.083	4.817	0.001	0.003	0.364	0.336	1.619	0.040	0.118	4.402	0.923	0.027	1.333	0.281	0.001		
29	Moores Creek, NC	2		MOCR 1010	508	618	2809	5752	50	921464	4044	7010	1913	74	990	295	0.075	0.513	0.000	0.003	0.039	0.518	0.266	0.323	6.364	13.378	0.026	1.568	0.154	0.001			
29	Moores Creek, NC	2		MOCR 1390	768	170	651	2096	26	492933	3101	4805	1173	99	366	198	0.270	2.098	0.000	0.001	0.085	0.313	0.266	0.145	0.464	3.163	3.697	0.022	0.566	0.169	0.001		
29	Moores Creek, NC	2		MOCR 1250	221	2367	1516	314	38	791202	3740	7654	1750	225	309	617	7.146	4.073	0.000	0.003	0.043	1.732	0.126	0.292	0.869	1.732	0.292	0.132	0.292	0.132	0.001		
29	Moores Creek, NC	2		MOCR 1244	784	683	1514	1898	30	875333	4842	6829	1726	896	4168	339	0.215	1.888	0.000	0.002	0.519	2.415	0.454	0.396	1.654	3.957	4.652	0.017	0.877	0.196	0.005		
29	Moores Creek, NC	2		MOCR 1233	218	415	772	1430	23	637075	5041	5734	1336	3458	483	218	7.159	4.551	0.000	0.001	2.588	0.362	0.163	0.311	0.859	4.292	0.140	0.017	0.578	0.163	0.001		
29	Moores Creek, NC	2		MOCR 1028	491	501	1555	3222	20	838819	4570	6576	1685	4053	2312	440	1.753	2.122	0.001	0.002	2.405	1.372	0.291	0.297	0.217	3.903	0.570	0.012	0.923	0.261	0.003		
29	Moores Creek, NC	2		MOCR 1389	115	121	614	2043	10	413854	2340	3755	907	109	250	205	0.436	0.460	0.000	0.001	0.120	0.276	0.127	0.133	0.484	4.140	2.294	0.011	0.627	0.226	0.001		
29	Moores Creek, NC	2		MOCR 1388	577	672	1785	2545	18	921507	4820	6984	1858	1059	998	157	1.061	0.578	0.000	0.002	0.570	0.537	0.311	0.362	0.673	3.759	0.942	0.010	0.964	0.084	0.001		
29	Moores Creek, NC	2		MOCR 1238	445	707	1146	981	17	959280	6622	8208	1866	22106	2350	189	9.407	0.189	0.000	0.001	11.847	1.259	0.238	0.379	0.301	4.399	0.106	0.009	0.614	0.101	0.002		
29	Moores Creek, NC	2		MOCR 1376	288	573	1887	3314	38	791202	3740	7654	1750	225	309	617	7.146	4.073	0.000	0.003	0.043	1.732	0.126	0.292	0.869	1.732	0.292	0.132	0.292	0.132	0.001		
29	Moores Creek, NC	2		MOCR 1230	301	871	1487	2453	1	1019971	6540	6941	1961	1622	4692	312	0.346	0.064	0.000	0.001	0.827	2.393	0.153	0.444	0.186	3.540	2.893	0.001	0.758	0.210	0.005		
30	Mount Pleasant 9EF169 20	2	British Standard	mp75-5	121	891	1654	1281	1	901825	6543	7252	2027	6274	3658	306	1.715	0.033	0.000	0.002	3.095	1.805	0.060	0.440	0.244	3.578	0.583	0.000	0.816	0.151	0.004		
30	Mount Pleasant 9EF169 20	2	British Standard	mp70-8	655	1046	2710	10880	257	1144491	2446	8928	3520	113	1609	966	0.070	0.407	0.001	0.002	0.032	0.457	0.186	0.297	0.650	2.536	14.239	0.073	0.760	0.274	0.001		
30	Mount Pleasant 9EF169 20	2	Fusil	mp58-19	365	782	1935	4593	18	884024	4114	8156	2002	8292	1246	394	6.655	2.293	0.000	0.002	4.142	0.622	0.182	0.391	0.628	4.074	0.150	0.009	0.967	0.197	0.001		
30	Mount Pleasant 9EF169 20	2	Fusil	mp78-12	612	748	1630	1850	88	913532	5302	11335	2061	6912	79178	260	0.807	0.008	0.000	0.002	3.354	38.417	0.297	0.363	0.009	5.500	11.455	0.043	0.791	0.126	0.087		
30	Mount Pleasant 9EF169 20	2	Fusil	mp62-1	323	777	1710	1462	49	896513	5438	7274	1810	4372	7176	183	0.069	0.045	0.000	0.002	2.415	3.965	0.178	0.429	0.108	4.019	0.145	0.041	0.945	0.101	0.008		
30	Mount Pleasant 9EF169 20	2	Fusil	mp92-50	297	425	2694	3571	99	945534	3105	8056	2699	4957	1808	395	2.742	0.154	0.000	0.003	1.837	0.670	0.110	0.232	0.346	2.985	0.365	0.037	0.998	0.143	0.002		
30	Mount Pleasant 9EF169 20	2	Fusil	mp91-22	758	699	2109	10614	101	863267	1761	9517	2932	4425	17828	399	0.248	0.043	0.000	0.002	1.509	6.080	0.259	0.238	0.039	3.246	4.029	0.034	0.719	0.136	0.021		
30	Mount Pleasant 9EF169 20	2	Fusil	mp93-41	873	627	2193	5855	21	780253	2574	8659	2324	3132	1160	528	2.700	0.753	0.001	0.003	1.348	0.499	0.376	0.270	0.541	3.726	0.370	0.009	0.944	0.227	0.001		
30	Mount Pleasant 9EF169 20	2	Fusil	mp92-4	100	926	1778	949	116	1003214	6112	7172	2284	2709	1552	431	1.745	0.064	0.000	0.002	1.186	0.680	0.044	0.405	0.597	3.140	0.573	0.051	0.778	0.189	0.002		
30	Mount Pleasant 9EF169 20	2	Fusil	mp91-14	497	1075	2405	7189	10	1044598	2685	9203	3338	3715	2831	361	1.312	1.176	0.000	0.002	1.113	0.848	0.149	0.322	0.380	2.757	0.762	0.003	0.720	0.108	0.003		
30	Mount Pleasant 9EF169 20	2	Fusil	mp73-1	628	1030	2144	5116	125	1086136	4653	9863	2941	3049	34976	423	0.087	0.018	0.000	0.002	1.037	11.893	0.214	0.350	0.029	3.354	11.471	0.043	0.729	0.144	0.032		
30	Mount Pleasant 9EF169 20	2	Fusil	mp92-3	314	643	1808	1591	1	830468	5138	7311	1623	1056	24952	341	0.060	0.013	0.000	0.002	0.928	15.374	0.193	0.396	0.026	4.763	16.568	0.001	1.114	0.210	0.030		
30	Mount Pleasant 9EF169 20	2	Fusil	mp64-17	283	988	1877	2641	129	1079627	5191	9012	2920	2495	28264	302	0.088	0.010	0.000	0.002	0.854	9.679	0.097	0.048	0.106	3.086	11.328	0.046	0.643	0.103	0.026		
30	Mount Pleasant 9EF169 20	2	Fusil	mp95-20	342	589	1889	3314	44	1007280	2786	9110	2900	2138	14285	314	0.116	0.110	0.000	0.002	0.869	6.910	0.118	0.345	0.049	3.163	8.128	0.015	0.630	0.144	0.023		
30	Mount Pleasant 9EF169 20	2	Fusil	mp62-14	348	497	1711	6643	38	793476	2085	10694	2717	1999	18467	390	0.108	0.019	0.000	0.002	0.736	6.797	0.128	0.183	0.027	3.996	9.238	0.014	0.630	0.144	0.023		
30	Mount Pleasant 9EF169 20	2	Fusil	mp93-26	366	1072	2527	5217	163	1147148	2951	8777	3265	2231	13163	499	0.169	0.028	0.000	0.002	0.683	4.032	0.112	0.328	0.081	2.688	5.900	0.050	0.774	0.153	0.011		
30	Mount Pleasant 9EF169 20	2	Fusil	mp93-29	852	613	2165	5242	186	858788	2952	7716	2296	797	1163	246	0.685	0.733	0.000	0.004	0.347	5.007	0.371	0.267	0.527	3.361	1.459	0.081	1.378	0.107	0.001		
30	Mount Pleasant 9EF169 20	2	Fusil	mp90-1	268	603	1549	6821	1	800529	2400	7188	1755	327	4498	456	0.073	0.060	0.000	0.002	1.186	2.563	0.153	0.344	0.134	4.096	13.755	0.001	0.883	0.260	0.006		
30	Mount Pleasant 9EF169 20	2	Fusil	mp64-4	108	973	1740	1744	137	1016230	6164	7452	2070	314	7672	371	0.041	0.014	0.000	0.002	0.152	3.706	0.052	0.470	0.127	3.600	24.433	0.066	0.841	0.179	0.008		
30	Mount Pleasant 9EF169 20	2	Fusil	mp91-10	1218	457	1620	7557	84	947220	1042	10976	2002	278	1421	589	0.096	0.057	0.001	0.003	0.139	0.710	0.608	0.228	0.322	4.848	5.112	0.042	0.809	0.044	0.004		
30	Mount Pleasant 9EF169 20	2	Fusil	mp91-10	725	745	1202	3214	37	861904	2536	3507	1880	238	1480	318	0.140	0.015	0.000	0.002	0.099	0.519	0.302	0.009	0.519	0.302	0.009	0.519	0.302	0.009	0.519	0.302	0.009
30	Mount Pleasant 9EF169 20	2	Fusil	mp91-5	42	891	1702	1443	3	994611	6278	7069	2031	72	1271	511	0.057	0.083	0.001	0.002	0.035	0.626	0.021	0.439	0.701	3.481	17.653	0.001	0.838	0.252	0.001		
30	Mount Pleasant 9EF169 20	2	Rifle	mp74-10	197	873	2016	4787	45	905832	3415	7503	1968	7324	1205	356	6.078	0.163	0.000	0.002	3.722	0.612	0.100	0.444	0.724	3.813	0.165	0.023	1.024	0.181	0.001		
30	Mount Pleasant 9EF169 20	2	Rifle	mp72-17	336	1048	1813	1752	166	1053324	7420	6006	2270	4549	1243	360	3.660	0.270	0.000	0.002	2.004	0.548	0.148	0.462	0.843	3.042	0.273	0.073	0.799	0.159	0.001		
30	Mount Pleasant 9EF169 20	2	Rifle	mp72-4	122	966	1933	1147	45	1032716	8102	6733	1986	120	1080	431	0.111	0.113	0.000	0.002	0.060	0.544	0.061	0.486	0.894	3.390	9.000	0.023	0.973	0.217	0.001		
30	Mount Pleasant 9EF169 20	2	Sprue, gang mold	mp60-15	421	851	2293	3462	1	888758	2419	7688	2788	6580	2260	462	2.912	0.186	0.001	0.003	2.360	0.811	0.151	0.305	0.377	2.758	0.343	0.000	0.822	0.166	0.003		
30	Mount Pleasant 9EF169 20	2	Wall gun	mp93-1	983	557	1861	8487	103	798604	2020	11122	3235	180	2775	376	0.065	0.057	0.000	0.002	0.056	0.858	0.044	0.172	0.201	3.438	15.417	0.032	0.575	0.116	0.003		
31	Mount Pleasant 9EF169 Blz	3	Charleville	MP44-51.5	216	582	921	538	242	381046	2136	3140	1140	219	14285	314	0.140	0.015	0.000	0.002	0.869	3.845	0.118	0.345	0.049	3.163	8.128	0.015	0.630	0.144	0.023		
31	Mount Pleasant 9EF169 Blz	3	Fusil	MP48-15	144	525	728	353	246	175296	1032	227	62	4544	614	30	7.401																

33 Puryburg 38A158	2	Fusil	pb430	395	1314	2218	861	61	1201653	8047	8396	2430	13543	1741	386	7.779	0.227	0.000	0.002	5.573	0.716	0.163	0.541	0.755	3.455	0.129	0.025	0.913	0.159	0.001	
33 Puryburg 38A158	2	Fusil	pb398	274	953	1853	1354	68	983485	7398	8416	1934	10344	17609	382	5.877	0.016	0.000	0.002	5.349	0.915	0.142	0.493	0.554	3.352	1.702	0.035	0.958	0.198	0.018	
33 Puryburg 38A158	2	Fusil	pb420	445	930	1746	964	67	987416	7198	7753	2043	10841	1359	291	7.937	0.033	0.000	0.002	5.306	0.665	0.022	0.455	0.684	3.795	0.125	0.033	0.955	0.142	0.001	
33 Puryburg 38A158	2	Fusil	pb206	592	1206	2209	3547	77	121222	6150	8266	2207	10841	1359	291	3.279	0.049	0.000	0.002	4.209	1.230	0.183	0.374	0.401	2.359	0.147	0.035	0.958	0.142	0.003	
33 Puryburg 38A158	2	Fusil	pb440	326	873	1657	1079	73	1008024	7095	7357	1938	1112	4667	211	1.310	0.070	0.000	0.002	3.154	2.408	0.168	0.450	0.187	3.796	0.754	0.038	0.855	0.109	0.005	
33 Puryburg 38A158	2	Fusil	pb179	1115	1226	2389	2775	122	1174089	6918	15083	3730	11194	125647	446	0.089	0.009	0.000	0.002	3.017	33.867	0.301	0.330	0.010	4.065	11.224	0.033	0.644	0.120	0.107	
33 Puryburg 38A158	2	Fusil	pb136	830	1381	2059	2667	59	1247886	7697	8549	3494	9722	1615	259	6.020	0.514	0.000	0.002	2.782	0.462	0.238	0.395	0.855	2.447	0.166	0.017	0.589	0.074	0.001	
33 Puryburg 38A158	2	Fusil	pb194	1238	1453	2726	2678	2	1278861	7064	10375	4987	13861	23255	268	0.596	0.053	0.000	0.002	2.779	4.663	0.248	0.291	0.062	2.080	1.678	0.000	0.547	0.054	0.018	
33 Puryburg 38A158	2	Fusil	pb347	349	1620	2180	1249	57	1406020	8884	9412	5436	13751	1790	234	7.682	0.195	0.000	0.002	2.530	0.329	0.064	0.298	0.905	1.731	0.130	0.010	0.401	0.043	0.001	
33 Puryburg 38A158	2	Fusil	pb379	740	1303	2137	9628	37	1087795	5419	12402	5216	7551	78763	388	0.096	0.009	0.000	0.002	2.348	24.491	0.230	0.405	0.017	3.856	10.431	0.000	0.664	0.121	0.072	
33 Puryburg 38A158	2	Fusil	pb311	264	1263	2209	3547	77	121222	6150	8266	2207	10841	1359	291	3.279	0.049	0.000	0.002	4.209	1.230	0.183	0.374	0.401	2.359	0.147	0.035	0.958	0.142	0.003	
33 Puryburg 38A158	2	Fusil	pb108	506	851	6765	1326	18	939090	6716	7057	2187	4175	3136	356	1.331	0.161	0.000	0.007	1.909	1.434	0.231	0.389	0.271	3.227	0.751	0.008	0.393	0.163	0.003	
33 Puryburg 38A158	2	Fusil	pb308	410	2064	2038	1174	186	1486498	9139	9042	5379	8206	1948	402	4.213	0.210	0.000	0.001	1.526	0.362	0.076	0.384	1.060	1.681	0.227	0.035	0.375	0.075	0.001	
33 Puryburg 38A158	2	Fusil	pb443	212	921	1736	879	74	1045253	7486	7085	1897	2627	1360	334	2.932	0.156	0.000	0.002	1.385	0.717	0.112	0.486	0.677	3.735	0.518	0.039	0.915	0.176	0.001	
33 Puryburg 38A158	2	Fusil	pb134	1333	1116	1982	2092	47	1121183	6760	7726	3131	3546	1371	205	1.586	0.972	0.000	0.002	1.133	0.438	0.426	0.356	0.814	2.468	0.387	0.015	0.633	0.065	0.001	
33 Puryburg 38A158	2	Fusil	pb370	649	1023	1975	608	40	1067044	7099	7530	2834	2550	1365	425	1.868	0.475	0.000	0.002	0.900	0.482	0.229	0.361	0.749	2.657	0.535	0.014	0.697	0.150	0.001	
33 Puryburg 38A158	2	Fusil	pb404	342	1172	1833	983	32	1117699	8131	7808	2424	1824	1440	211	1.267	0.238	0.000	0.002	0.813	0.642	0.152	0.522	0.814	3.480	0.789	0.014	0.817	0.094	0.001	
33 Puryburg 38A158	2	Fusil	pb357	264	1510	2105	1128	375	1242228	7778	8158	3296	1870	6303	458	0.297	0.042	0.000	0.002	0.567	1.912	0.080	0.458	0.240	2.487	3.371	0.053	0.659	0.142	0.005	
33 Puryburg 38A158	2	Fusil	pb367	337	1151	1705	2001	73	1114543	6736	7679	2952	1522	1487	457	1.030	0.227	0.000	0.002	0.519	0.504	0.114	0.390	0.774	2.601	0.971	0.025	0.578	0.155	0.001	
33 Puryburg 38A158	2	Fusil	pb343	243	804	1886	841	165	951854	7454	7075	1973	801	954	435	0.840	0.255	0.000	0.002	0.406	0.484	0.123	0.405	0.839	3.586	1.191	0.084	0.956	0.220	0.001	
33 Puryburg 38A158	2	Fusil	pb298	173	1101	1865	957	123	1148370	7331	7782	3129	1092	3482	482	0.314	0.050	0.000	0.002	0.349	1.113	0.055	0.352	0.316	2.487	3.189	0.039	0.596	0.154	0.003	
33 Puryburg 38A158	2	Fusil	pb132	338	908	1803	980	39	996063	7434	6843	2051	671	1137	349	0.590	0.297	0.000	0.002	0.327	0.554	0.165	0.443	0.799	3.336	1.694	0.019	0.879	0.170	0.001	
33 Puryburg 38A158	2	Fusil	pb146	1018	949	1827	1135	61	1095028	6475	7994	3190	923	13368	397	0.069	0.076	0.000	0.002	0.289	4.191	0.319	0.297	0.071	2.506	14.483	0.019	0.573	0.124	0.012	
33 Puryburg 38A158	2	Fusil	pb221	405	744	1554	819	128	992119	7677	6658	2222	438	1031	303	0.425	0.393	0.000	0.002	0.197	0.464	0.182	0.335	0.722	2.996	2.354	0.058	0.699	0.136	0.001	
33 Puryburg 38A158	2	Fusil	pb406	151	1110	1858	671	91	1099529	6869	7732	3085	507	1350	513	0.376	0.112	0.000	0.002	0.164	0.438	0.049	0.327	0.815	2.566	2.663	0.029	0.662	0.165	0.001	
33 Puryburg 38A158	2	Fusil	pb216	1062	814	1602	883	75	1235245	7851	7856	3238	261	1560	339	0.248	0.845	0.000	0.001	0.141	0.562	0.423	0.304	0.285	2.432	0.039	0.626	0.109	0.012	0.001	
33 Puryburg 38A158	2	Fusil	pb401	202	1321	2077	1014	166	1189410	8566	7536	2338	261	1560	339	0.167	0.129	0.000	0.002	0.117	0.697	0.090	0.590	0.847	3.567	5.977	0.074	0.928	0.151	0.001	
33 Puryburg 38A158	2	Fusil	pb88	796	1000	1775	1448	23	1062325	8023	6830	2277	257	1301	296	0.198	0.612	0.000	0.002	0.113	0.571	0.350	0.439	0.769	3.000	5.062	0.010	0.780	0.130	0.001	
33 Puryburg 38A158	2	Fusil	pb303	1431	1698	1961	2055	59	1398437	8251	8322	5148	547	1786	337	0.306	0.801	0.000	0.001	0.106	0.347	0.278	0.330	0.951	1.617	3.265	0.011	0.381	0.065	0.001	
33 Puryburg 38A158	2	Fusil	pb331	450	1058	1965	810	243	1038933	7622	7190	2444	171	1339	324	0.128	0.336	0.000	0.002	0.070	0.548	0.184	0.433	0.790	2.942	7.830	0.099	0.804	0.133	0.001	
33 Puryburg 38A158	2	Fusil	pb18	222	1022	1637	869	192	1074636	7963	7220	2120	128	1294	213	0.099	0.172	0.000	0.002	0.060	0.610	0.105	0.482	0.790	3.406	10.109	0.091	0.772	0.100	0.001	
33 Black Swamp, SC	2	Fusil	pb207	161	1239	2303	898	115	1184922	8088	8705	2438	136	1271	195	0.007	0.608	0.000	0.001	0.045	8.171	0.066	0.508	0.662	3.571	146.478	0.047	0.945	0.080	0.001	
33 Puryburg 38A158	2	Fusil	pb268	340	1402	1808	883	46	1235245	7851	7856	3238	261	1560	339	0.062	0.208	0.000	0.001	0.056	0.611	0.114	0.433	0.184	2.923	15.347	0.056	1.462	0.196	0.001	
33 Puryburg 38A158	2	Fusil	pb89	1058	1263	1907	705	50	1121883	8017	7231	2717	1116	1629	350	0.071	0.409	0.000	0.002	0.043	0.600	0.389	0.465	0.775	2.611	14.043	0.018	0.661	0.129	0.001	
33 Puryburg 38A158	2	Fusil	pb102	944	1144	1964	1895	88	1115448	8092	7083	2565	105	1284	290	0.082	0.735	0.000	0.002	0.041	0.501	0.368	0.446	0.891	2.761	12.229	0.034	0.766	0.113	0.001	
33 Puryburg 38A158	2	Fusil	pb419	1130	946	1819	671	141	1022381	7332	6778	2050	81	1318	225	0.061	0.857	0.000	0.002	0.040	0.643	0.551	0.461	0.718	3.306	16.272	0.069	0.887	0.110	0.001	
33 Puryburg 38A158	2	Fusil	pb209	59	1182	1775	740	97	1138762	7994	7330	2881	88	1663	246	0.053	0.335	0.000	0.002	0.032	0.598	0.021	0.425	0.711	2.636	18.898	0.035	0.638	0.088	0.001	
33 Puryburg 38A158	2	Fusil	pb104	426	1360	1722	1014	5	1213718	7855	7788	3487	91	1685	327	0.054	0.253	0.000	0.001	0.026	0.483	0.122	0.390	0.807	2.233	18.516	0.001	0.494	0.094	0.001	
33 Puryburg 38A158	2	Fusil	pb152	496	800	1581	2021	45	965555	4757	5711	3085	80	1155	389	0.069	0.429	0.000	0.002	0.026	0.374	0.161	0.259	0.693	2.438	14.438	0.015	0.512	0.126	0.001	
33 Puryburg 38A158	2	Rifle	pb325	853	262	2090	1541	75	126344	7511	11149	3338	663	103099	295	0.062	0.208	0.000	0.001	0.047	4.773	0.063	0.236	0.603	3.233	15.347	0.056	1.462	0.196	0.001	
33 Puryburg 38A158	2	Rifle	pb300	468	536	2130	2592	1	111315	5666	9617	1615	6603	63846	254	0.103	0.007	0.000	0.003	0.408	0.989	39.533	0.290	0.332	0.008	5.988	9.669	0.001	1.319	0.157	0.086
33 Puryburg 38A158																															

33	Purysburg 38A158	2	Melted lead	pb167	416	1720	3120	1467	145	1400313	8328	10240	5478	1094	33554	324	0.033	0.012	0.000	0.002	2.104	6.125	0.076	0.314	0.051	1.869	30.671	0.026	0.570	0.059	0.024	
33	Purysburg 38A158	2	Melted lead	pb431	207	713	1753	2933	1	876885	4846	6748	1885	40	1022	272	0.039	0.203	0.000	0.002	2.104	5.442	0.110	0.378	0.698	3.580	25.550	0.001	0.930	0.144	0.021	
33	Purysburg 38A158	2	Melted lead	pb033	437	131	1349	30359	1	201604	225	10633	2190	424	4555	671	0.093	0.095	0.003	0.007	2.104	2.080	0.198	0.060	0.029	4.855	10.743	0.000	0.616	0.297	0.023	
33	Purysburg 38A158	2	Rifle or Fusil	pb05	532	1083	1602	964	374	1153458	7389	7742	3043	639	1274	227	4.359	0.418	0.000	0.001	2.104	0.419	0.175	0.356	0.850	2.544	0.206	0.575	0.075	0.001		
33	Purysburg 38A158	2	Rifle or Fusil	pb162	516	796	1740	716	100	916921	7138	7419	2124	2961	4540	203	0.652	0.114	0.000	0.002	2.104	2.138	0.243	0.375	0.175	3.493	1.534	0.047	0.819	0.190	0.005	
33	Purysburg 38A158	2	Rifle or Fusil	pb27	376	1492	2031	1576	135	1285481	8104	8393	3365	4883	2450	264	1.993	0.153	0.000	0.002	2.104	0.728	0.112	0.443	0.609	2.494	0.502	0.040	0.604	0.078	0.002	
33	Purysburg 38A158	2	Rifle or Fusil	pb143	622	671	1865	1174	67	940824	7155	7828	2004	4208	17308	239	0.243	0.036	0.000	0.002	2.104	8.637	0.310	0.335	0.039	3.906	4.113	0.033	0.931	0.119	0.018	
33	Purysburg 38A158	2	Rifle or Fusil	pb101	580	1227	1701	671	75	1092520	7159	7354	3026	1495	1174	234	1.273	0.494	0.000	0.002	2.104	0.388	0.192	0.405	1.045	2.430	0.785	0.025	0.662	0.077	0.001	
33	Purysburg 38A158	2	Rifle or Fusil	pb160	331	797	1768	944	35	915825	7493	6951	1885	115	1187	437	0.097	0.279	0.000	0.002	2.104	0.630	0.176	0.423	0.671	3.688	10.322	0.019	0.938	0.232	0.001	
33	Purysburg 38A158	2	Rifle or Fusil	pb304	965	1118	3026	1282	51	1094846	7077	10875	3460	5945	62672	511	0.095	0.015	0.000	0.003	2.104	18.113	0.279	0.323	0.018	3.143	10.542	0.015	0.875	0.148	0.057	
33	Purysburg 38A158	2	Rifle or Fusil	pb16	901	1366	2012	964	34	1153458	7389	7742	3043	639	1274	227	4.359	0.418	0.000	0.001	2.104	0.419	0.175	0.356	0.850	2.544	0.206	0.575	0.075	0.001		
33	Purysburg 38A158	2	Rifle or Fusil	pb84	561	1084	1472	1417	33	1121918	6677	7244	2811	81	1385	244	0.058	0.405	0.000	0.001	2.104	0.493	0.200	0.386	0.783	2.577	17.099	0.012	0.524	0.087	0.001	
33	Purysburg 38A158	2	Rifle or Fusil	pb248	241	1176	1896	2364	6	1090394	7519	7580	2663	4378	2430	401	1.802	0.099	0.000	0.002	2.104	0.913	0.090	0.442	0.484	2.846	0.555	0.002	0.712	0.154	0.002	
33	Purysburg 38A158	2	Rifle or Fusil	pb171	1436	1798	2407	867	1	1460621	8971	8761	5820	2934	1825	501	1.608	0.787	0.000	0.002	2.104	0.314	0.247	0.309	0.985	1.505	0.622	0.000	0.414	0.086	0.001	
33	Purysburg 38A158	2	Roundball-pb373	pb373	252	982	1620	793	28	1019911	7254	7434	2317	2913	1271	355	2.292	0.198	0.000	0.002	2.104	0.549	0.109	0.424	0.773	3.208	0.436	0.012	0.699	0.153	0.001	
34	Savannah River misc.	6	SR-Carved Ball		53	55	379	766	34	128355	463	1451	40	1653	535	159	3.090	0.099	0.001	0.003	41.325	13.375	1.325	1.375	0.103	36.275	0.324	0.850	9.475	3.975	0.004	
35	Shubrick plantation	9	John Allison Shubrick 1 180sec		453	223	2266	3126	98	519792	1892	5635	119	117	1051	313	0.111	0.431	0.001	0.004	0.983	8.832	3.807	1.874	0.212	47.353	8.983	0.824	19.042	2.630	0.022	
35	Shubrick plantation	9	John Allison Shubrick 2 180sec		123	274	540	1972	70	542462	2785	5679	148	46	928	158	0.050	0.135	0.000	0.001	0.313	6.270	0.831	1.251	0.295	38.372	20.174	0.541	4.324	1.968	0.002	
35	Shubrick plantation	9	John Allison Shubrick 4 180sec		165	216	1741	5642	64	479523	1316	6537	134	87	997	314	0.087	0.165	0.001	0.004	0.649	7.440	1.231	1.612	0.217	48.784	11.460	0.478	12.993	2.343	0.002	
35	Shubrick plantation	9	John Allison Shubrick 3 180sec		250	178	2038	2950	23	496233	1874	5815	101	123	1317	236	0.093	0.190	0.000	0.004	1.218	13.040	2.475	1.762	0.135	57.574	10.707	0.228	20.178	2.337	0.003	
36	Belle Terre Farm, NJ	8	British Standard	22705-11 Dan 5	56	49	151	254	68	33889	180	41	30	479	89	24	5.382	0.629	0.001	0.004	15.967	2.967	1.867	1.633	0.551	1.367	0.186	2.267	5.033	0.800	0.003	
36	Belle Terre Farm, NJ	8	British Standard	22705-4 Dan 5	58	86	135	296	66	33155	206	32	17	68	639	16	0.106	0.091	0.000	0.004	4.000	37.588	3.412	0.509	0.135	1.882	0.937	3.882	7.941	0.941	0.019	
36	Petticoat Bridge, NJ	8	British Standard	P98925-1 Dan 5	55	83	166	331	84	37728	241	50	38	35	156	13	0.224	0.353	0.000	0.004	0.921	4.105	1.447	2.184	0.532	1.316	4.457	2.211	1.368	0.342	0.004	
36	Belle Terre Farm, NJ	8	British Standard	22705-12 impact Dan 5	44	43	138	484	52	29409	103	36	44	23	86	15	0.267	0.512	0.001	0.005	0.523	1.955	1.000	0.977	0.500	0.818	3.739	1.182	3.336	0.341	0.003	
36	Belle Terre Farm, NJ	8	Charleville	9027-1 Dan 5	132	69	129	416	54	32524	162	32	17	399	1245	20	0.320	0.208	0.000	0.001	23.471	73.235	7.765	4.059	0.055	1.882	3.120	3.176	7.588	1.176	0.038	
36	Belle Terre Farm, NJ	8	Charleville	9126-1 Dan 5	62	293	162	455	98	96710	486	6717	306	45	967	76031	19	0.007	0.001	0.000	0.010	12.326	1652.848	1.348	6.370	0.084	6.370	0.084	134.093	0.512	4.150	0.001
36	Belle Terre Farm, NJ	8	Charleville	22705-12 Dan 5	68	55	137	600	44	42736	162	35	32	17	96	10	0.177	0.708	0.000	0.004	0.531	3.000	1.225	1.719	0.573	1.004	5.647	1.375	4.281	0.313	0.003	
37	Spring Hill Redoubt, 9C70	2	British Standard	sh30a	265	857	1957	2065	104	969626	6036	7258	2139	5852	1080	352	5.419	0.245	0.000	0.002	2.736	0.505	0.124	0.401	0.794	3.393	0.185	0.049	0.915	0.165	0.001	
37	Spring Hill Redoubt, 9C70	2	British Standard	sh30	632	1395	1926	1818	1	1338018	7720	8130	4759	2351	1984	783	1.185	0.319	0.001	0.001	0.494	0.417	0.133	0.293	0.703	1.708	0.844	0.000	0.405	0.165	0.001	
37	Spring Hill Redoubt, 9C70	2	British Standard	sh19	1018	1612	2153	3612	71	1310397	6417	8085	4993	435	1613	1075	0.270	0.613	0.001	0.002	0.087	0.323	0.204	0.323	0.999	1.619	3.708	0.014	0.431	0.215	0.001	
37	Spring Hill Redoubt, 9C70	2	British Standard	sh126a	161	1414	2008	1164	1	1201311	6654	8055	3671	161	1467	1380	0.110	0.110	0.001	0.002	0.044	0.400	0.044	0.385	0.964	2.194	9.112	0.000	0.547	0.376	0.001	
37	Spring Hill Redoubt, 9C70	2	British Standard	sh73	343	827	2649	1079	35	890889	5866	6227	1885	53	1120	440	0.047	0.306	0.000	0.003	0.028	0.594	0.182	0.209	0.738	3.675	21.132	0.019	1.405	0.233	0.001	
37	Spring Hill Redoubt, 9C70	2	Charleville	sh126b	481	1770	2164	3598	14	1327245	7163	8449	4546	689	3573	489	0.324	0.286	0.000	0.003	0.226	0.305	0.093	0.344	1.125	0.840	0.310	0.009	0.417	0.145	0.001	
37	Spring Hill Redoubt, 9C70	2	Charleville	sh126	603	1157	1759	4194	93	1127569	6536	7846	3274	1215	1408	1795	0.863	0.428	0.002	0.002	0.371	0.430	0.184	0.353	0.822	2.369	1.159	0.028	0.537	0.548	0.001	
37	Spring Hill Redoubt, 9C70	2	Charleville	sh19b	812	1472	2692	2374	203	1309966	5502	8413	5029	896	4591	1086	0.195	0.177	0.001	0.002	0.178	0.913	0.161	0.293	0.321	1.673	5.124	0.040	0.535	0.216	0.004	
37	Spring Hill Redoubt, 9C70	2	Charleville	sh97	171	687	7266	3636	102	788466	3316	8687	3075	138	13655	351	0.010	0.013	0.000	0.009	0.045	4.441	0.056	0.223	0.505	1.825	98.949	0.033	2.363	0.114	0.017	
37	Spring Hill Redoubt, 9C70	2	Charleville	sh19a	136	1793	1939	1139	65	1406668	8059	8355	4916	271	4833	535	0.056	0.028	0.000	0.001	0.055	0.983	0.028	0.365	0.371	1.700	17.834	0.010	0.394	0.109	0.003	
38	Stark Farm 220K778	6	220K778 MD 011 180sec		164	441	1123	1792	114	303752	2344	22873	190	3751	300564	223	0.125	0.001	0.001	0.004	197.584	1581.916	0.863	2.321	0.001	120.384	8.006	0.600	5.911	1.174	0.990	
38	Stark Farm 220K778	6	220K778 MD 011		37	65	145	626	27	101158	750	7660	82	1432	9389	73	0.124	0.000	0.001	0.004	151.610	1218.159	0.451	0.793	0.001	93.415	8.035	0.329	5.061	0.890	0.987	
39	Tar Bluff, SC	8	British Standard	Tar Bluff bb 2 Allison	89	59	151	320	60	34236	88	33	16	412	262	26	1.573	0.340	0.001	0.004	25.750	16.375	5.563	3.688	0.225	2.063	0.636	3.750	9.438	1.625	0.008	
39	Tar Bluff, SC	8	British Standard	Tar Bluff bb 3 Allison	30	72	130	178	74	36711	235	23	11	88	127	25	0.693	0.236	0.001	0.004	8.000	11.545	2.7									

# Federal ' i | Report

(Follow form Instructions)

OMB Number: 4040-0014  
Expiration Date: 01/31/2019

<b>1. Federal Agency and Organizational Element to Which Report is Submitted</b> United States Department of Interior, National Park Service		<b>2. Federal Grant or Other Identifying Number Assigned by Federal Agency (To report multiple grants, use FFR Attachment)</b> 16AP00371	
<b>3. Recipient Organization (Name and complete address including Zip code)</b> Recipient Organization Name: The LAMAR Institute, Inc.			
Street1: P.O. Box 2992		Street2:	
City: Savannah		County: Chatham	
State: A: Georgia		Province:	
Country: SA: UNITED STATES		ZIP / Postal Code: 31402-2292	
<b>4a. DUNS Number</b> 0549086400000	<b>4b. EIN</b> 8-1537572	<b>5. Recipient Account Number or Identifying Number (To report multiple grants, use FFR Attachment)</b> 124	
<b>6. Report Type</b> <input type="checkbox"/> Quarterly <input type="checkbox"/> Semi-Annual <input type="checkbox"/> Annual <input checked="" type="checkbox"/> Final	<b>7. Basis of Accounting</b> <input checked="" type="checkbox"/> Cash <input type="checkbox"/> Accrual	<b>8. Project/Grant Period</b> From: 09/15/2016 To: 09/15/2017	<b>9. Reporting Period End Date</b> 09/15/2017
<b>10. Transactions</b>			Cumulative
<i>(Use lines a-c for single or multiple grant reporting)</i>			
<b>Federal Cash (To report multiple grants, also use FFR attachment):</b>			
a. Cash Receipts			0.00
b. Cash Disbursements			0.00
c. Cash on Hand (line a minus b)			0.00
<i>(Use lines d-o for single grant reporting)</i>			
<b>Federal Expenditures and Unobligated Balance:</b>			
d. Total Federal funds authorized			32,000.00
e. Federal share of expenditures			32,000.00
f. Federal share of unliquidated obligations			0.00
g. Total Federal share (sum of lines e and f)			32,000.00
h. Unobligated balance of Federal Funds (line d minus g)			0.00
<b>Recipient Share:</b>			
i. Total recipient share required			0.00
j. Recipient share of expenditures			0.00
k. Remaining recipient share to be provided (line i minus j)			0.00
<b>Program Income:</b>			
l. Total Federal program income earned			0.00
m. Program Income expended in accordance with the deduction alternative			0.00
n. Program Income expended in accordance with the addition alternative			0.00
o. Unexpended program income (line l minus line m or line n)			0.00


12. R k : A h y x y q by F y w h v :

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13. f y f y j v v . . . w 18 w 1001 y f

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## Federal Financial Report Instructions

### Report Submissions

- 1) Recipients will be instructed by Federal agencies to submit the *Federal Financial Report (FFR)* to a single location, except when an automated payment management reporting system is utilized. In this case, a second submission location may be required by the agency.
- 2) If recipients need more space to support their *FFRs*, or *FFR Attachments*, they should provide supplemental pages. These additional pages must indicate the following information at the top of each page: Federal grant or other identifying number (if reporting on a single award), recipient organization, Data Universal Numbering System (DUNS) number, Employer Identification Number (EIN), and period covered by the report.

### Reporting Requirements

- 1) The submission of interim *FFRs* will be on a quarterly, semi-annual, or annual basis, as directed by the Federal agency. A final *FFR* shall be submitted at the completion of the award agreement. The following reporting period end dates shall be used for interim reports: 3/31, 6/30, 9/30, or 12/31. For final *FFRs*, the reporting period end date shall be the end date of the project or grant period.
- 2) Quarterly and semi-annual interim reports shall be submitted no later than 30 days after the end of each reporting period. Annual reports shall be submitted no later than 90 days after the end of each reporting period. Final reports shall be submitted no later than 90 days after the project or grant period end date.

Note: For single award reporting:

- 1) Federal agencies may require both cash management information on lines 10(a) through 10(c) and financial status information lines 10(d) through 10(o).
- 2) 10(b) and 10(e) may not be the same until the final report.

### Line Item Instructions for the Federal Financial Report

FFR Number	Reporting Item	Instructions
<b>Cover Information</b>		
1	Federal Agency and Organizational Element to Which Report is Submitted	Enter the name of the Federal agency and organizational element identified in the award document or as instructed by the agency.
2	Federal Grant or Other Identifying Number Assigned by Federal Agency	For a single award, enter the grant number assigned to the award by the Federal agency. For multiple awards, report this information on the <i>FFR Attachment</i> . <i>Do not complete this box if reporting on multiple awards.</i>
3	Recipient Organization	Enter the name and complete address of the recipient organization including zip code.
4a	DUNS Number	Enter the recipient organization's Data Universal Numbering System (DUNS) number or Central Contract Registry extended DUNS number.
4b	EIN	Enter the recipient organization's Employer Identification Number (EIN).
5	Recipient Account Number or Identifying Number	Enter the account number or any other identifying number assigned by the recipient to the award. This number is for the recipient's use only and is not required by the Federal agency. For multiple awards, report this

FFR Number	Reporting Item	Instructions
		M k
7	B	
8	P P : M Y	
	P P : M Y	"P P : M Y "
	P : M Y	
	<b>Transactions</b>  L L L L k	
<b>Federal Cash (To report multiple grants, also use FFR Attachment)</b>		
		k   L
	M L H L	L L

FFR Number	Reporting Item	Instructions
<b>Federal Expenditures and Unobligated Balance:</b>		
		; ; ; ; ; ;
		<i>y L 10 L 10</i> <i>y L 10 L 10</i> ( - )
<b>Recipient Share:</b>		

FFR Number	Reporting Item	Instructions
<b>Program Income:</b>		
<b>Indirect Expense:</b>		
<b>Remarks, Certification, and Agency Use Only</b>		

<b>FFR Number</b>	<b>Reporting Item</b>	<b>Instructions</b>