

Report

on the non-destructive handheld XRF analysis of metallic idiophones
from the collection of four Hungarian museums

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INTRODUCTION

Metallic idiophones (pellet bells and bells) from the collection of four Hungarian museums [the Hungarian National Museum (Budapest, 20 objects), the Rippl-Rónai Museum (Kaposvár, 31 objects), Balaton Museum (Keszthely, 9 objects) and Savaria Museum (Szombathely, 26+2 objects)] were analysed non-destructively using a handheld XRF in the framework of ‘*Metallic Idiophones between 800 BC and 800 AD*’ project. The analysed objects are listed in the table below (red: not in the original list).

Inventory number	Site	Period	Object	Photo
Hungarian National Museum (Budapest)				
11.1935.1	?	Avar	pellet bell	
72.3.147	Solymár (burial 32)	Avar	pellet bell	
1961.82.1	unknown	Avar	pellet bell	
2.1936.85	Szebény (burial 30)	Avar	pellet bell	
46.1878.30	unknown	Avar	pellet bell	
34.1933.2		Avar	pellet bell	
50.1891.102	?	Avar	pellet bell	
4.1941.4	Pilismarót (strayfind)	Avar	bell	
54.1950.13	unknown	Avar	pellet bell	
62.149.9	unknown	Avar	pellet bell	
26.935.378	Szebény (burial 228)	Avar	pellet bell	



Inventory number	Site	Period	Object	Photo
4.1935.38	Kiskörös, burial 30	Avar	pellet bell	
5.1930.79	Cikó	Avar	pellet bell	
60.9.14	Jánoshida (burial 79)	Avar	pellet bell	
26.1935.446	Szebény (burial 276)	Avar	pellet bell	
91.1892.130	Regöly-Kapuvár, Bozót-dűlő (burial A-1)	Avar	bell	
14.1952.4	unknown	Avar	pellet bell	
52.1881.17		Avar	pellet bell	
108.1892.495	Gerjen	Avar	2 bells - earrings	
1964.20.327	Halimba-Belátó-domb (burial 172)	Avar	bell	
Rippl Rónai Museum (Kaposvár)				
RRM 78.27.3	Kaposvár 33 (tomb 36)	Avar	pellet bell	
RRM 78.31.7	Kaposvár 33 (tomb 43)	Avar	pellet bell	
RRM 78.31.8	Kaposvár 33 (tomb 43)	Avar	pellet bell	
RRM 78.35.4	Kaposvár 33 (tomb 48)	Avar	pellet bell	
RRM 76.702.2	Kaposvár 33 (tomb 18)	Avar	pellet bell	
RRM 76.625.11	Kaposvár 33 (tomb 52)	Avar	pellet bell	

Inventory number	Site	Period	Object	Photo
RRM 77.11.32	Kaposvár 33 (tomb 57)	Avar	pellet bell	
RRM 77.11.31	Kaposvár 33 (tomb 57)	Avar	pellet bell	
RRM 77.11.34	Kaposvár 33 (tomb 57)	Avar	pellet bell	
RRM 77.11.33	Kaposvár 33 (tomb 57)	Avar	pellet bell	
RRM 76.474.1	Kaposvár–Fészerlak (tomb 47)	Avar	pellet bell	
	Kaposvár–Fészerlak	Avar	pellet bell 1	
RRM 93.5.56	Kaposvár–61. sz. út (tomb 82)	Avar	pellet bell	
RRM 247.1.2352.2	Zamárdi–Réti földek (tomb 2352)	Avar	pellet bell	
	Zamárdi–Réti földek (tomb 2125)	Avar	pellet bell 2	
RRM 247.1.792.10	Zamárdi–Réti földek (tomb 792)	Avar	pellet bell	
RRM 247.1.1689.1	Zamárdi–Réti földek (tomb 1689)	Avar	pellet bell	
	Zamárdi–Réti földek (tomb 2349)	Avar	pellet bell 3	
RRM 247.1.1688.9	Zamárdi–Réti földek (tomb 1688)	Avar	pellet bell	
	Zamárdi–Réti földek (tomb 2275)	Avar	pellet bell 4	
RRM 247.1.1885.1	Zamárdi–Réti földek (tomb 1885)	Avar	pellet bell	

Inventory number	Site	Period	Object	Photo
RRM 247.1.2357.9	Zamárdi–Réti földek (tomb 2357)	Avar	pellet bell	
RRM 247.1.2099.1	Zamárdi–Réti földek (tomb 2099)	Avar	pellet bell	
RRM 247.1.1685.3	Zamárdi–Réti földek (tomb 1685)	Avar	pellet bell	
RRM 247.1.1711.8	Zamárdi–Réti földek (tomb 1711)	Avar	pellet bell	
RRM 247.1.1905.4	Zamárdi–Réti földek (tomb 1905)	Avar	pellet bell	
	Zamárdi–Réti földek (stray find)	Avar	pellet bell 5	
RRM 247.1.614.1	Zamárdi–Réti földek (tomb 614)	Avar	bell	
RRM 84.224.8	Zamárdi–Réti földek (tomb 407)	Avar	bell	
RRM 247.1.960.3	Zamárdi–Réti földek (tomb 960)	Avar	bell	
RRM 93.233.1	Vörs–Papkert B (tomb 321)	Avar	pellet bell	
Balaton Museum (Keszthely)				
47/3	Gyenes	Avar	pellet bell	
497	Zalaszabar–Borjúállás	Avar	pellet bell	
104/1	Gyenes	Avar	pellet bell	
55/1	Gyenes	Avar	pellet bell	
256/1	Gyenes	Avar	pellet bell	

Inventory number	Site	Period	Object	Photo
GyN.81.7.1	Esztergályhorváti	Avar	pellet bell	
GyN.81.10.1	Esztergályhorváti	Avar	pellet bell	
GyN.81.10.2	Esztergályhorváti	Avar	pellet bell	
	Zalaszabar–Borjúállás (grave 193)	Avar	pellet bell	
Savaria Museum (Szombathely)				
R.92.2.8	Tokorcs	Roman	bell	
2009.2.7316	Szombathely	Roman	bell	
2003.1.48	Szombathely	Roman	bell	
N.85.1.6	Szombathely	Avar	pellet bell	
K.96.1.130.2	Ikervár–Virág utca	10 th –11 th c.	bell	
N.2019.8.11	Vát–Telekes-dűlő	9 th c.	pellet bell	
N.90.1.29	Lukácsháza	Avar	pellet bell	
54.385.8	Szombathely?	Avar(?)	pellet bell	
54.712.10	Vasasszonyfa	Avar	pellet bell	
54.380.1		Roman	bell	
54.380.2		Roman	bell	

Inventory number	Site	Period	Object	Photo
54.380.3		Roman	bell	
54.380.4		Roman	bell	
54.380.5		Roman	bell	
54.380.6		Roman	bell	
54.380.7		Roman	bell	
54.380.8		Roman	bell	
54.380.10		Roman	bell	
54.380.9		Roman	bell	
54.380.11		Roman	bell	
54.380.12		Roman	bell	
54.380.13		Roman	bell	
54.380.14		Roman	bell	
54.380.15		Roman	bell	
54.374.20		Roman	bell	
54.374.21		Roman	bell	

Inventory number	Site	Period	Object	Photo
54.401.19	Szombathely	Roman	bell	
54.771.31	unknown	Roman	bell	

METHODOLOGY

SPECTRO xSORT Combi type handheld XRF spectrometer, 15–50 kV, 30–120 μ A, Rh anode, SDD detector, ‘Light Elements’ built-in calibration, measurement area 3 mm in diameter, 60 sec measurement time. The images of the measurement points are in Appendix I–IV.

RESULTS AND DISCUSSION

The analysed metallic idiophones were manufactured from different types of copper alloys: mainly bronze, leaded bronze, and leaded copper; two objects were made of gunmetal, one object of leaded gunmetal and six objects of brass (*Figs. 1–5; Tables 1–4*). There is no significant difference in the composition of the pellet bells and bells from various archaeological periods (*Fig. 5*). The composition of the alloys is very heterogeneous, generally the measured concentration of the alloying elements (Pb, Zn, Sn) is very high. It can be due to corrosion processes (especially in case of Pb and Sn, which can be enriched in the surface layer of the objects), or manufacturing processes (e.g. to enhance sounding).

The heavily corroded objects are the following: RRM 247.1.2352.2; pellet bell 2,3,4; RRM 247.1.1885.1; RRM 247.1.2099.1; RRM 247.1.1711.8; RRM 247.1.1905.4 and RRM 247.1.960.3 from the Rippl-Rónai Museum (Kaposvár); BM 47/3; BM 497; BM 104/1 and BM 55/1 from the Balaton Museum (Keszthely); 2009.2.7316; K.96.1.130.2; N.90.1.29; 54.385.8; 54.380.1; 54.380.7; 54.380.9; 54.380.13; 54.380.14 and 54.374.20 from the Savaria Museum (Szombathely) and 60.9.14; 91.1892.130; 11.1935.1; 34.1933.2; 50.1891.102; 4.1941.4; 54.1950.13; 1961.82.1; 2.1936.85; 72.3.147; 26.935.378; 4.1935.38; 5.1930.79; 26.1935.446; 108.1892.495 and 1964.20.327 from the Hungarian National Museum (Budapest). Data of these objects can be taken into consideration only qualitatively.

3 objects (BM 497 and N.90.1.29 pellet bells, 1964.20.327 bell) are gilded. RRM 76.625.11 and RRM 77.11.31–3 pellet bells were presumed to be gilded; however, the measurements disproved gilding.

Elevated silver content (4.1 wt%) was measured in case of RRM 78.31.7 pellet bell, but no sign of silvering is seen by naked eye.

Elevated chromium content (3.3 wt%) was measured in case of 54.385.8 pellet bell, indicating the use of some chromium pigment on its surface, supported by the yellowish green colour of the object.

In case of N.2019.8.11 pellet bell and 54.380.14 bell, elevated iron content was detected (20.1 and 12.2 wt%, respectively), which is higher than expected based on the extent of corrosion.

REFERENCE

Bayley, J. (1989): A suggested nomenclature for copper alloys. Ancient Monuments Laboratory Report 80/89, 12 p.

(<https://research.historicengland.org.uk/Report.aspx?i=4049&ru=%2fResults.aspx%3fp%3d1%26n%3d10%26a%3d789%26t%3dnomenclature%26ns%3d1>)

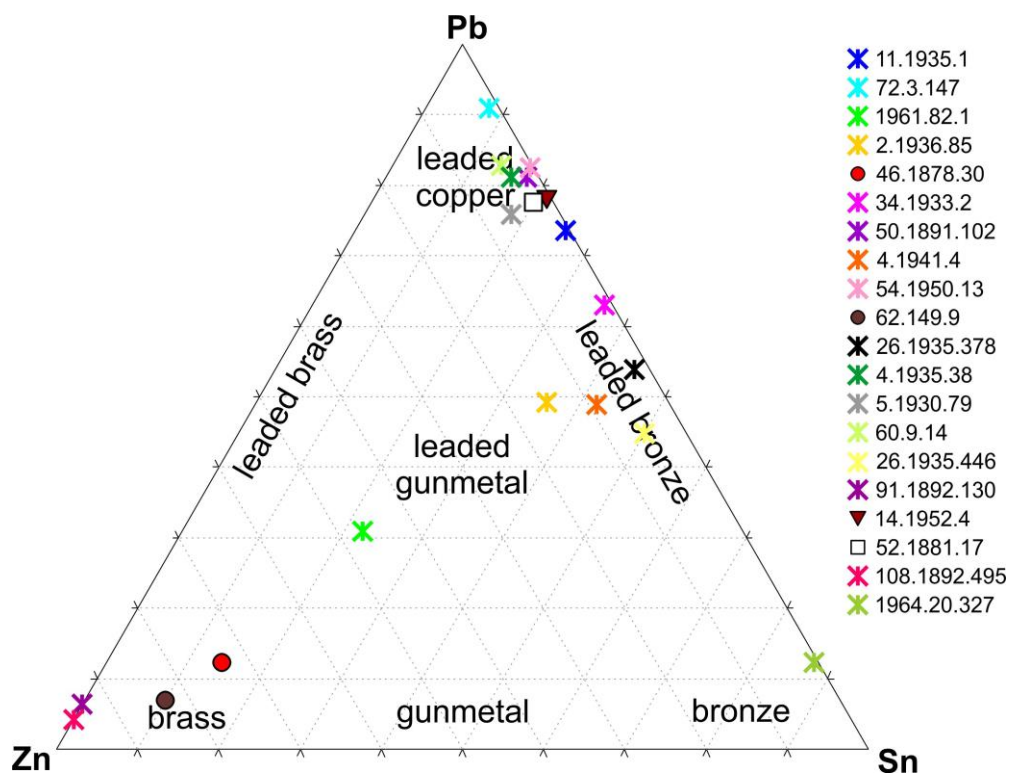


Fig. 1. Chemical composition of the metallic idiophones from the Hungarian National Museum (Budapest) plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface (*: corroded objects).

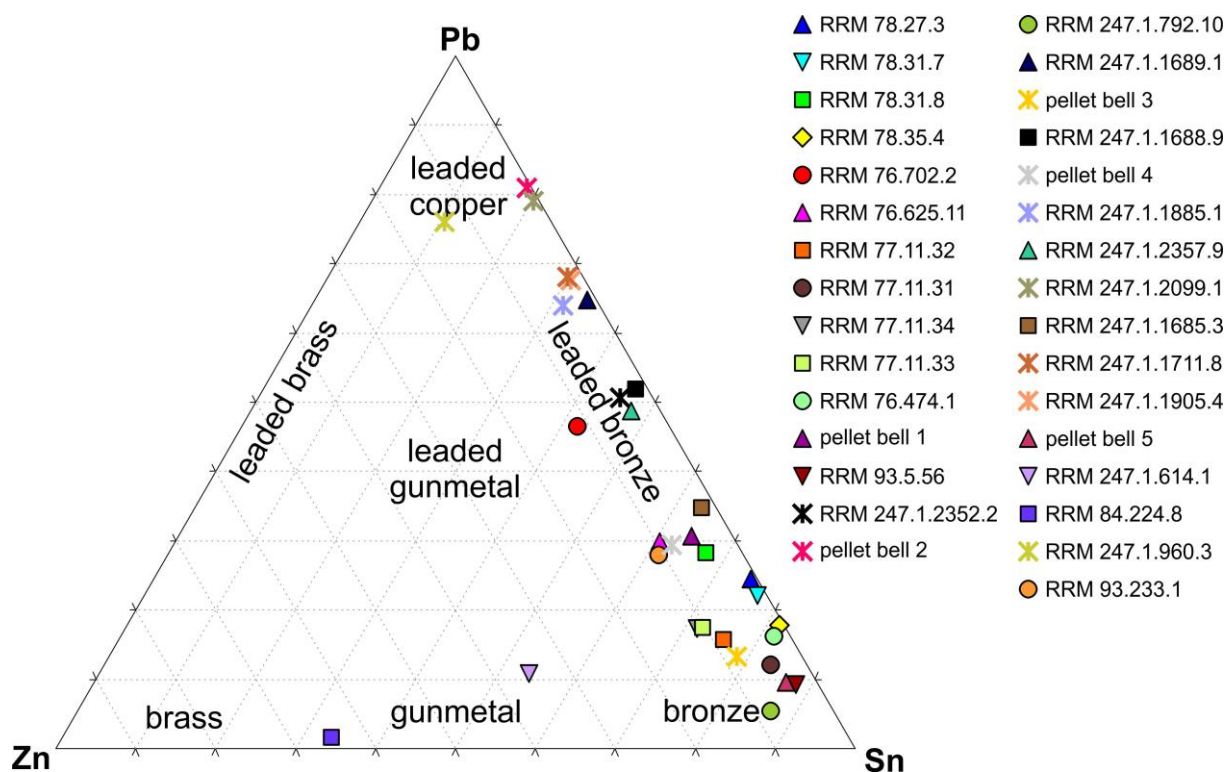


Fig. 2. Chemical composition of the metallic idiophones from the Rippl-Rónai Museum (Kaposvár) plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface (*: heavily corroded objects).

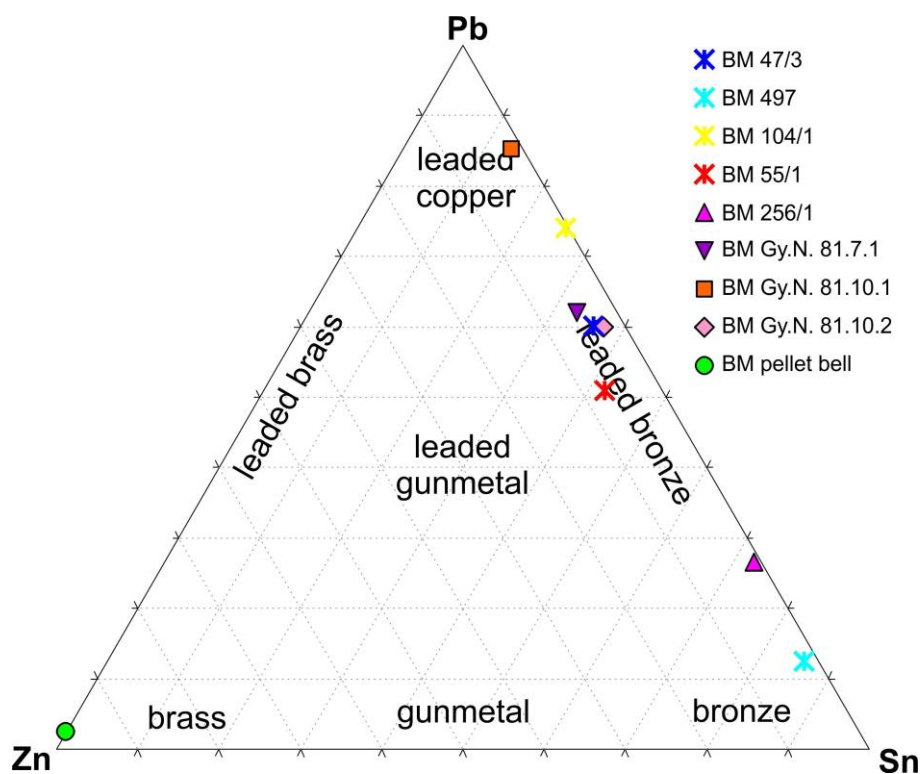


Fig. 3. Chemical composition of the metallic idiophones from the Balaton Museum (Keszthely) plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface (*: heavily corroded objects).

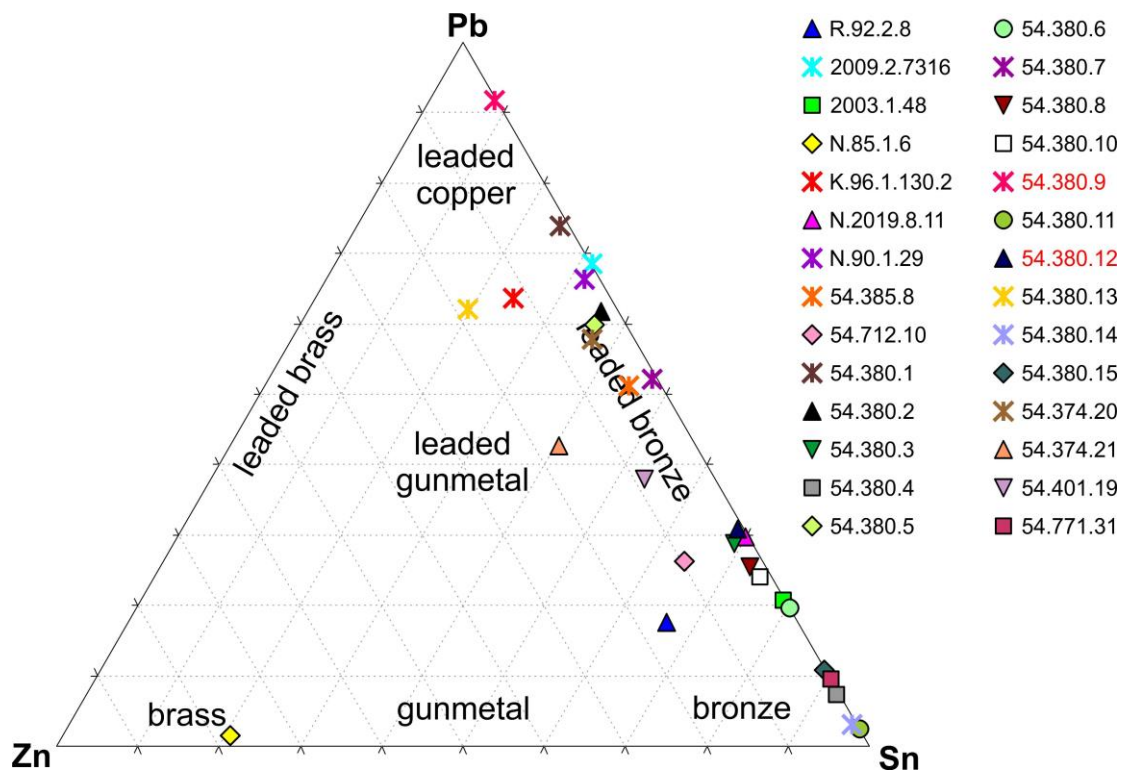


Fig. 4. Chemical composition of the metallic idiophones from the Savaria Museum plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface (*: heavily corroded objects).

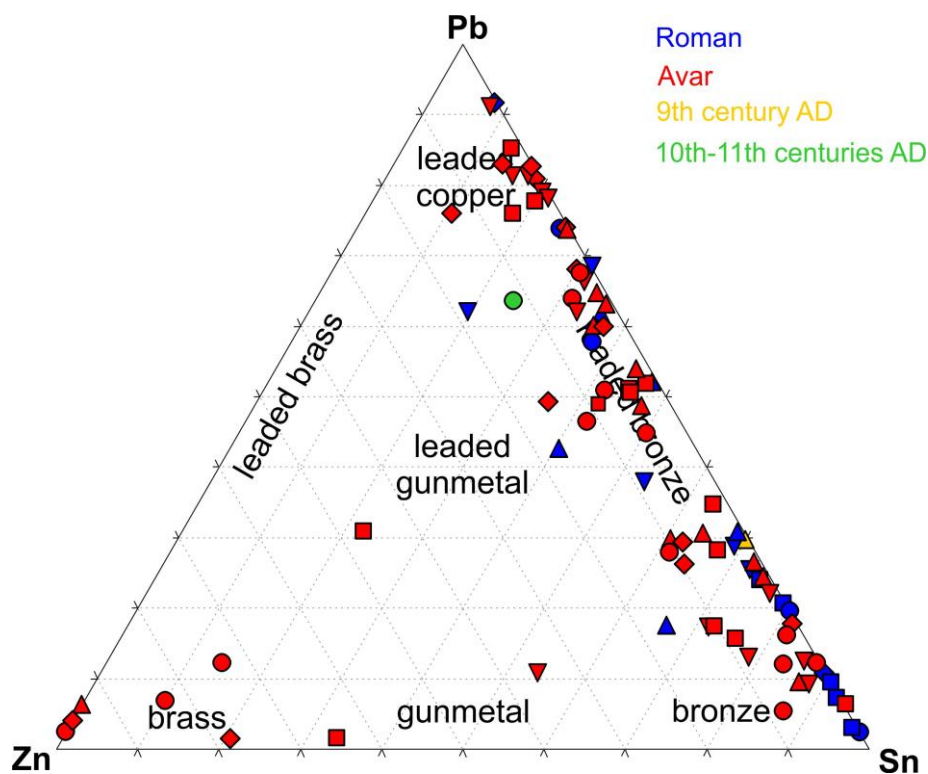


Fig. 5. Chemical composition of the metallic idiophones from various archaeological periods plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface.

Table 1: Chemical composition of the metallic idiophones from the Hungarian National Museum (Budapest) measured by hXRF. The results are in weight%.

LOD = limit of detection. The elevated Fe, Al, Si, P and S content is due to corrosion processes and soil contamination. Blue: gilding.

No.	Inventory number	Object	Cu	Sn	Pb	Zn	Au	Fe	Ag	Sb	Al	Si	P	S
10601	11.1935.1	pellet bell	68.2	4.2	11.8	0.1	< LOD	5.2	< LOD	0.5	1.5	1.4	6.2	< LOD
10602	72.3.147	pellet bell	71.2	2.0	23.7	0.3	< LOD	0.1	2.5	0.1	< LOD	< LOD	< LOD	< LOD
10603	1961.82.1	pellet bell	54.1	8.3	11.5	17.4	< LOD	1.5	< LOD	0.0	0.8	3.7	2.5	< LOD
10604	2.1936.85	pellet bell	58.2	11.7	16.1	4.9	< LOD	1.6	< LOD	0.1	1.4	1.2	1.6	< LOD
10605	46.1878.30	pellet bell	59.3	3.9	3.4	20.3	< LOD	0.4	< LOD	0.2	3.6	6.3	1.9	0.3
10606	34.1933.2	pellet bell	65.6	9.8	17.0	0.3	0.1	1.4	0.2	0.2	< LOD	0.2	4.8	< LOD
10607	50.1891.102	pellet bell	57.4	6.3	29.8	0.5	0.1	4.5	0.3	0.2	< LOD	< LOD	< LOD	< LOD
10608	4.1941.4	bell	49.0	19.2	22.3	4.1	< LOD	0.3	0.2	0.1	0.7	1.0	1.8	< LOD
10609	54.1950.13	pellet bell	45.4	8.4	40.7	0.2	< LOD	1.6	0.1	0.2	0.4	< LOD	2.3	< LOD
10610	62.149.9	pellet bell	68.7	2.8	2.0	23.7	< LOD	0.3	< LOD	0.1	< LOD	0.4	0.3	1.8
10611	26.935.378	pellet bell	43.1	22.8	27.6	1.0	< LOD	0.6	0.6	0.4	1.0	2.1	0.8	< LOD
10612	4.1935.38	pellet bell	57.7	4.2	22.2	0.9	0.1	0.3	0.4	0.2	0.5	11.6	1.6	< LOD
10613	5.1930.79	pellet bell	28.6	10.9	45.9	3.7	< LOD	7.2	0.2	0.3	0.4	2.3	< LOD	< LOD
10614	60.9.14	pellet bell	40.4	5.9	36.6	1.7	< LOD	2.4	1.5	0.2	1.0	9.7	0.4	< LOD
10615	26.1935.446	pellet bell	84.6	5.7	5.1	0.6	< LOD	0.3	< LOD	< LOD	0.8	2.4	0.1	< LOD
10616	91.1892.130	bell	78.5	< LOD	0.6	9.1	< LOD	0.2	0.2	< LOD	1.2	3.8	5.1	0.8
10617	14.1952.4	pellet bell	74.7	4.0	14.7	0.1	< LOD	0.3	< LOD	0.5	1.7	3.1	0.4	< LOD
10618	52.1881.17	pellet bell	69.8	5.6	21.8	0.7	< LOD	0.1	< LOD	0.2	1.5	0.2	< LOD	< LOD
10619	108.1892.495	2 bells - earrings	81.1	< LOD	0.4	9.2	< LOD	0.4	< LOD	0.1	1.1	3.1	3.7	0.9
10620	1964.20.327	bell	77.7	15.5	2.2	0.1	0.7	0.1	0.0	< LOD	< LOD	0.8	1.3	0.5
10621	1964.20.327	bell - gilding	60.2	14.6	1.0	< LOD	22.4	0.2	0.2	0.1	< LOD	1.0	< LOD	< LOD

Table 2: Chemical composition of the metallic idiophones from the Rippl-Rónai Museum (Kaposvár) measured by hXRF. The results are in weight%. LOD = limit of detection. The elevated Fe, Al, Si, and P content is due to corrosion processes and soil contamination.

Red: gilding presumed, but not proved; purple: silvering(?).

No.	Inventory No.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag	Fe	Al	Si	P
11261	RRM 78.27.3	pellet bell	88.9	0.1	7.8	2.5	0.1	<LOD	<LOD	0.6	0.02	<LOD	<LOD	<LOD
11262	RRM 78.31.7	pellet bell	80.6	0.1	9.3	2.7	0.1	0.1	0.1	4.1	0.03	1.6	<LOD	0.3
11263	RRM 78.31.8	pellet bell	86.4	0.5	7.7	3.3	0.7	0.1	<LOD	0.4	0.1	<LOD	<LOD	0.4
11264	RRM 78.35.4	pellet bell	70.1	0.2	22.6	5.0	0.2	0.3	0.4	0.1	0.2	<LOD	<LOD	0.5
11265	RRM 76.702.2	pellet bell	88.8	0.9	3.3	3.7	0.1	0.2	0.1	0.6	0.1	1.5	<LOD	0.2
11266	RRM 76.625.11	pellet bell	82.2	1.3	8.0	3.9	0.1	0.2	0.2	0.2	0.7	<LOD	<LOD	2.9
11267	RRM 76.625.11	pellet bell	86.4	1.2	6.2	3.0	0.1	0.1	0.2	0.1	0.5	<LOD	0.2	1.7
11268	RRM 77.11.32	pellet bell	90.3	0.8	6.9	1.5	0.1	0.03	0.1	0.1	0.1	<LOD	<LOD	<LOD
11269	RRM 77.11.32	pellet bell	87.2	2.3	6.7	0.7	<LOD	0.1	<LOD	<LOD	0.1	0.5	1.6	0.1
11270	RRM 77.11.31	pellet bell	90.2	0.4	7.6	1.1	0.1	0.1	0.1	0.2	0.1	<LOD	<LOD	<LOD
11271	RRM 77.11.31	pellet bell	88.1	5.5	4.0	0.1	<LOD	<LOD	<LOD	<LOD	0.1	<LOD	<LOD	0.1
11272	RRM 77.11.34	pellet bell	88.4	1.1	7.0	1.8	0.1	0.03	<LOD	0.1	0.2	<LOD	1.1	0.1
11273	RRM 77.11.33	pellet bell	89.8	1.0	7.0	1.7	0.1	<LOD	<LOD	0.1	0.1	<LOD	<LOD	0.04
11274	RRM 77.11.33	pellet bell	88.4	2.9	6.7	1.2	<LOD	0.1	<LOD	<LOD	0.1	<LOD	0.1	0.1
11275	RRM 76.474.1	pellet bell	77.2	0.4	14.6	3.0	0.2	0.04	0.2	0.2	0.4	<LOD	1.0	1.7
11276	pellet bell 1	pellet bell	85.3	0.6	7.2	3.4	0.2	0.1	<LOD	1.8	0.3	0.5	0.5	0.1
11277	RRM 93.5.65	pellet bell	85.9	0.3	9.3	1.0	0.3	0.1	0.2	0.4	0.2	<LOD	<LOD	1.6
11278	RRM 247.1.2352.2	pellet bell	66.5	0.7	7.5	8.5	0.1	0.1	<LOD	0.04	0.4	2.9	11.4	1.8
11279	pellet bell 2	pellet bell	67.5	0.2	5.1	22.6	0.1	0.6	0.1	0.03	0.4	<LOD	0.7	2.6
11280	RRM 247.1.792.10	pellet bell	67.9	2.3	25.1	1.7	0.1	0.6	<LOD	<LOD	0.2	<LOD	1.3	0.8
11281	RRM 247.1.1689.1	pellet bell	65.0	0.5	11.0	21.0	0.3	0.3	<LOD	0.1	0.1	<LOD	<LOD	1.8
11282	pellet bell 3	pellet bell	84.7	0.5	4.8	0.8	<LOD	<LOD	<LOD	<LOD	0.2	2.8	6.0	0.2
11283	RRM 247.1.1688.9	pellet bell	49.2	0.8	21.9	24.7	0.2	0.8	<LOD	0.7	0.7	0.5	0.2	0.1
11284	pellet bell 4	pellet bell	76.9	0.8	6.1	2.9	<LOD	<LOD	<LOD	0.04	0.2	2.7	4.7	5.7
11285	RRM 247.1.1885.1	pellet bell	35.7	2.7	18.0	36.9	0.3	<LOD	<LOD	0.2	1.3	<LOD	1.0	3.5

No.	Inventory No.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag	Fe	Al	Si	P
11286	RRM 247.1.2357.9	pellet bell	73.1	1.0	11.6	11.9	0.3	0.4	<LOD	0.5	0.1	0.3	0.4	<LOD
11287	RRM 247.1.2099.1	pellet bell	63.5	0.2	6.4	25.6	0.2	0.3	<LOD	0.4	0.1	0.8	0.2	2.1
11288	RRM 247.1.1685.3	pellet bell	81.6	0.3	10.1	5.6	0.1	0.1	<LOD	0.1	1.7	<LOD	<LOD	0.2
11289	RRM 247.1.1711.8	pellet bell	63.4	0.5	7.2	16.6	0.3	0.6	<LOD	<LOD	0.6	1.9	5.9	2.9
11290	RRM 247.1.1905.4	pellet bell	56.6	0.7	11.6	25.7	0.5	0.6	<LOD	0.1	0.2	<LOD	<LOD	3.9
11291	pellet bell 5	pellet bell	88.2	0.4	8.2	0.9	0.1	0.1	<LOD	0.8	0.1	<LOD	0.8	0.2
11292	RRM 247.1.614.1	bell	90.4	2.7	4.1	0.9	0.04	0.1	<LOD	<LOD	0.3	0.9	0.4	0.2
11293	RRM 84.224.8	bell	81.1	10.4	5.3	0.3	0.1	0.3	<LOD	<LOD	0.5	0.7	<LOD	0.1
11294	RRM 247.1.960.3	bell	51.1	4.6	3.6	26.4	0.03	0.4	0.2	<LOD	6.2	0.2	<LOD	7.0
11295	RRM 93.233.1	pellet bell	70.8	2.7	15.4	7.1	0.1	0.3	<LOD	0.6	0.2	<LOD	<LOD	1.3

Table 3: Chemical composition of the metallic idiophones from the Balaton Museum (Keszthely) measured by hXRF. The results are in weight%. LOD = limit of detection. The elevated Fe, Al, Si, P and S content is due to corrosion processes and soil contamination. Blue: gilding.

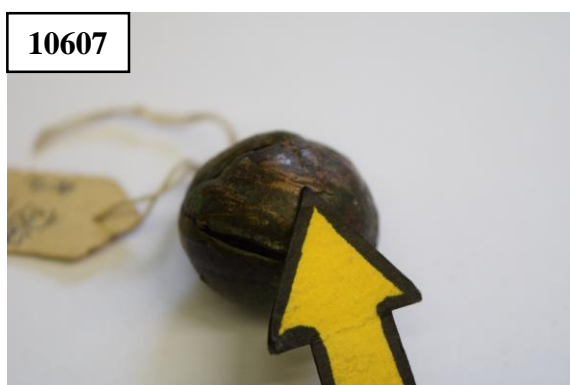
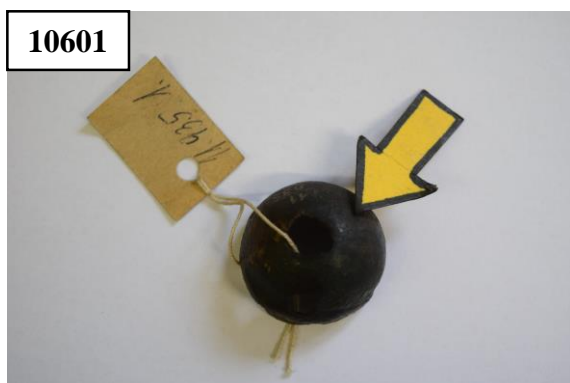
No.	Inventory No.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag	Hg	Fe	Al	Si	P	S
11296	BM 47/3	pellet bell	67.9	1.0	8.2	13.5	<LOD	<LOD	<LOD	<LOD	<LOD	1.4	0.6	0.1	7.3	<LOD
11297	BM 497	pellet bell	93.0	0.1	2.3	0.4	<LOD	0.1	1.1	<LOD	<LOD	0.1	1.6	0.7	0.6	<LOD
11298	BM 497	pellet bell	68.0	<LOD	3.1	<LOD	0.1	0.2	21.1	0.6	0.3	0.3	<LOD	<LOD	<LOD	<LOD
11299	BM 104/1	pellet bell	53.3	0.2	11.2	32.1	0.3	1.2	0.1	0.1	<LOD	0.1	0.4	<LOD	0.6	<LOD
11300	BM 55/1	pellet bell	47.5	3.0	17.7	21.4	0.2	1.2	<LOD	<LOD	<LOD	0.6	<LOD	1.1	6.8	<LOD
11301	BM 256/1	pellet bell	85.7	0.1	7.5	2.7	2.1	0.9	0.1	0.3	<LOD	0.1	<LOD	<LOD	0.2	<LOD
11302	BM 81.7.1	pellet bell	80.4	0.8	5.1	9.6	0.1	0.4	<LOD	0.2	<LOD	0.2	1.4	0.4	0.6	0.7
11303	BM 81.10.1	pellet bell	86.0	0.1	1.0	6.7	0.1	0.7	0.2	0.2	<LOD	1.1	1.4	1.1	0.1	1.1
11304	BM 81.10.2	pellet bell	57.9	1.1	13.5	21.7	0.5	0.9	0.3	0.8	<LOD	0.2	0.7	0.4	1.6	<LOD
11305	BM 193	pellet bell	69.5	21.8	<LOD	0.6	0.1	1.5	<LOD	<LOD	<LOD	0.1	1.0	3.6	0.3	1.6

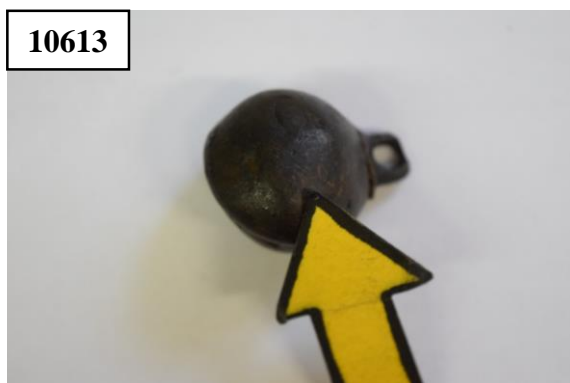
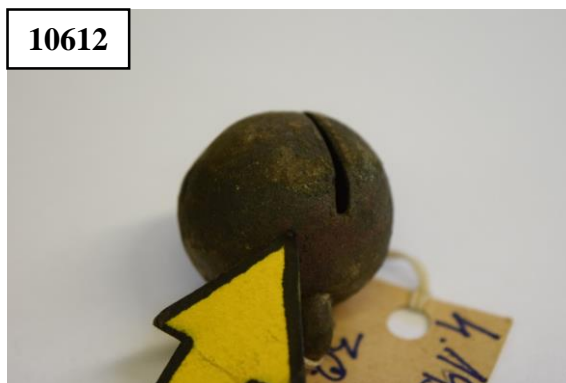
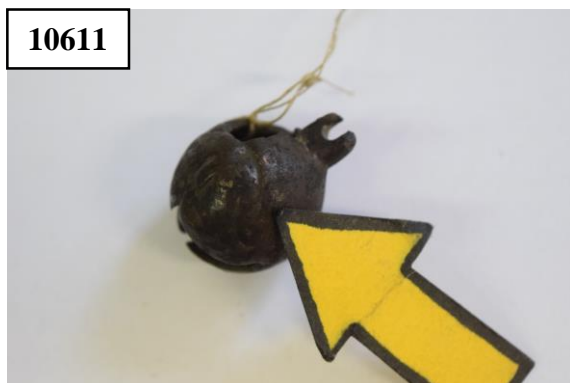
Table 4: Chemical composition of the metallic idiophones from the Savaria Museum (Szombathely) measured by hXRF. The results are in weight%. LOD = limit of detection. The elevated Fe, Al, Si, P and S content is due to corrosion processes and soil contamination. Blue: gilding; green: elevated chromium; pink: elevated iron.

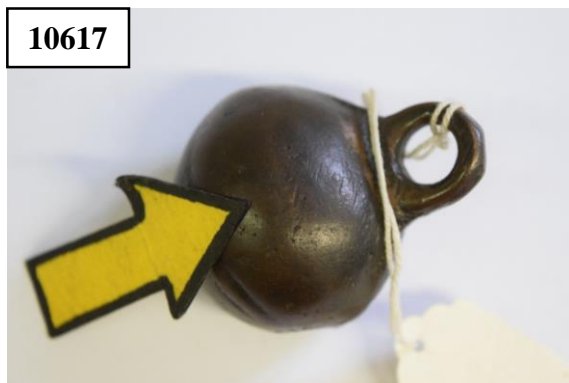
No.	Inventory No.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag	Hg	Fe	Cr	Al	Si	P	S
11306	R.92.2.8	bell	86.3	1.5	6.0	1.6	0.1	0.1	<LOD	0.04	<LOD	0.3	<LOD	<LOD	2.8	1.1	<LOD
11307	R.2009.2.7316	bell	46.1	<LOD	14.1	30.9	0.5	<LOD	<LOD	<LOD	<LOD	0.2	<LOD	<LOD	4.3	3.9	<LOD
11308	2003.1.48	bell	61.0	0.1	24.3	6.4	0.1	<LOD	<LOD	<LOD	<LOD	0.4	<LOD	1.2	4.0	2.1	<LOD
11309	N.85.1.6	pellet bell	70.6	20.7	5.5	0.4	0.1	0.2	<LOD	<LOD	<LOD	0.4	<LOD	0.6	1.1	0.2	0.2
11310	K.96.1.130.2	bell	31.7	7.0	14.0	36.8	0.2	1.2	<LOD	<LOD	<LOD	1.3	<LOD	<LOD	2.7	5.1	<LOD
11311	N.2019.8.11	pellet bell	48.9	0.1	7.4	3.1	3.6	0.5	<LOD	0.1	<LOD	20.1	<LOD	2.5	5.4	7.6	<LOD
11314	N.90.1.29	pellet bell	42.8	0.1	1.3	2.8	0.3	0.2	30.8	1.6	<LOD	14.0	<LOD	<LOD	<LOD	1.3	<LOD
11316	54.385.8	pellet bell	63.5	1.1	11.0	12.6	0.3	0.5	<LOD	0.4	<LOD	0.6	3.3	1.2	1.5	2.7	1.2
11317	54.712.10	pellet bell	86.9	1.0	6.4	2.6	0.1	<LOD	0.1	0.5	<LOD	0.1	<LOD	1.0	0.4	<LOD	0.7
11318	54.380.1	bell	50.3	0.5	9.4	28.1	0.2	0.6	<LOD	<LOD	<LOD	2.3	0.02	1.5	<LOD	6.9	<LOD
11319	54.380.2	bell	60.0	0.7	10.8	18.3	0.2	0.3	0.1	<LOD	<LOD	0.4	<LOD	1.1	3.7	4.2	<LOD
11320	54.380.3	bell	62.1	0.7	20.4	8.7	0.1	0.3	<LOD	<LOD	<LOD	0.5	<LOD	1.1	4.7	1.0	<LOD
11321	54.380.4	bell	75.8	0.1	18.4	1.4	0.1	0.2	<LOD	<LOD	<LOD	0.4	<LOD	<LOD	1.1	2.2	<LOD
11322	54.380.5	bell	38.3	1.5	12.7	21.0	0.3	0.4	<LOD	<LOD	<LOD	7.8	<LOD	2.5	14.0	1.0	<LOD
11323	54.380.6	bell	79.6	0.0	14.7	3.6	0.2	<LOD	0.1	<LOD	<LOD	0.3	<LOD	<LOD	0.3	1.1	<LOD
11324	54.380.7	bell	44.5	0.4	19.5	21.3	0.2	0.3	<LOD	1.1	<LOD	0.5	<LOD	3.1	7.1	1.8	<LOD
11325	54.380.8	bell	80.0	0.4	13.8	4.9	0.1	0.1	<LOD	<LOD	<LOD	0.2	<LOD	<LOD	<LOD	0.2	<LOD
11326	54.380.10	bell	82.4	0.3	11.1	3.6	0.2	0.3	<LOD	<LOD	<LOD	0.5	<LOD	<LOD	<LOD	0.8	0.1
11327	54.380.9	bell	30.0	0.3	4.6	53.6	0.1	<LOD	<LOD	<LOD	<LOD	1.7	<LOD	1.2	6.9	1.2	<LOD
11328	54.380.11	bell	82.6	0.03	13.9	0.3	0.1	0.1	<LOD	<LOD	<LOD	0.5	<LOD	<LOD	1.1	0.9	0.3
11329	54.380.12	bell	67.1	0.2	10.8	4.8	<LOD	<LOD	<LOD	<LOD	<LOD	1.5	<LOD	2.6	12.5	0.5	<LOD
11330	54.380.13	bell	64.2	4.2	4.4	14.2	0.1	0.3	<LOD	<LOD	<LOD	1.1	<LOD	1.2	4.8	5.0	<LOD
11331	54.380.14	bell	52.9	0.1	16.0	0.5	0.1	0.4	<LOD	<LOD	<LOD	12.2	<LOD	1.5	4.7	10.8	0.4
11332	54.380.15	bell	63.9	0.1	28.0	3.4	0.2	0.2	0.2	<LOD	<LOD	0.3	<LOD	<LOD	1.9	1.3	<LOD
11333	54.374.20	bell	37.3	2.8	18.5	29.0	0.5	0.6	<LOD	0.3	<LOD	1.0	<LOD	<LOD	4.6	5.1	<LOD

No.	Inventory No.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag	Hg	Fe	Cr	Al	Si	P	S
11334	54.374.21	bell	55.1	4.5	10.5	11.0	0.3	0.5	<LOD	<LOD	<LOD	2.5	<LOD	2.3	6.3	6.6	<LOD
11335	54.401.19	bell	56.8	2.5	14.9	10.7	0.1	0.4	<LOD	<LOD	<LOD	1.8	0.03	1.9	8.7	1.9	<LOD
11336	54.771.31	bell	54.9	0.1	33.9	3.6	0.3	0.1	<LOD	<LOD	<LOD	0.9	<LOD	0.8	3.4	2.1	<LOD

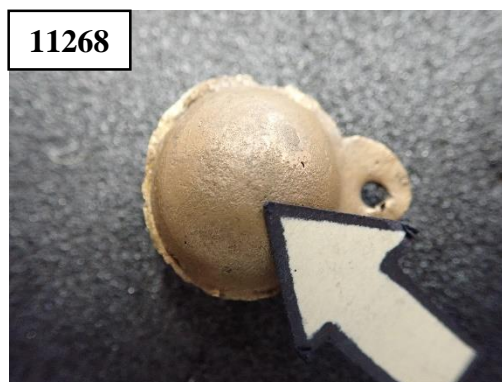
Appendix I: hXRF measurement points – Hungarian National Museum (Budapest)

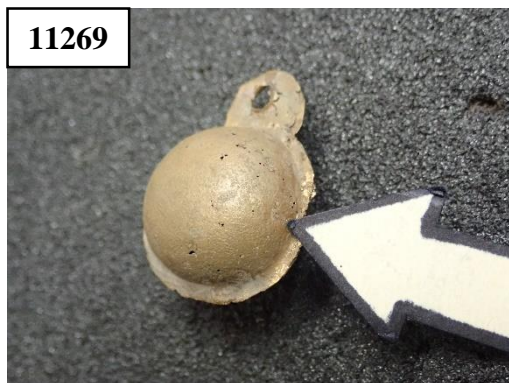






Appendix II: hXRF measurement points – Rippl-Rónai Museum (Kaposvár)



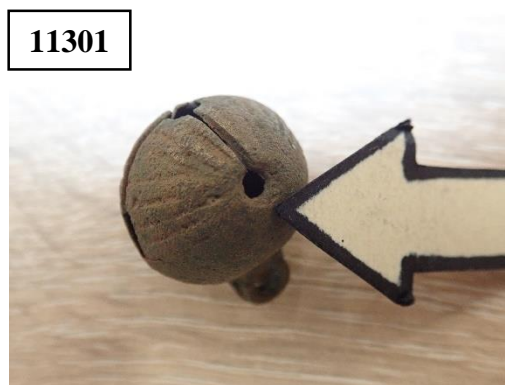








Appendix III: hXRF measurement points – Balaton Museum (Keszthely)





Appendix IV: hXRF measurement points – Savaria Museum (Szombathely)



