Technological Study of a Byzantine Trumpet Bell

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The instrument

In 1986 the Musée d'art et d'histoire of Geneva acquired from a Swiss antiquities dealer thirteen Roman and Byzantine copper-alloy objects, including various vessels, lamps, and furniture fittings, as well as a trumpet fragment (Figure 1). Our knowledge of wind instruments of this period being largely limited to appearances in a few contemporary texts and images, the object presented a rare opportunity for a technological investigation, consisting of X-radiography as well as metallography of two small samples. The present paper presents the results of this study.

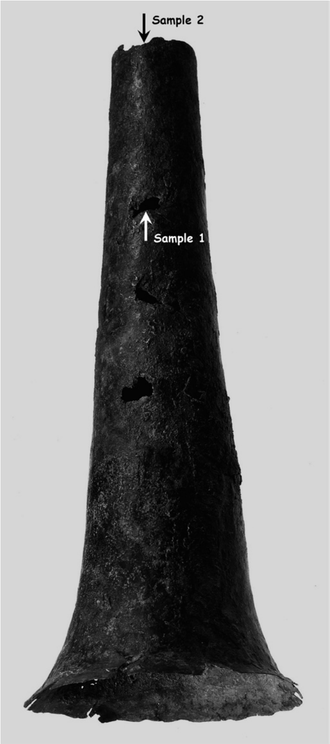

Fig. 1: Byzantine trumpet bell, MAH (Musées d'art et d'histoire) Geneva, inv. no. AA 2003-0053, 32.3 cm long. Sampled areas are indicated. Photo: Flora Bevilaqua (MAH).

DOI: 10.2153/0120090011005

The Geneva fragment, inventory no. AA 2003-0053, 32.2 cm long with a minimum diameter of 4.2 cm and a maximum diameter of 12.6 cm, is assumed to have belonged to a Roman or early Byzantine *tuba*. At its top (the small-diameter end) the metal of the instrument is not broken but ends with a clean-cut edge, suggesting that we are in fact looking at the bell of an instrument designed to be taken apart, possibly for easier transport. The fragile fragment with a number of cracks and holes is now partly mineralized, but with some sound metal preserved at the interior.

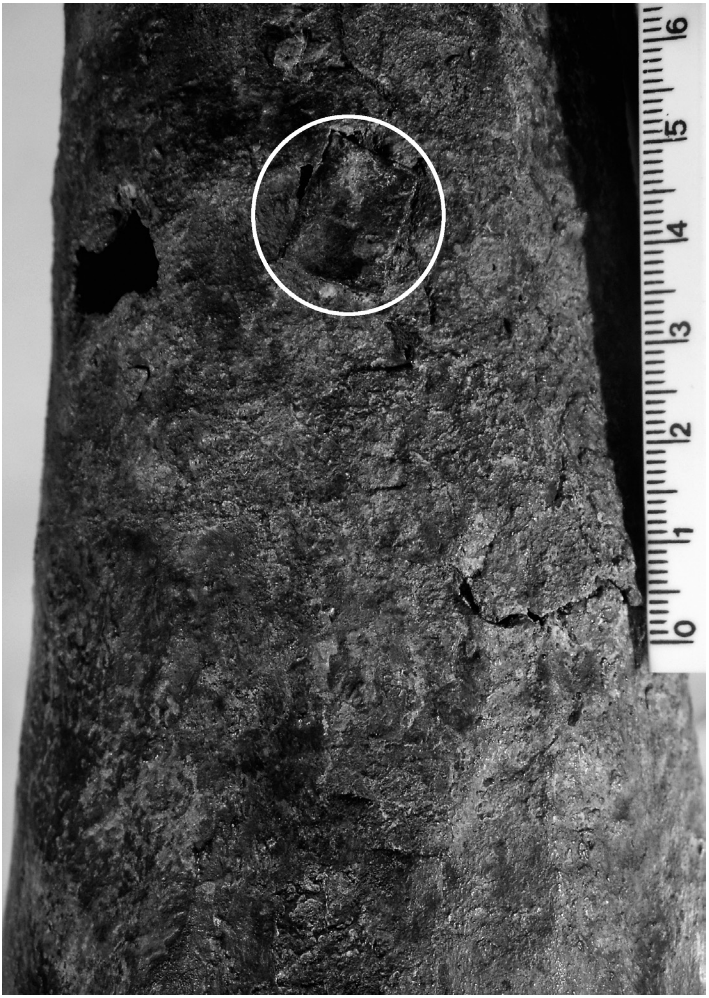

Fig. 2: Detail of the trumpet bell with ancient repair (circle) and crenellated seam. Scale in cm. Photo: author.

The instrument was manufactured from sheet metal bent into tubular shape using the crenellation technique.[1] On one side of the seam, a band of irregular rectangular tabs 4–6 mm wide was cut into the sheet metal. The opposite edge was carefully inserted between the tabs and the joint secured by a line of solder. The crenellation runs over the full length of the fragment (Figures 2 and 3). Little attempt was made to smoothen or hide the joint. It remains clearly visible today despite the corroded surface and must have been even more apparent at the time of its use. To increase the diameter, an additional triangle of sheet metal was integrated into the opening of the bell using the same technique. Several holes in the instrument were repaired using crudely clipped rectangular patches of sheet metal, which were soldered onto the damaged areas (Figures 2 and 3).

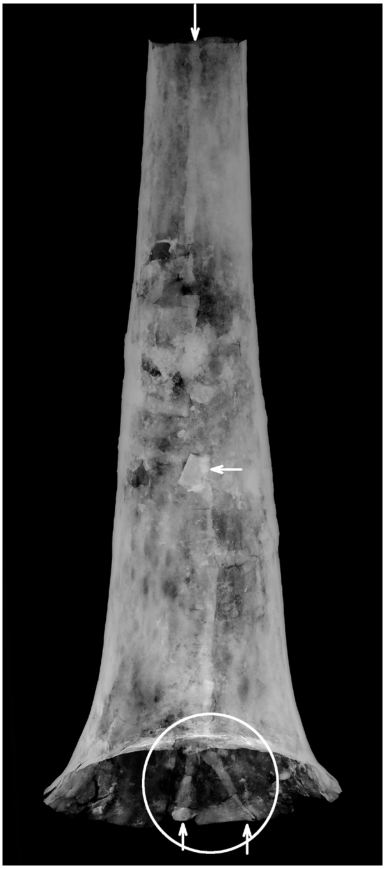

Fig. 3: X-radiograph of the trumpet. Note the crenellation (vertical arrows), an ancient repair (horizontal arrow) and the inset triangular copper sheet (circle). Experimental conditions: 105 kV, 3.8 mA, 2 min, distance tube-object 1 m, Agfa Structurix film. Photo: Colette Hamard (MAH) + author.

X-radiography

In order to investigate further the seam in the sheet metal, now partly obscured by surface corrosion, X-radiographs of the object were taken. The radiograph (Figure 3) illustrates the assembly technique for the tube as well as the soldering line on the seam (arrows). The added triangle, bordered by solder lines, is also very obvious in the same image.

Metallography

Two samples of approximately 1 mm each were taken with a jeweller's saw from damaged areas of the object (Figure 1). Both were mounted as cross-sections in polyester resin and polished to a mirror finish. Because of the advanced mineralization of the samples as well as the presence of lead inclusions, no metallographic etch was used. The mounted samples were used for optical as well as scanning electron microscopy with qualitative energy-dispersive X-ray analysis (SEM-EDX), to characterize the composition of the metal.

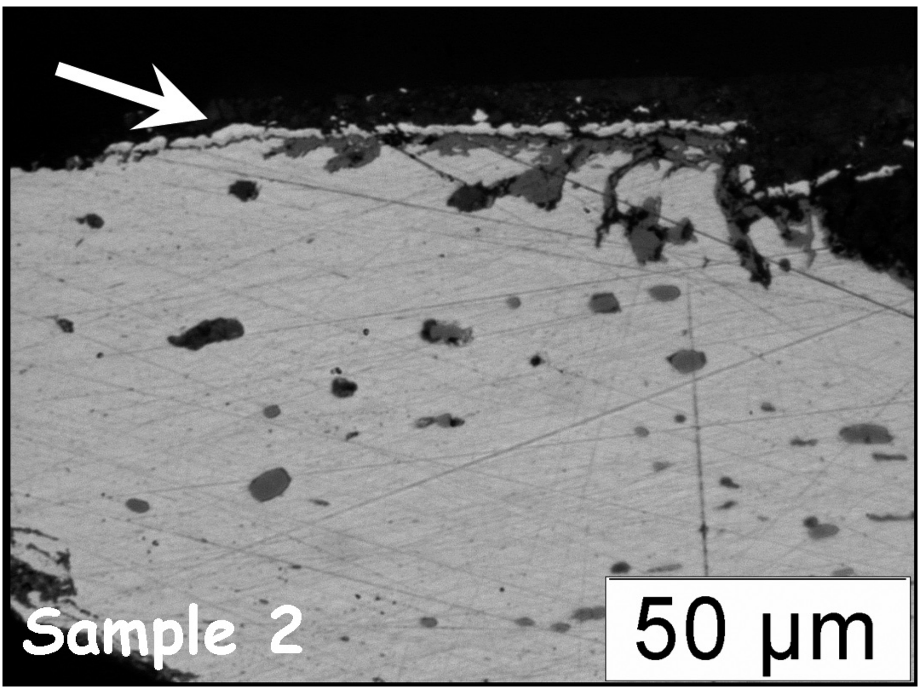

Fig. 4: Metallographic section of sample 2, not etched. Copper with lead inclusions (grey) and remnants of a tinning layer on the original surface (arrow: η-Cu_6Sn_5 phase). Photo: author.

Both optical microscopy and scanning electron microscopy show clear evidence for a tinning layer on the surface. The so-called η-phase, a silver-colored copper-tin intermetallic with the composition Cu_6Sn_5 and a characteristic wavy section with a thickness of a few µm, is continuously present in both samples on the original outer surface of the trumpet (Figures 4 and 5). This is confirmed by the SEM-EDX results, showing a high tin concentration in this layer. The surface is still visibly gray where the corrosion layer was partly removed when the object was cleaned.

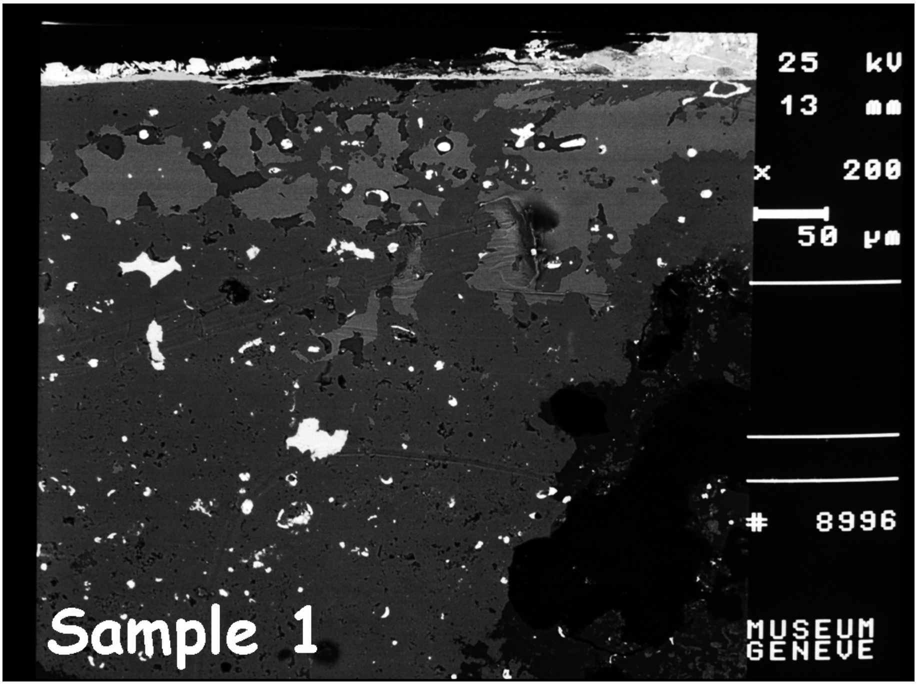

Fig. 5: Scanning electron micrograph of sample 1, not etched. Heavily mineralized copper with lead inclusions (bright) and remnants of a tinning layer on the original surface (bright: η-Cu6Sn5 phase and tin corrosion products). Photo: André Piuz (MHN Geneva).

SEM-EDX analysis of the metal substrate carried out on the metallographic samples in areas not affected by corrosion demonstrates that relatively pure leaded copper was used, with no traces of tin or zinc in the EDX spectrum (estimated detection limits around 0.5%). From the metallographic images, the lead content of the alloy was estimated to be around 10% (Figures 4 and 5).

Discussion

It is rather unfortunate that, as is the case with most objects purchased on the antiquities market, provenance and archaeological context have been irretrievably lost. Family contacts between the dealer and the Levantine region (Syria, Lebanon, Palestine) suggest that this part of the world would be the most likely origin of the objects. The dating of the trumpet remains equally uncertain. Assuming that it was in fact archaeologically associated with a set of furniture fittings sold as part of the same lot (inv. no. AA 2003-0048 to -0052), an early Byzantine date (fourth to seventh century C.E.) appears to be most likely. Otherwise, given the scarcity of information on wind instruments in late Antiquity, it could date anywhere between the second century C.E. and the Middle Ages.

Generally, our knowledge of ancient and early medieval wind instruments relies on two types of sources. Images, such as those in a small number of mosaics, inscriptions on stone, and towards the end of the period in question, illuminated manuscripts, are complemented by a few literary texts and inscriptions conveying to us names and technical

Fig. 6: Suovetaurilia sacrifice with military musicians playing tubae.
Trajan's column, Rome, ca. 110 AD [7, plate X, detail].
Source: http://commons.wikimedia.org/wiki/Image:010_Conrad_Cichorius,_Die_Reliefs_der_Traianss%C3%A4ule,_Tafel_X.jpg#file

terms used at the time for different types of instruments. In addition, a handful of actual brass instruments or fragments have emerged from the archaeological record. The available material and literary evidence is presented and reviewed by Klar,[2] Ginsberg-Klar,[3] Büchler,[4] and Alexandrescu.[5] Roman *tubae* are depicted for example on Trajan's column, ca. 110 C.E. (Figure 6).[6]

The crenellation method employed for creating a tube from sheet metal had a long tradition already in Roman times, a fact demonstrated by an Egyptian silver trumpet from the tomb of Tutankhamun (fourteenth century B.C.E.) made with the same technique,[7] even though at present this remains an isolated example because of the general scarcity of ancient trumpets in the archaeological record. The method continued to be used through the Middle Ages well into the nineteenth century, when seamless tubes were introduced.

Alexandrescu discusses the available archaeological evidence for the use of the crenellation technique, arriving at the conclusion that the crenellated and soldered Zsámbek tuba, now in the Budapest National Museum, could well be late medieval (fourteenth century or later) rather than being a Roman object as it had always been assumed.[8] Unlike the Geneva instrument with its rectangular crenellation tabs running along the full length of the fragment, the Zsámbek trumpet is reported to have irregular triangular crenellation in some parts, the joint elsewhere being secured by a simple soldering line applied to straight-edged sheet metal without crenellation.

Despite the attested use of the crenellation technique in copper alloy metalworking from at least the third century C.E. and a geographical link to the Danube region,[9] it becomes evident from Alexandru's compilation how little we still know about the evolution of musical instruments and indeed of metalworking techniques in general. This uncertainty is aggravated by the fact that, like the Geneva trumpet, many of the reference objects have lost their archaeological provenance and context.

The only copper-alloy trumpet from Antiquity made from sheet metal for which an analysis of the alloy composition is known to the author is the trumpet from Neuvy-en-Sullias (Loiret), now at the Musée Historique et Archéologique in Orléans (France). This instrument, a chance find from a sandpit without any archaeological context, possibly dates from around the first century C.E. Spectrographic point analysis was carried out on six different parts of the object in 1972 by the Laboratoire des Musées de France, with widely varying results (0.33–12.8% zinc, 0.15–13.5% tin, 0.14–7.1% lead). Due to the heavily corroded state of the instrument it would have been difficult to obtain a meaningful result for the sheet metal composition with any other technique than analytical scanning electron microscopy on metallographic sections that included sound metal. In spectrographic analysis of corroded sheet metal, any corrosion products included in the sample potentially lead to entirely unreliable results. It is difficult to see how this could have been avoided using 1970s technology. This would readily explain the wide spread in the analytical results. The analysis of the cast rings joining the sheet metal tubes of the Neuvy-en-Sullias trumpet are potentially more reliable, as the thickness of the material would have permitted drill samples to be taken, consisting of nothing but sound, uncorroded metal. Whether this was actually done or not is not clear from the published analytical data. Nevertheless, the analyses appear to confirm the presence of zinc in the sheet metal alloy, an element which is essentially absent (< 0.5 %) from the Geneva trumpet.

Microscopic evidence for tin plating of archaeological copper alloys has been extensively studied by Meeks,[10] who compared metallographic sections of tin-plated archaeological finds with replication samples of tin plating applied at different temperatures. The presence of a wavy layer of η-phase (Cu_6Sn_5) with a typical thickness of 2–5 μm was found to be characteristic of wipe-tinning carried out at relatively low temperatures, up to approximately 250°C. As pure tin melts at 232°C, this represented a simple way for tinning large copper alloy surfaces, a technique widely practiced and continually used from Antiquity until today. The η-phase is archaeologically very stable and represents an important feature for the recognition of tinning layers even on heavily corroded copper-alloy objects. Tinning on copper surfaces served a practical purpose, increasing corrosion resistance of instruments intended for outdoor use. It would also have enhanced their aesthetic qualities, imitating the appearance of silver trumpets.

Conclusion

The trumpet bell presented here was manufactured from sheet metal rolled to form a tube, the joint being secured by soldering on a crenellated seam. The original appearance of the trumpet would have been red copper on the inside and silver-colored tin plating on the outside. Workmanship, finish, and repairs appear rather crude to our modern eyes, accustomed to brass instruments with totally invisible joints in the metal. The trumpet bell gives the impression of belonging to a relatively cheap, rapidly produced instrument for simple military signaling purposes.

Kilian Anheuser studied chemistry, art history, and classics at the universities of Marburg, Freiburg, Bonn (Germany), and Oxford (UK). After several years as Lecturer in Conservation Science at Cardiff University (UK), he occupies since 2003 the post of Senior Conservation Scientist at the Musées d'art et d'histoire in Geneva (Switzerland). His research interests include historic metalworking techniques and the preventive conservation of museum objects.

Acknowledgments
The author would like to thank Marielle Martiniani-Reber, curator of the Applied Arts department at the Musée d'art et d'histoire, for permission to study the object, as well as André Piuz of the Geneva Natural History Museum, for scanning electron microscopy.

NOTES

[1] Geert Jan van der Heide, "Brass Instrument Metal Working Techniques: The Bronze Age to the Industrial Revolution," *Historic Brass Society Journal* 3 (1991): 122–50.
[2] Marlies Klar, "Musikinstrumente der Römerzeit in Bonn," *Bonner Jahrbücher* 171 (1971): 301–33.
[3] Maria E. Ginsberg-Klar, "The archaeology of musical instruments in Germany during the Roman period," *World Archaeology* 12 (1981): 313–20.
[4] Alfred Büchler, "Horns and Trumpets in Byzantium: Images and Texts," *Historic Brass Society Journal* 12 (2000): 23–59.
[5] Cristina-Georgeta Alexandrescu, "Zur Frage der Datierung der Trompete von Zsámbek, Ungarn," in Ellen Hickmann, Arnd Adje Both, and Ricardo Eichmann, eds., *Studien zur Musikarchäologie* V, *Orient-Archäologie* 20 (Rahden: Marie Leidorf, 2006): 207–20.
[6] For further images from Antiquity to the Middle Ages, see Alexandrescu, "Zur Frage der Datierung" and idem, "The Iconography of Wind Instruments in Ancient Rome: Cornu, Bucina, Tuba, and Lituus," *Music in Art* 32 (2007): 33–46.
[7] van der Heide, "Brass Instrument Metal Working Techniques"; and Alexandrescu, "Zur Frage der Datierung der Trompete von Zsámbek."
[8] Alexandrescu, "Zur Frage der Datierung der Trompete von Zsámbek."
[9] Stephan Bender, (1992), "Zum Buntmetallkessel des sogenannten Seuso-Schatzes," *Archäologisches Korrespondenzblatt* 22 (1992): 119–24.
[10] Nigel D. Meeks, "Tin-rich surfaces on bronze—some experimental and archaeological considerations," *Archaeometry* 28 (1986): 133–62; and idem, "Surface characterization of tinned bronze, high-tin bronze, tinned iron and arsenical bronze," in *Metal plating and patination,* ed. Susan La Niece and Paul Craddock (Oxford: Butterworth-Heinemann, 1993), 247–75.