Journal of the American Musical Instrument Society

VOLUME XXXVII • 2011

The Jamestown Mouthpiece: A Historical, Technical, and Comparative Study*

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A lip-reed instrument's mouthpiece is crucial to its tonal properties. Far fewer early mouthpieces survive than instruments, however—an unfortunate circumstance that is the result of the object's small size and the fact that it was customarily detachable from the instrument itself. The unearthing of such an object more than four hundred years old is thus a matter of considerable importance to historians of brass instruments.

In October 1994 Preservation Virginia archaeologists uncovered a trash pit of circa 1610 associated with James Fort, England's first successful transatlantic colony in what is now the United States. Recognizing that one of the artifacts from the pit might be a mouthpiece for a brass instrument, curator Beverly A. Straube contacted one of the authors, Stewart Carter, in 2006 and invited him to inspect the object.[1] In October 2007 both authors looked at the fragment together, taking detailed photographs and measurements. In February 2008, upon our request, the object's metal content was analyzed by Emily Williams, John Watson, and Olga Trofimova, a team of conservators and metallurgists at the Colonial Williamsburg Foundation. This was done in the hope that metal analysis would shed light on the age, provenance, and original design of the mouthpiece.

A Brief History of James Fort and Its Excavation

In December 1606 more than one hundred men and boys left Blackwall, near London, in three small ships—the *Discovery*, the *Susan Constant*, and the *Godspeed*—under the sponsorship of the Virginia Company, a joint-stock corporation chartered by King James I. Their principal objective was to settle the area of North America that later became

*For their assistance in our research, the authors would like to thank Louise Bacon, Beatrix Darmstädter, Martin Kirnbauer, Graham Nicholson, Myra Stansbury, Beverly Straube, Olga Trofimova, Hannes Vereecke, John Watson, and Emily Williams.

1. Object number 171-JR, recovered from layer 2G of Pit 1.

the Virginia Colony, named for the Company. After passing through Chesapeake Bay and following the James River (fig. 1), they landed on what is today known as Jamestown Island in May 1607. The Virginia Company had close ties with the Society of Mines Royal and the Company of Mineral and Battery Works, both established by Queen Elizabeth I to foster the mining of metals, which were desired by the crown for the development of wealth and military power. The explorers hoped that in America they would discover deposits of gold and other metallic ores, such as calamine (the ore containing zinc, a metal needed to produce brass), which were in short supply in England.

Prior to 1994 the original site of James Fort was thought to have been washed away by erosion of the James River shoreline and lost forever.[2] But an extensive archaeological search around the brick church tower, the only seventeenth-century remnant of the Jamestown settlement above ground, unearthed evidence of the fort, as well as numerous objects that document daily life in early seventeenth-century America. A trash pit excavated in 1994 yielded, among many other objects, the mouthpiece that is the subject of this discussion.

The Arrival of the Mouthpiece in America

Following the initial landing in 1607, several other ships arrived over the next three years, any of which might have carried this mouthpiece to the Jamestown colony. The context of the excavation offers two possible explanations for the presence of the mouthpiece: it may have belonged to a brass instrument that was used on one of the ships and in the newly established fort; or it may have left England in its present incomplete state, together with other old metal fragments. The explorers are known to have brought scrap metal with them in the hope of finding other metals with which the scrap could be smelted.[3] The exploration of these two possibilities is important for the interpretation of the mouthpiece. If it was used on one of the ships and/or in the fort, it most likely belonged

2. William M. Kelso, with Beverly A. Straube, *Jamestown Rediscovery, 1994–2004* (Richmond, VA: The Association for the Preservation of Virginia Antiquities, 2004), 33.

3. Carter C. Hudgins, "Old World Industries and New World Hope: The Industrial Role of Scrap Copper at Jamestown," *Journal of the Jamestown Rediscovery Center* 2 (January 2004), http://apva.org/rediscovery/pdf/hudgins_low.pdf (accessed April 15, 2009).

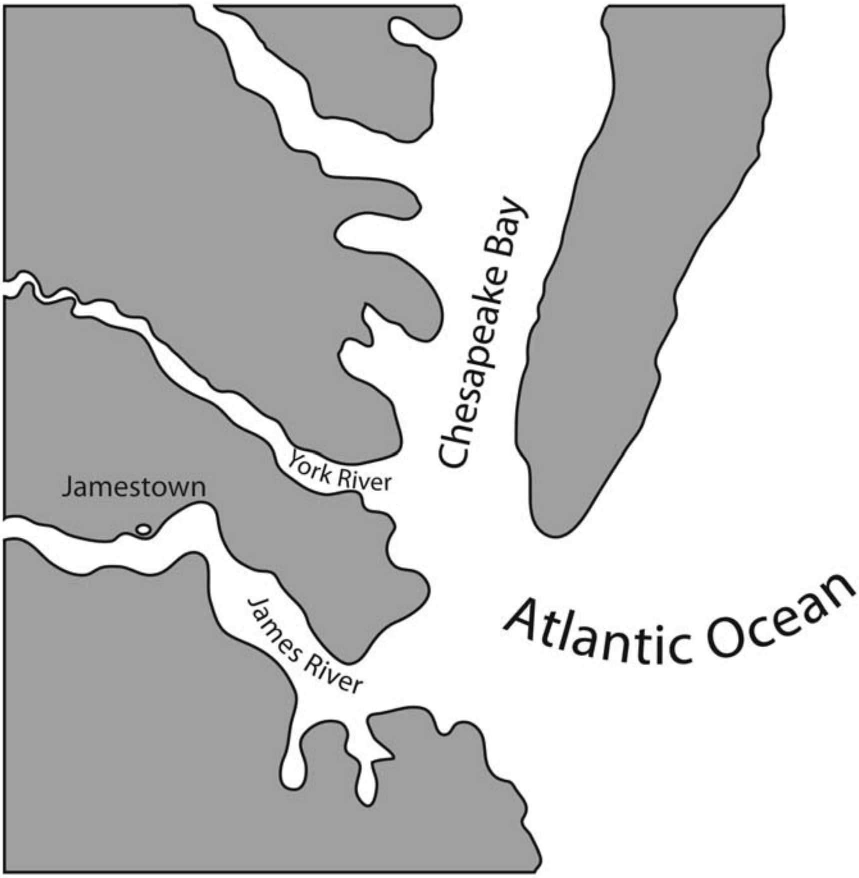


FIGURE 1. Map showing the location of Jamestown. Drawing by Sabine K. Klaus.

to a signal trumpet. If it was brought to the New World as scrap metal, it could have belonged to a trumpet or a trombone.

The first possibility seems the more likely of the two, as one of the colonists, Captain John Smith, mentions trumpets several times in his writings. Smith was a prolific writer whose published works exerted enormous influence on subsequent travelers and secured for their author an enduring place in history. In *An Accidence or the Path-way to Experience Necessary for all Young Sea-men* (1626) and *A Sea Grammar* (1627), he writes of the duties of a ship's trumpeter and even specifies the share of the profits the trumpeter and trumpeter's mate are to receive from a merchant voyage.[4] More to the point for the present discussion, however, are Smith's descriptions of his exploits in Virginia. In *A True relation of such occurrences and accidents of noate, as hath hapned in Virginia . . .* (1608), Smith describes a meeting with Chief Powhatan: "But seeing Captaine Nuport, and Maister Scrivener, coming a shore, the King [i.e., Powhatan] returned to his house, and I went to meete him [i.e., Newport]. With a trumpet before him, wee marched to the King, who after his old manner kindly received him."[5] In *The Generall History of Virginia, the Somer Iles, and New England . . .* (1623), Smith describes negotiations with Powhatan's men that took place in 1611: "Yet wee promised them truce till the next day at noone, and then if they would fight with us, they should know when we would begin by our Drums and Trumpets."[6] Thus it is clear that the English colonists in early Jamestown used trumpets ceremonially and to signal military action.

Physical Characteristics of the Mouthpiece

Only the upper brass-colored bowl of the mouthpiece survives, while the shank—the segment that was inserted into the instrument—is lost (figs. 2 and 3), as is also, most likely, a ferrule that covered the junction between bowl and shank. The lower end of the bowl is stepped and shows a darker, grayish color, suggesting that a separate shank was once soldered to it. The exterior is decorated with a series of engraved lines and is nicely finished. The cup-shaped interior has a flat rim with a fairly sharp inner edge (figs. 4 and 5). The transition between cup and throat shows a distinct step, as is typical of a mouthpiece for either a trumpet or trombone from this time. Although it is well crafted, the mouthpiece is not totally symmetrical. The slope of the wall on the interior is steeper on one side than it is on the other, and when placed upside down on its rim the vertical axis is not perpendicular to the plane of the rim. The dimensions of the mouthpiece are rather large (fig. 6); the significance of this will be discussed below.

4. See *An Accidence,* 19 [3:22], 25 [3:23], and 35 [3:27]; and *A Sea Grammar,* 35 [3:83], 39 [3:86], 60 [3:102], 62 [3:103], and 72 [3:110]. In this and in the following notes, page numbers in brackets identify the location of these passages in *The Complete Works of Captain John Smith (1580–1631),* ed. Philip L. Barbour, 3 vols. (Chapel Hill, NC: University of North Carolina Press, 1986).

5. *A True relation*, fol. D1v [1:69].

6. *The Generall History*, 113 [2:245].

FIGURE 2. The mouthpiece fragment, exterior view 1. Photo by Sabine K. Klaus, published courtesy of Preservation Virginia. For color view, see p. 18.

FIGURE 3. The mouthpiece fragment, exterior view 2. Photo by Sabine K. Klaus, published courtesy of Preservation Virginia.

FIGURE 4. The mouthpiece fragment, interior view. Photo by Sabine K. Klaus, published courtesy of Preservation Virginia.

FIGURE 5. The mouthpiece fragment, side view. Photo by Sabine K. Klaus, published courtesy of Preservation Virginia.

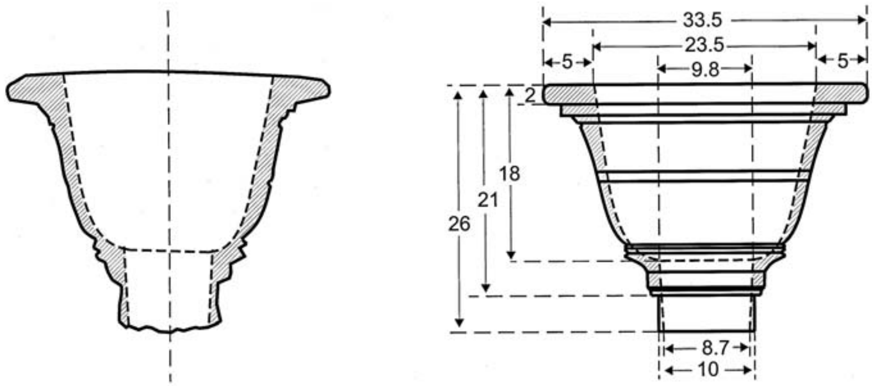


FIGURE 6. Drawing and measurements of the mouthpiece fragment. Drawing by Sabine K. Klaus, published courtesy of Preservation Virginia.

After excavation, the mouthpiece was immediately cleaned mechanically, abraded with aluminum oxide powder, and polished with an undetermined compound. It was then placed in an ethanol bath to degrease it, and then soaked in a 3% solution of Benzotriazole (a corrosion inhibitor) in 50:50 v/v ethanol and water. It was dried in a vacuum and then coated with two coats of Incralac.[7]

Analysis of the Metal

Analysis of the manufacturing technique and elemental composition was carried out in an attempt to answer the following questions:

1. What is the composition of the metal?
2. Was the mouthpiece cast, or manufactured from sheet metal?
3. Were the bowl and rim made in one piece or manufactured separately?
4. Is there any evidence that the darker section at the bottom of the bowl represents remnants of solder material, indicating that a lost shank was attached to this area?

7. E. Jordan, unpublished conservation report (1994), on file with the Jamestown Rediscovery Project, Rediscovery Center, Historic Jamestowne (Preservation Virginia).

The first step was to examine and record the surface of the object using a Hirox 3-D digital microscope. This examination revealed no evidence that the bowl and rim were made separately and then joined; instead, the evidence pointed to a single cast piece. The examination also showed that the surface of the mouthpiece is heavily pitted and uneven. Shallow grooves are visible on the rim, with deeper ones on the exterior and interior of the cup (fig. 7). These striations appear to be the result of the cleaning rather than the manufacturing process.

Examination under the microscope also revealed an area on the exterior of the rim that may possibly show the remains of a maker's mark (fig. 8). "It appears to consist of a small design area with a rectangular area beneath that may have contained some initials beginning with the letter 'V'. The area is heavily worn and it is difficult to make out all the details even under high magnification."[8] The authors believe that the putative letter "V" may be followed by an "N," and further, that the letter above the rectangular area could be an "F," possibly standing for *fecit* ("made by").

To determine the composition of the metal, the researchers at Williamsburg examined the side of the bowl, the rim, and the dark-colored base area with a Hitachi S570 Scanning Electron Microscope with attached Energy Dispersive X-Ray Spectrometry (EDS/EDX) detector (fig. 9). Further analysis was carried out with a Bruker Tracer-III portable X-ray fluorescence device, analyzing surface areas only; no cross-sections were taken. The results appear in Appendix 1.

The Rim. Analysis of four points along the rim suggests that the mouthpiece was cast from brass consisting of copper and zinc; aluminum, silica, and iron are also present, but no tin. The aluminum is likely a residue of the conservation and cleaning treatment mentioned above, as it involved abrasion with aluminum oxide, while the iron and silica may be residues from the burial environment. Many objects found in the tidewater area of Virginia are made of iron, and their corrosion products can contaminate other materials found in close proximity. Silica is a common element in most soils. The chlorine found in one of the analyzed samples is likely a contaminant of the burial environment as well.

The Side. Two points were analyzed on the side of the bowl. At both, the metal was brass, with an approximate weight-percent ratio of 4:1, copper

8. Emily Williams, John Watson, and Olga Trofimova, "Metal Analysis Report," Colonial Williamsburg Foundation.

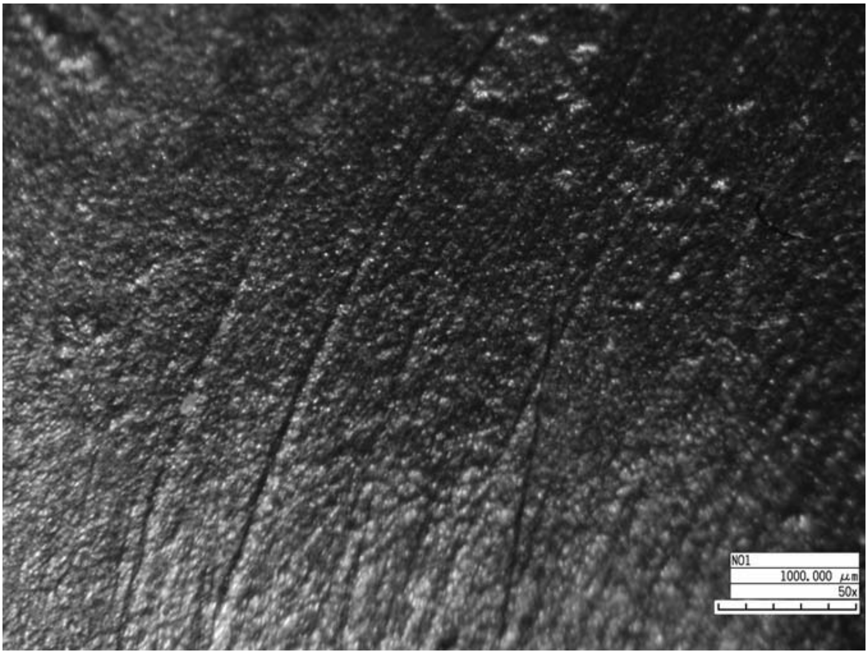


FIGURE 7. Striation and pitting on the inside of the bowl at 50x magnification. Photo courtesy of Jefferson Laboratory, Colonial Williamsburg Foundation.

to zinc, roughly the same proportion as in the rim. Trace amounts of aluminum, silica, and lead are also present.

The Stepped Base. Five points were analyzed at the base of the mouthpiece where the shank would have been attached and where remnants of solder material were suspected (see figs. 2 and 3). The analysis indicated that both tin and lead are present. The ratios of tin to lead suggest the use of a high-tin solder. In addition, the elements calcium and phosphorus are found in this area but not elsewhere on the mouthpiece, suggesting that they may have been associated with the process of soldering, possibly as part of the flux.

In their report, Williams, Watson, and Trofimova stress that Energy Dispersive X-Ray Spectrometry, the method used for the analysis of this mouthpiece, is a technique with surface penetration in the region of micrometers (thousandths of a millimeter) only. Consequently, surface activities such as contamination, corrosion, and cleaning may affect the

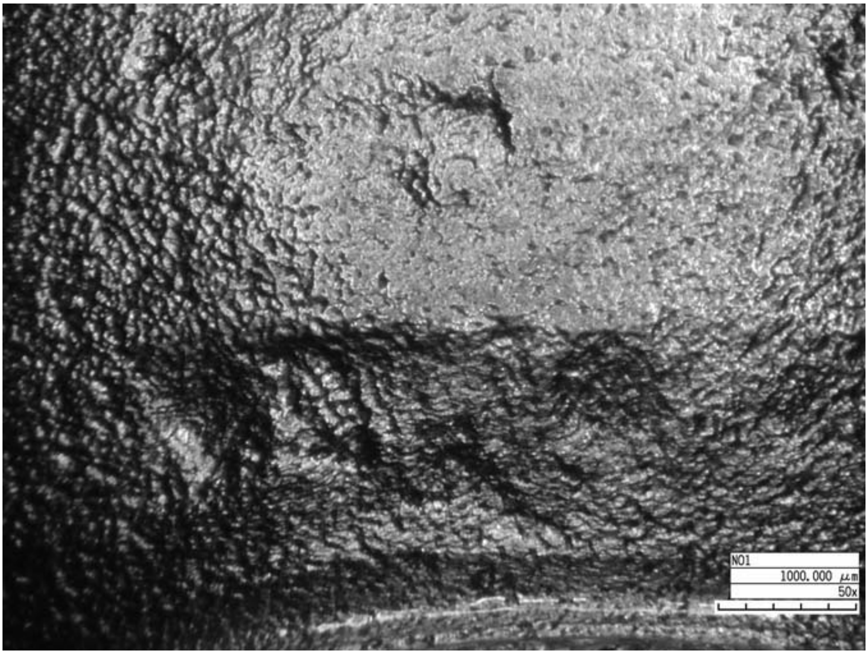


FIGURE 8. Possible maker's mark on the rim exterior of the mouthpiece. Photo courtesy of Jefferson Laboratory, Colonial Williamsburg Foundation.

quality of the results. Unfortunately, on an excavation site all these factors are present. The team thus concludes: "It must therefore be remembered that the results obtained do not necessarily represent the exact mixture or alloy that was used to create the artifact." While it is unlikely that a trace element that was present in the original condition has disappeared, it is possible that its ratio in relation to other elements has changed as a result of any or all the above-mentioned factors.

Historical Context of the Mouthpiece

Despite the caveats mentioned above, analysis of the metal provides crucial clues as to the manufacturing process and original design of the Jamestown mouthpiece and helps to establish its place in the history of brass instruments. The surviving portion of the mouthpiece is clearly a single piece of cast brass, and the shank was presumably soldered to the

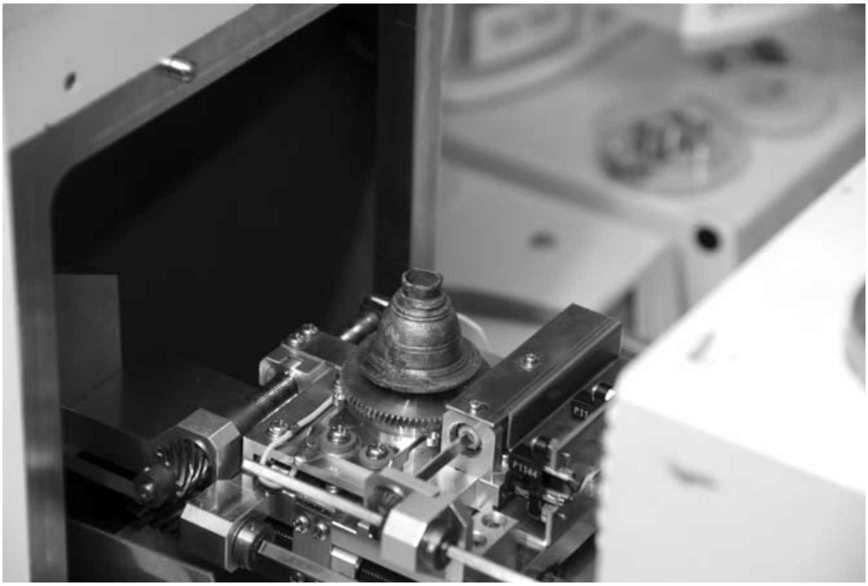
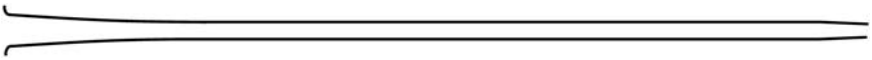


FIGURE 9. The mouthpiece in the Scanning Electron Microscope at Jefferson Laboratory. Photo by John Watson, Colonial Williamsburg Foundation.

stepped bottom of the bowl; the latter was therefore easily broken off. Unfortunately, examination of scrap pieces found in the vicinity of the mouthpiece did not reveal any possible candidate for the lost shank.

In the sixteenth and seventeenth centuries, two brasswind mouthpiece types can be distinguished that differ considerably from modern designs: those made entirely from sheet metal and those with cast cup and sheet-metal shank. Both of these types lack the so-called "backbore" of the modern mouthpiece, a smooth tapering that follows the throat or central hole. Composite mouthpieces made of layers of sheet metal are the oldest form. The so-called Billingsgate trumpet, a straight trumpet from the late fourteenth century that was excavated from the Thames foreshore, has a mouthpiece of this type (fig. 10), and trumpet mouthpieces made in 1442 by Marcian Guitbert of Limoges[9] and in 1578 by the municipal trumpeter Jacob Steiger of Basel are of similar construction

9. Pierre-Yves Madeuf, Jean-François Madeuf, and Graham Nicholson, "The Guitbert Trumpet: A Remarkable Discovery," *Historic Brass Society Journal* 11 (1999): 181–86.



10a. Drawing of the tube segment.

10b. The tube segment.

10c. The rim.

FIGURES 10a–c. The first tube segment of the "Billingsgate trumpet," ending in a funnel; this is the instrument's integral mouthpiece. A collar soldered to the end of the tube is formed into a rounded rim, joined by a seam. Museum of London, BWB83[335]<225>. Photo and drawing by Sabine K. Klaus, published by permission of the Museum of London.

(fig. 11).[10] As no other exemplars of this type are known to survive, the design may have disappeared by the end of the sixteenth century.

The combination of a cast bowl with a cylindrical sheet-metal shank, tapering very slightly at the distal end to fit into the instrument, is confirmed in a trumpet by Anton Schnitzer, made in Nuremberg in 1581 (figs. 12a–c).[11] This design is particularly well documented in English trumpet mouthpieces of the seventeenth century,[12] but also appears regularly on mouthpieces from the European continent.

Analysis of the metal has established unambiguously that the Jamestown mouthpiece belongs to the second type described above, as it consists of a cast bowl that is preserved and a lost sheet-metal shank. Such mouthpieces typically have a ferrule covering the joint between bowl and shank. The Jamestown mouthpiece probably had such a ferrule as well, but no trace of it survives.

Where was the Mouthpiece Made?

The authors hoped that analysis of the metal in the mouthpiece bowl would help identify the region where the mouthpiece was made. Comparisons with the few early mouthpieces for which metal analysis exists, both from England and from Nuremberg—the two most likely regions of origin for the Jamestown mouthpiece—show no significant difference in the metal composition of the cast sections (see Appendix 2). For example, there is no significant difference between the metal composition of the cast bowl of this mouthpiece and of the one associated with a trumpet by Simon Beale,[13] made in London in 1667, nor of the one that survives with a trumpet by the Nuremberg maker Conrad Droschel from 1618.[14] The sheet-metal shank of the Beale trumpet mouthpiece, on the other hand, has a much higher copper content than sheet brass used in Nuremberg in the same period—for example, in an alto trombone by Michael Nagel (1663; London, Horniman Museum,

10. Historisches Museum Basel, 1880.206. Martin Kirnbauer, *Die Basler Standestrompeten von 1578* (Basel: Historisches Museum Basel, 2008), 27–28.

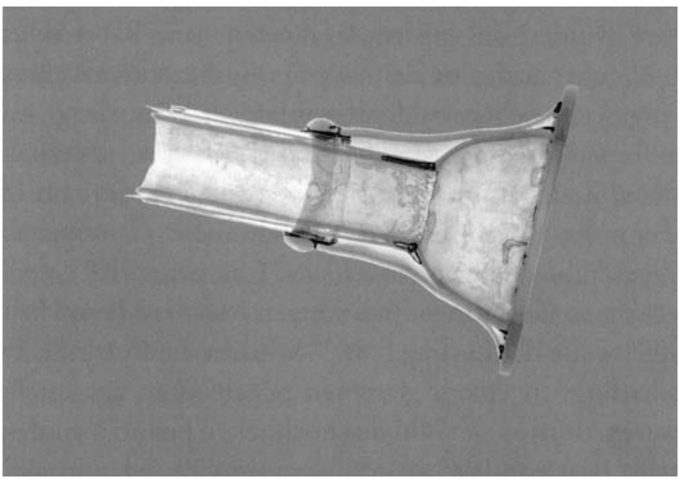
11. Vienna, Kunsthistorisches Museum, SAM 248.

12. Eric Halfpenny, "Early British Trumpet Mouthpieces," *Galpin Society Journal* 20 (1967): 76–88.

13. Bate Collection, University of Oxford, no. 78.

14. See Jeremy N. Green, *The Loss of the Verenigde Oostindische Compagnie retourschip Batavia, Western Australia 1629: An Excavation Report and Catalogue of Artefacts*, BAR International Series, no. 489 (Oxford: B.A.R., 1989), 74.

11a. Trumpet mouthpiece. Photo by Peter Portner, Historisches Museum Basel.

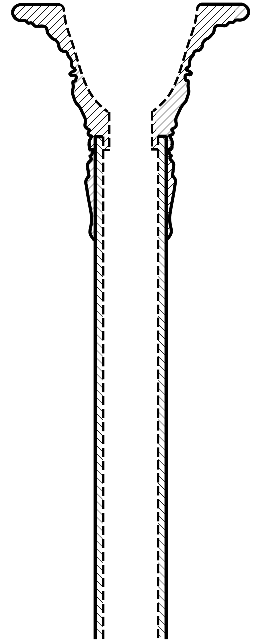


11b. Neutron imaging of the trumpet mouthpiece, showing the seven different sheet-metal layers. Photo by Paul Scherrer Institut, Villingen.

FIGURE 11. Trumpet mouthpiece by Jacob Steiger, Basel, 1578. Basel, Historisches Museum, 1880.206. Photos from Martin Kirnbauer, *Die Basler Standestrompeten von 1578* (Basel: Historisches Museum Basel, 2008), 28–29.

12a. Mouthpiece.

12b. X-ray of the mouthpiece. Photo by Prof. Dr. Manfred Schreiner, Institute of Science and Technology, Academy of Fine Arts, Vienna.



12c. Drawing of the internal profile. Drawing by Sabine K. Klaus.

FIGURE 12. Mouthpiece of trumpet by Anton Schnitzer, Nuremberg, 1581, with cast bowl, cylindrical sheet-metal shank, and ferrule. Vienna, Kunsthistorisches Museum, SAM 248. Photo courtesy of the Sammlung alter Musikinstrumente, Kunsthistorisches Museum, Vienna.

14.5.47/228) and a trumpet bell by Paul Hainlein (1664; Trumpet Museum Bad Säckingen, 11201). Extensive metal analysis of brass instruments undertaken by Louise Bacon has shown that English trumpets built in the second half of the seventeenth century typically were made from sheet metal with a very high copper content, consisting of either a binary alloy (copper and tin = bronze), or a ternary alloy with copper as the main component and tin and zinc as the next major elements.[15] Trumpets and trombones from Nuremberg, on the other hand, were made of sheet brass with fairly high zinc content—at least 20% and up to more than 30%—at least by the 1660s and possibly earlier (see Appendix 2). Thus the answer to the question as to where the Jamestown mouthpiece was made should probably have come from the sheet metal that was used for the shank, rather than from the cast bowl. As the shank is now missing, this evidence is lost.[16]

It is therefore not possible at this time to determine whether this mouthpiece was made in England or in Nuremberg. Nuremberg wares, such as jetons (small metal disks, used primarily as counters), were excavated in great numbers from the mud of the River Thames in London, and also made their way to early overseas settlements.[17] Nuremberg jetons and a brass thimble with a Nuremberg maker's mark have been found in Jamestown.[18] On the other hand, the settlers came from England, and they began their journey in London, so the mouthpiece could have been manufactured in the British Isles.[19]

15. Alice Louise Bacon, "A Technical Study of the Alloy Composition of 'Brass' Wind Musical Instruments (1661–1867) Utilizing Non-Destructive X-Ray Flourescence," 2 vols. (PhD diss., Institute of Archaeology, University College of London, University of London, 2003).

16. It is hoped that ongoing archaeological excavations of James Fort may reveal the missing shank.

17. M. B. Mitchiner, C. Mortimer, and A. M. Pollard, "Nuremberg and its Jetons, c. 1475 to 1888: Chemical Compositions of the Alloys," *Numismatic Chronicle* 147 (1987): 114–55, esp. 118.

18. Thomas Eser, "Unter Tage, unter Wasser: Nürnberger Artefakte als archäologische Funde," in *Quasi Centrum Europae: Europa kauft in Nürnberg, 1400–1800*, ed. Hermann Maué et al. (Nuremberg: Germanisches Nationalmuseum, 2002), 110–12.

19. At least three makers of cup-mouthpiece instruments—George Langdall, Simon Brewer, and John Kirby—were active in England during the closing decades of the sixteenth century and the first decade of the seventeenth, but no connection can be established between any of them and the Jamestown mouthpiece, nor do their initials match any of the conceivable interpretations of those possibly engraved on the object, as represented in figure 8. See Maurice Byrne, "The Goldsmith-Trumpet-Makers of the British Isles," *Galpin Society Journal* 19 (1966): 71–83.

A Mouthpiece for a Trumpet or a Trombone?

For what kind of instrument was the mouthpiece intended—a trumpet or a trombone? Circumstantial evidence outlined above would make it more likely that the mouthpiece belonged to a trumpet. While there are many references to trumpets in the writings of Captain Smith, trombones are not mentioned at all.

At first glance, the Jamestown mouthpiece appears to be rather large for a trumpet. The exterior diameter of the rim, however, compares well with that of surviving mouthpieces for both tenor trombones and trumpets from the sixteenth and seventeenth centuries (see Appendix 3)—an observation that is confirmed in the scale drawings in Michael Praetorius's *Theatrum Instrumentorum* (fig. 13, mouthpieces for nos. 3, 10, and 11).

Conclusion

The Jamestown mouthpiece is the earliest accessory for a brass instrument found in North America and dates from sometime before 1610. Its design, consisting of a cast bowl with a sheet-metal shank and possibly a ferrule, both now missing, was commonly found in Britain and on the European continent in the late sixteenth and early seventeenth centuries.

Several questions remain, however. Where was this mouthpiece made, and by whom? Possibly the craftsman responsible for it was an unidentified maker whose name is represented by the initial "V." If the correct reading of the following letter is "N," a provenance in Nuremberg would be plausible, but there is no trumpet maker recorded whose first or last name begins with the letter "V." Circumstantial evidence suggests that the mouthpiece originally belonged to a signal trumpet, but association with a trombone cannot be ruled out entirely.

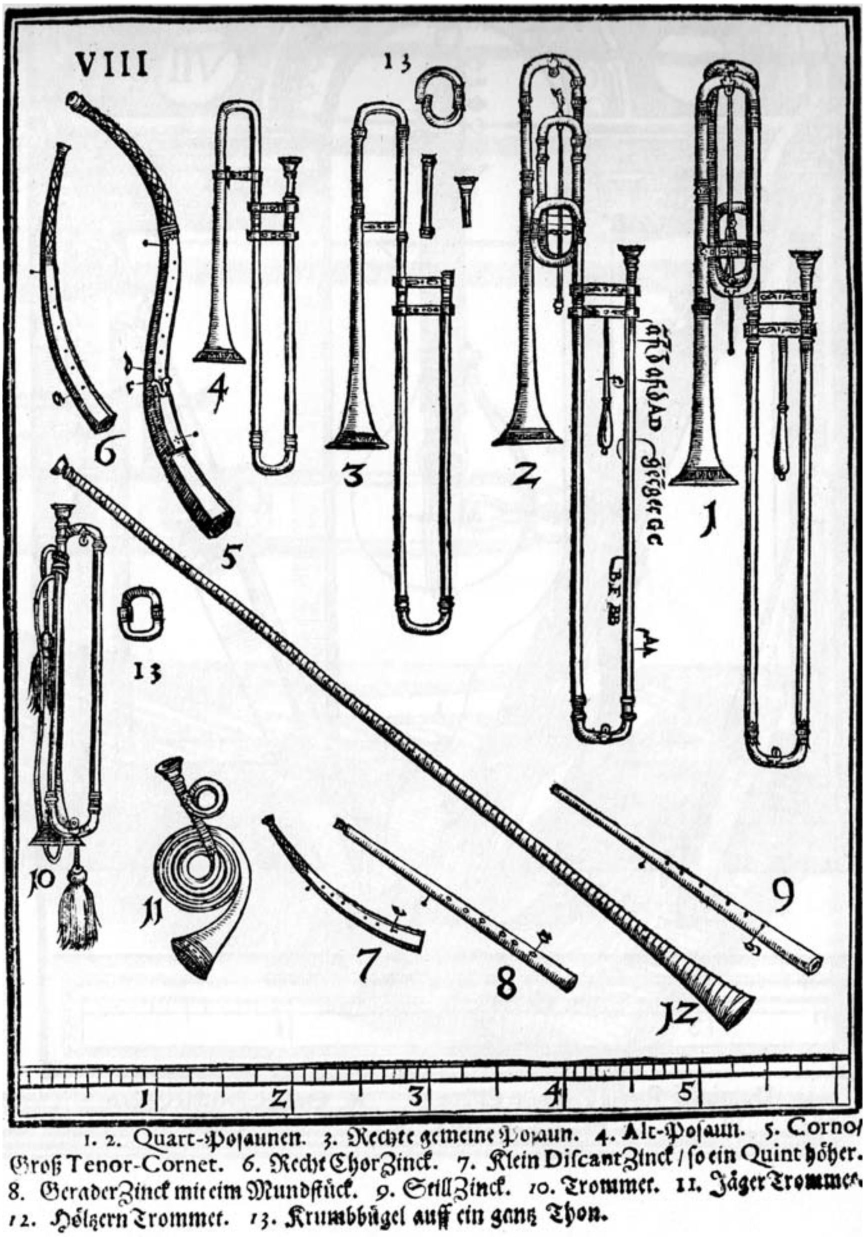


FIGURE 13. Michael Praetorius, *Theatrum Instrumentorum* (Wolfenbüttel, 1620), plate VIII. The mouthpieces of the trumpet (no. 10), *Jägertrompete* (no. 11), and tenor trombone (no. 3) are identical in size.

APPENDIX 1:

Metal Analysis of the Jamestown Mouthpiece Fragment (171-JR, recovered from layer 2G of Pit 1)

The analysis was carried out by Emily Williams, John Watson, and Olga Trofimova, at Jefferson Laboratory, Colonial Williamsburg Foundation, on February 19 and 20, 2008.

The Rim:

Sample 1:

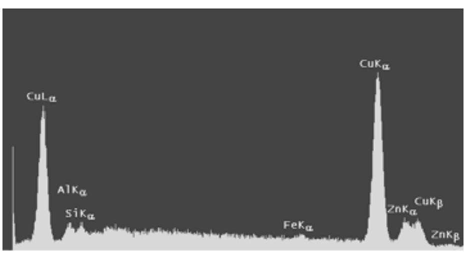
Quantitative Analysis Results - Standardless Analysis :
Spectrum2 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 410.58
Correction: ZAF, Cycles: 2

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
O	Ka:EDS	-0.1553	0.0060*	0.3844	<0.0120	0.0060	29.42
Si	Ka:EDS	0.0215	0.0022	0.4328	0.0429	0.0050	8.15
Cu	Ka:EDS	1.1313	0.0270	0.9906	0.9571	0.0272	1.67
Zn	Ka:EDS	0.0024	0.0157*	0.9915	<0.0314	0.0157	1.55

* =< 2 Sigma

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
Si	9.20	Si	4.29	0.22	4.29
Cu	90.80	Cu	95.71	2.70	95.71
<Total>	100.00		100.00		100.00

Sample 2:

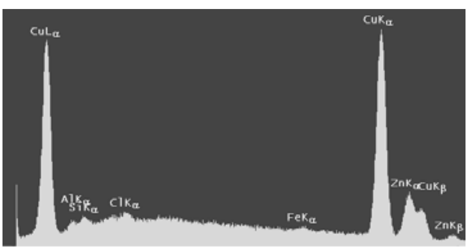


Quantitative Analysis Results - Standardless Analysis :
Spectrum2 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 6.74
Correction: ZAF, Cycles: 3

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0058	0.0003	0.2995	0.0190	0.0010	9.61
Si	Ka:EDS	0.0043	0.0003	0.4196	0.0100	0.0008	8.15
Fe	Ka:EDS	0.0111	0.0014	1.1574	0.0094	0.0012	2.11
Cu	Ka:EDS	0.8552	0.0079	0.9930	0.8403	0.0080	1.67
Zn	Ka:EDS	0.1235	0.0055	0.9942	0.1213	0.0055	1.55

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
Al	4.31	Al	1.90	0.03	1.90
Si	2.19	Si	1.00	0.03	1.00
Fe	1.03	Fe	0.94	0.14	0.94
Cu	81.09	Cu	84.03	0.79	84.03
Zn	11.38	Zn	12.13	0.55	12.13
<Total>	100.00		100.00		100.00

Sample 3:

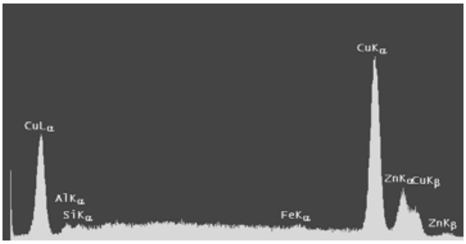


Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 4.52
Correction: ZAF, Cycles: 3

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0026	0.0002	0.2954	0.0088	0.0006	9.61
Si	Ka:EDS	0.0025	0.0002	0.4179	0.0058	0.0005	8.15
Cl	Ka:EDS	0.0035	0.0003	0.7478	0.0046	0.0004	5.31
Fe	Ka:EDS	0.0056	0.0008	1.1574	0.0047	0.0007	2.11
Cu	Ka:EDS	0.7926	0.0047	0.9955	0.7849	0.0048	1.67
Zn	Ka:EDS	0.1932	0.0038	0.9967	0.1911	0.0038	1.55

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
Al	2.03	Al	0.88	0.02	0.88
Si	1.30	Si	0.58	0.02	0.58
Cl	0.81	Cl	0.46	0.03	0.46
Fe	0.53	Fe	0.47	0.08	0.47
Cu	77.09	Cu	78.49	0.47	78.49
Zn	18.25	Zn	19.11	0.38	19.11
<Total>	100.00		100.00		100.00

Sample 4:



Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 5.96
Correction: ZAF, Cycles: 3

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0030	0.0002	0.2940	0.0100	0.0006	9.61
Si	Ka:EDS	0.0018	0.0002	0.4157	0.0043	0.0004	8.15
Fe	Ka:EDS	0.0067	0.0010	1.1576	0.0057	0.0009	2.11
Cu	Ka:EDS	0.7720	0.0058	0.9961	0.7655	0.0058	1.67
Zn	Ka:EDS	0.2165	0.0047	0.9974	0.2144	0.0047	1.55

Element	Atoms%	Compound	Weight%	Error (±)	Norm%
Al	2.33	Al	1.00	0.02	1.00
Si	0.96	Si	0.43	0.02	0.43
Fe	0.64	Fe	0.57	0.10	0.57
Cu	75.51	Cu	76.55	0.58	76.55
Zn	20.56	Zn	21.44	0.47	21.44
<Total>	100.00		100.00		100.00

THE SIDE:

Sample 1:

Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 6.89
Correction: ZAF, Cycles: 3

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0096	0.0002	0.2992	0.0311	0.0008	9.61
Si	Ka:EDS	0.0018	0.0002	0.4151	0.0043	0.0006	8.15
Cu	Ka:EDS	0.8207	0.0054	0.9930	0.8009	0.0054	1.67
Zn	Ka:EDS	0.1678	0.0041	0.9940	0.1638	0.0041	1.55

Element	Atoms%	Compound	Weight%	Error (±)	Norm%
Al	7.02	Al	3.11	0.02	3.11
Si	0.93	Si	0.43	0.02	0.43
Cu	76.79	Cu	80.09	0.54	80.09
Zn	15.26	Zn	16.38	0.41	16.38
<Total>	100.00		100.00		100.00

Sample 2:

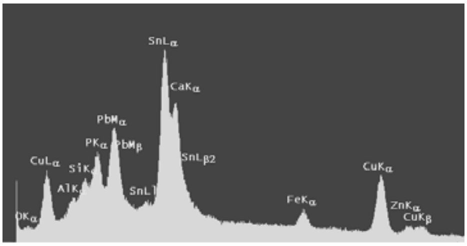
Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 4.33
Correction: ZAF, Cycles: 3

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0092	0.0003	0.3019	0.0297	0.0011	9.61
Cu	Ka:EDS	0.8227	0.0067	0.9985	0.8012	0.0067	1.67
Zn	Ka:EDS	0.1556	0.0049	1.0000	0.1513	0.0049	1.55
Pb	Ma:EDS	0.0124	0.0015	0.6801	0.0178	0.0022	6.01

Element	Atoms%	Compound	Weight%	Error (±)	Norm%
Al	6.84	Al	2.97	0.03	2.97
Cu	78.26	Cu	80.12	0.67	80.12
Zn	14.37	Zn	15.13	0.49	15.13
Pb	0.53	Pb	1.78	0.15	1.78
<Total>	100.00		100.00		100.00

THE STEPPED BASE:

Sample 1:

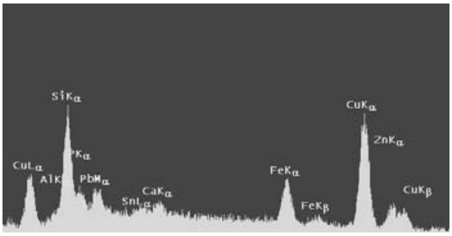


Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 17.33
Correction: ZAF, Cycles: 4

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
O	Ka:EDS	0.0251	0.0011	0.1943	0.1039	0.0057	29.42
Al	Ka:EDS	0.0061	0.0003	0.4753	0.0105	0.0006	9.61
Si	Ka:EDS	0.0098	0.0004	0.5725	0.0140	0.0006	8.15
P	Ka:EDS	0.0264	0.0004	0.6747	0.0321	0.0007	6.99
Ca	Ka:EDS	0.0535	0.0010	0.9836	0.0447	0.0010	3.72
Fe	Ka:EDS	0.0412	0.0013	1.0144	0.0334	0.0012	2.11
Cu	Ka:EDS	0.3145	0.0036	1.0071	0.2568	0.0036	1.67
Zn	Ka:EDS	0.0439	0.0030	1.0180	0.0354	0.0029	1.55
Sn	La:EDS	0.3280	0.0028	0.8455	0.3139	0.0033	3.81
Pb	Ma:EDS	0.1515	0.0018	0.7945	0.1554	0.0023	6.01

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
O	35.87	O	10.39	0.11	10.39
Al	2.14	Al	1.05	0.03	1.05
Si	2.76	Si	1.40	0.04	1.40
P	5.73	P	3.21	0.04	3.21
Ca	6.16	Ca	4.47	0.10	4.47
Fe	3.30	Fe	3.34	0.13	3.34
Cu	22.31	Cu	25.68	0.36	25.68
Zn	2.99	Zn	3.54	0.30	3.54
Sn	14.60	Sn	31.39	0.28	31.39
Pb	4.14	Pb	15.54	0.18	15.54
<Total>	100.00		100.00		100.00

Sample 2:

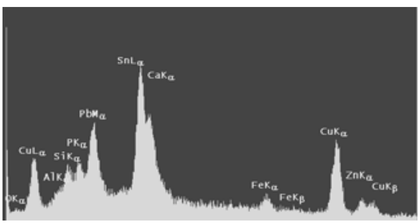


Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0037	0.0006	0.3416	0.0099	0.0017	9.61
Si	Ka:EDS	0.0481	0.0009	0.4732	0.0919	0.0019	8.15
P	Ka:EDS	0.0122	0.0008	0.5426	0.0204	0.0015	6.99
Ca	Ka:EDS	0.0109	0.0012	0.9616	0.0103	0.0012	3.72
Fe	Ka:EDS	0.1088	0.0035	1.0768	0.0919	0.0033	2.11
Cu	Ka:EDS	0.6291	0.0105	0.9760	0.5839	0.0107	1.67
Zn	Ka:EDS	0.1436	0.0086	0.9796	0.1332	0.0087	1.55
Sn	La:EDS	-0.0002	0.0030*	0.8205	<0.0060	0.0030	3.81
Pb	Ma:EDS	0.0439	0.0028	0.6792	0.0586	0.0041	6.01

* =< 2 Sigma

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
Al	2.06	Al	0.99	0.06	0.99
Si	18.48	Si	9.19	0.09	9.19
P	3.72	P	2.04	0.08	2.04
Ca	1.46	Ca	1.03	0.12	1.03
Fe	9.29	Fe	9.19	0.35	9.19
Cu	51.89	Cu	58.39	1.05	58.39
Zn	11.51	Zn	13.32	0.06	13.32
Pb	1.60	Pb	5.86	0.28	5.86
<Total>	100.00		100.00		100.00

Sample 3:

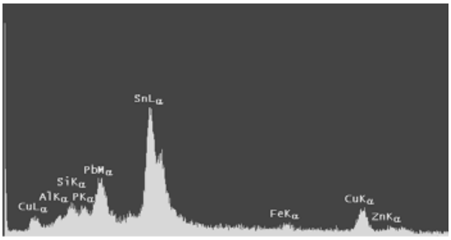


Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115nm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 50.83
Correction: ZAF, Cycles: 5

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
O	Ka:EDS	0.0434	0.0024	0.2228	0.1501	0.0108	29.42
Al	Ka:EDS	0.0035	0.0006	0.4315	0.0066	0.0013	9.61
Si	Ka:EDS	0.0107	0.0007	0.5418	0.0157	0.0013	8.15
P	Ka:EDS	0.0128	0.0009	0.6433	0.0159	0.0013	6.99
Ca	Ka:EDS	0.0361	0.0020	0.9744	0.0296	0.0021	3.72
Fe	Ka:EDS	0.0267	0.0025	1.0093	0.0211	0.0025	2.11
Cu	Ka:EDS	0.4005	0.0085	0.9825	0.3247	0.0087	1.67
Zn	Ka:EDS	0.0916	0.0071	0.9900	0.0738	0.0072	1.55
Sn	La:EDS	0.2539	0.0055	0.8378	0.2388	0.0066	3.81
Pb	Ma:EDS	0.1209	0.0037	0.7731	0.1238	0.0047	6.01

Element	Atoms%	Compound	Weight%	Error(±)	Norm%
O	45.41	O	15.01	0.24	15.01
Al	1.18	Al	0.66	0.06	0.66
Si	2.71	Si	1.57	0.07	1.57
P	2.48	P	1.59	0.09	1.59
Ca	3.57	Ca	2.96	0.20	2.96
Fe	1.83	Fe	2.11	0.25	2.11
Cu	24.73	Cu	32.47	0.85	32.47
Zn	5.47	Zn	7.38	0.71	7.38
Sn	9.74	Sn	23.88	0.55	23.88
Pb	2.89	Pb	12.38	0.37	12.38
<Total>	100.00		100.00		100.00

Sample 4:

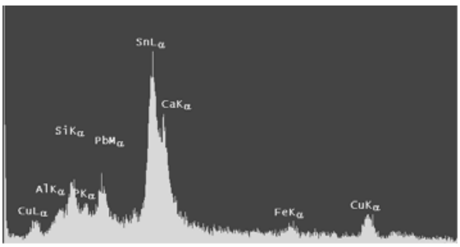


Quantitative Analysis Results - Standardless Analysis :
Spectrum1 ~115mm Nb (15KV, 80uA, 100X, 120s) Tue, Feb 19 2008
EDS Parameters - 15KV, Takeoff Angle: 21.2°, Fit Index: 46.53
Correction: ZAF, Cycles: 4

Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0054	0.0010	0.5019	0.0099	0.0019	9.61
Si	Ka:EDS	0.0140	0.0012	0.5748	0.0223	0.0021	8.15
P	Ka:EDS	0.0133	0.0013	0.6782	0.0180	0.0020	6.99
Fe	Ka:EDS	0.0261	0.0039	1.0640	0.0225	0.0037	2.11
Cu	Ka:EDS	0.2583	0.0115	1.0861	0.2185	0.0106	1.67
Zn	Ka:EDS	0.0498	0.0108	1.1043	0.0414	0.0098	1.55
Sn	La:EDS	0.4767	0.0103	0.8785	0.4923	0.0117	3.81
Pb	Ma:EDS	0.1564	0.0061	0.8159	0.1752	0.0075	6.01

Element	Atoms%	Compound	Weight%	Error (±)	Norm%
Al	3.28	Al	0.99	0.10	0.99
Si	7.07	Si	2.23	0.12	2.23
P	5.18	P	1.80	0.13	1.80
Fe	3.59	Fe	2.25	0.39	2.25
Cu	30.68	Cu	21.85	1.15	21.85
Zn	5.65	Zn	4.14	1.08	4.14
Sn	37.01	Sn	49.23	1.03	49.23
Pb	7.54	Pb	17.52	0.61	17.52
<Total>	100.00		100.00		100.00

Sample 5:



Element	Line	Kratio	Error	ZAF	Weight	Error	Ovolt
Al	Ka:EDS	0.0124	0.0012	0.5461	0.0205	0.0022	9.61
Si	Ka:EDS	0.0300	0.0015	0.5982	0.0452	0.0026	8.15
P	Ka:EDS	0.0143	0.0015	0.6841	0.0189	0.0023	6.99
Ca	Ka:EDS	0.0741	0.0047	1.0349	0.0647	0.0045	3.72
Fe	Ka:EDS	0.0348	0.0048	1.0300	0.0306	0.0046	2.11
Cu	Ka:EDS	0.1946	0.0119	1.0527	0.1672	0.0113	1.67
Sn	La:EDS	0.5265	0.0127	0.8895	0.5279	0.0143	3.81
Pb	Ma:EDS	0.1133	0.0063	0.8165	0.1250	0.0077	6.01

Element	Atoms%	Compound	Weight%	Error (±)	Norm%
Al	5.93	Al	2.05	0.12	2.05
Si	12.55	Si	4.52	0.15	4.52
P	4.76	P	1.09	0.15	1.09
Ca	12.59	Ca	6.47	0.47	6.47
Fe	4.27	Fe	3.06	0.48	3.06
Cu	20.52	Cu	16.72	1.19	16.72
Sn	34.68	Sn	52.79	1.27	52.79
Pb	4.71	Pb	12.50	0.63	12.50
<Total>	100.00		100.00		100.00

APPENDIX 2:

A Comparison of Metal Components in Seventeenth-Century Brass Instruments and Mouthpieces from England and Nuremberg, by Percentage

Mouthpieces

Mouthpiece or part	Cu	Zn	Pb	Sn	Fe	Ag	Ni	As	Sb	Co	Reference
Droschel trumpet, Nuremberg 1618, mpc I	75.6	21.3	?	0.3	0.2	?	0.2	?	?	?	Hachenberg, Stanbury
Droschel trumpet, Nuremberg 1618, mpc II	76.5	19.2	?	2.3	1.2	?	0.4	?	?	?	Hachenberg, Stanbury
Simon Beale, London 1667, cast part	76.25	21.21	0.41	1.31	0.78	0.00	0.00	0.00	0.00	0.03	Bacon
Simon Beale, London 1667, shank	90.25	5.24	traces	3.11	0.10	0.37	0.00	1.00	0.00	0.00	Bacon
Billingsgate trumpet, mouthpiece section	86.00	8.00	0.10	6.00	0.00	0.00	0.00	0.00	0.00	0.00	Bacon

Trumpets, Trombones, and Sheet Brass Segments

Instrument	Cu	Zn	Pb	Sn	Fe	Ag	Ni	As	Sb	Co	Reference
Michael Nagel, Nuremberg 1663, trombone	74.3	25.2	0.42	0	?	?	?	?	0.08	?	Hachenberg
Paul Hainlein, Nuremberg 1664, trumpet bell	77	22	0.17	<0.2	0.19	0.16	0.32	0.1	0.03	?	Hachenberg
J. W. Haas, Nuremberg 1682, horn ferrule	75.1	23.4	0.71	<0.25	0.21	0.08	0.37	<0.05	0.05	?	Hachenberg
J. W. Haas, Nuremberg 1680, trumpet	66.4	32.8	0.28	0	0.07	?	0.18	0.19	0.05	?	Hachenberg
J. C. Kodisch, Nuremberg 1694, trumpet	68.5	29.4	1.72	0.04	0.27	?	0.05	0	0.06	?	Hachenberg
Augustine Dudley, London 1651, trumpet (second yard)	88.23	4.63	0.80	3.44	0.25	0.70	0.20	1.00	0.00	traces	Bacon
Augustine Dudley, London 1665, trumpet (first yard)	88.06	6.28	0.96	3.99	0.35	0.20	0.02	0.00	0.14	0.00	Bacon
Augustine Dudley, London 1666, trumpet (bell)	86.48	4.08	0.25	8.75	0.39	traces	0.30	0.25	0.00	0.05	Bacon
Simon Beale, London 1667, trumpet (first bow)	89.89	4.14	0.00	2.96	0.14	2.44	0.00	0.41	0.00	0.02	Bacon

References

Bacon, Alice Louise. "A Technical Study of the Alloy Composition of 'Brass' Wind Musical Instruments (1661–1867) Utilizing Non-Destructive X-Ray Flourescence." 2 vols. PhD diss., Institute of Archaeology, University College of London, University of London, 2003.

Hachenberg, Karl F. "Nürnberger Musikinstrumente aus Messing—Chancen und Grenzen der Herkunftsbestimmung durch Metallanalyse." In *Anzeiger des Germanischen Nationalmuseums 2002,* edited by Hermann Maué and Christine Kupper, 201–23. Nuremberg: Germanisches Nationalmuseum, 2002.

Stanbury, Myra. "Analysis of the Batavia Wreck Mouthpieces" (in preparation).

APPENDIX 3:

Comparison of Sixteenth- and Seventeenth-Century Trumpet and Trombone Mouthpieces

TRUMPET MOUTHPIECES

Date	Instrument type	Maker	Type of mouthpiece	External diameter cup	Internal diameter cup	Cup depth	Throat diameter	Location
Late 14th century	trumpet, straight	unknown	sheet metal	29.5	21.5	funnel-shaped	ca. 11	Museum of London
1442	trumpet	Marcian Guitbert	sheet metal	34.7	19.7	15.8	5.5	Private ownership, France
1578	trumpet	Jacob Steiger	sheet metal	37.6	23.5	16.4	8.5	Basel, HMB
1581	trumpet	Anton Schnitzer	cast bowl, separate shank	39	23	17	7	Vienna, KHM
1589	trumpet	?Lissandro Millanese	cast bowl, separate shank	38.5	22.6	18.6	7.8	Lelystad, Nationaal Scheepsarcheologisch Depot; Shipwreck Scheurrak S01
ca. 1589	trumpet	?	cast bowl, separate shank, lead	35.5	21	11.5–13	ca. 5	Shipwreck Scheurrak S01
ca. 1589	trumpet	?	cast bowl, separate shank, tin	35.5	21	11.5–13	ca. 5	Shipwreck Scheurrak S01
16th century	trumpet	unknown	cast bowl, separate shank	33.9	21.5	20.9	7.6	Copenhagen, x-64-1
before 1610	trumpet	unknown	cast bowl, shank lost	33.5	23.5	18	9.8/8.7	Historic Jamestowne
before 1629	trumpet	unknown	cast bowl, shank lost	30	20	?		Fremantle, W. Australia; Shipwreck Batavia
before 1629	trumpet	unknown	cast bowl, shank lost	33	20	?	7	Shipwreck Batavia
before 1629	trumpet	unknown	cast bowl, shank lost	33	21	?	7	Shipwreck Batavia

1666	trumpet	Augustine Dudley	with backbore	21.1	17.5	9.5	4.5	Museum of London
1666	trumpet	unknown	cast bowl, separate shank	35	20.5	14	7	Oxford, Queen's College
1667	trumpet	Simon Beale	cast bowl, separate shank	33.5	20	13	6.1	Oxford, Bate Coll
1669	trumpet	Thomas McCuir	cast bowl, separate shank	31.4	20.5	12.3	6	Edinburgh, Nat'l Museum of Scotland
ca. 1675	trumpet	Robert Brock	cast bowl, separate shank	31.4	20.5	11.8	6	Nat'l Museum of Scotland
ca. 1680	trumpet	William Bull	with backbore	32.3	20.4	8.5	4.8	Museum of London

Trombone Mouthpieces

Date	Instrument type	Maker	Type of mouthpiece	External diameter cup	Internal diameter cup	Cup depth	Throat diameter	Location
1579	trombone, tenor	Anton Schnitzer Sr.	cast bowl, separate shank	37	24.6	17.9	8	Verona, Accademia Filarmonica
1581	trombone, tenor	Anton Schnitzer Sr.	cast bowl, separate shank	30	22	17	7	Nice, Palais Lascaris
1593	trombone, bass	Pierre Colbert	cast bowl, separate shank	40.8	25		7.5	Amsterdam, Rijksmuseum
1616	trombone, bass	Isaac Ehe	cast bowl, separate shank	43	28	20	8	Munich, BNM
1650	trombone, bass	Wolf Birckholz	cast bowl, separate shank	36	23.4	14.7	7.4	Leipzig, Grassi Museum
1670	trombone, alto	Hieronimus Starck	cast with backbore	26.8	17.2	8.1	3.6	Nuremberg, GNM
1677	trombone, tenor	Paul Hainlein	cast with backbore	34.9	22.9	20	5	Nuremberg, GNM

APPENDIX 3: continued

Date	Instrument type	Maker	Type of mouthpiece	External diameter cup	Internal diameter cup	Cup depth	Throat diameter	Location
1695	trombone, alto	Wolf Birckholz	cast with backbore	33	21	12.5	6.3	Nuremberg, GNM
1698	trombone, alto	Johann Carl Kodisch	cast bowl, separate shank	29.8	18.7	8.6	4.2/3.3	Rosenheim, Städtisches Museum

References

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Smith, David Hogan, *Trombone Technique in the Renaissance* (San Francisco: The King's Trumpets and Shawms, 1989).

All other measurements provided by the museums or gathered by the authors.