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zostavovateľ Zborníka SNM Archeológia v rokoch 2009 až 2020,
sa v tomto roku dožíva okrúhleho životného jubilea.

Kolegovia a priatelia želajú jubilantovi do ďalších rokov veľa zdravia, spokojnosti a úspechov!

PhDr. Vladimír Turčan,
long-term researcher of the Slovak National Museum – Archaeological Museum,
editor of the Zborník SNM Archeológia between 2009 and 2020,
is experiencing a round life jubilee this year.

Colleagues and friends wish the jubilant good health, satisfaction and success in the coming years!

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METALLIC IDIOPHONES OF THE EARLY HISTORY PERIOD FROM THE ARCHAEOLOGICAL COLLECTION OF THE SLOVAKIAN NATIONAL MUSEUM IN BRATISLAVA

BEATE MARIA POMBERGER – JÖRG MÜHLHANS – KAYLEIGH SAUNDERSON

Keywords: Avar period, Roman period, Slovakia, musicarchaeology, acoustics, psychoacoustics, archaeometallurgy, pellet bells, bells, textiles.

Abstract: *Metallic idiophones of the Early History Period from the archaeological collection of the Slovak National Museum in Bratislava.* Sixteen Avarian pellet bells and seven Roman bells housed in the Archaeological Slovak National Museum in Bratislava were investigated within the framework of the research project “Metallic Idiophones between 800 BC and 800 AD in Central Europe”. They originate from Bratislava-Rusovce (Roman Gerulata), Bratislava-Jarovce, Židovská ulica in Bratislava, Vištuk, Komárno, and Streda nad Bodrogom, and the Avar-period cemeteries Bratislava-Devínska Nová Ves (cemetery I), Bratislava-Záhorská Bystrica and Bratislava-Rusovce (site: Pri cintoríne). Due to their find positions they can give information about their function. Analyses on their sounds, their psychoacoustic features as well as their chemical compositions were carried out. Textile traces on one pellet bell were analysed. Comparisons of the existence of pellet bells in contemporary cultures are presented.

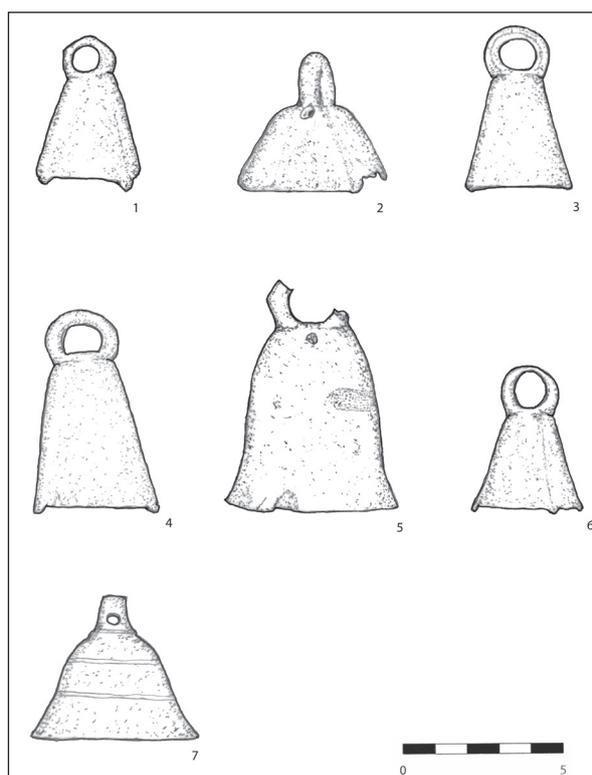
1. INTRODUCTION AND THE RESEARCH PROJECT

There are several bells from the Roman period and pellet bells from the Avar period in the collection of the Slovak National Museum – Archaeological Museum in Bratislava. They are part of the idiophones to be investigated in the research project “Metallic Idiophones between 800 BC and 800 AD in Central Europe”. This interdisciplinary project is funded by the Austrian Science Funds FWF and supported by the Natural History Museum Vienna. Archaeological, chemical, acoustic, psychoacoustic and textile investigations are carried out as had already

been described in previous articles (Pomberger et al. 2020; 2021; Pomberger/Mühlhans/Grömer 2021) and the results are presented in this paper.

Fig. 1. Bells from the Roman period and historic period. 1 – Bratislava-Rusovce (site: Pri cintoríne) AP009445, 2 – Bratislava-Jarovce AP52172, 3 – Vištuk AP76204, 4 – Komárno AP13771, 5 – Komárno AP13772, 6 – Streda nad Bodrogom-Hradištná; 7 – Bratislava – Židovská ulica HF32157 (graphic: B. M. Pomberger).

Obr. 1. Zvončeky z doby rímskej a historického obdobia. 1 – Bratislava-Rusovce (poloha: Pri cintoríne) AP009445, 2 – Bratislava-Jarovce AP52172, 3 – Vištuk AP76204, 4 – Komárno AP13771, 5 – Komárno AP13772, 6 – Streda nad Bodrogom-Hradištná; 7 – Bratislava – Židovská ulica HF32157 (grafika: B. M. Pomberger).



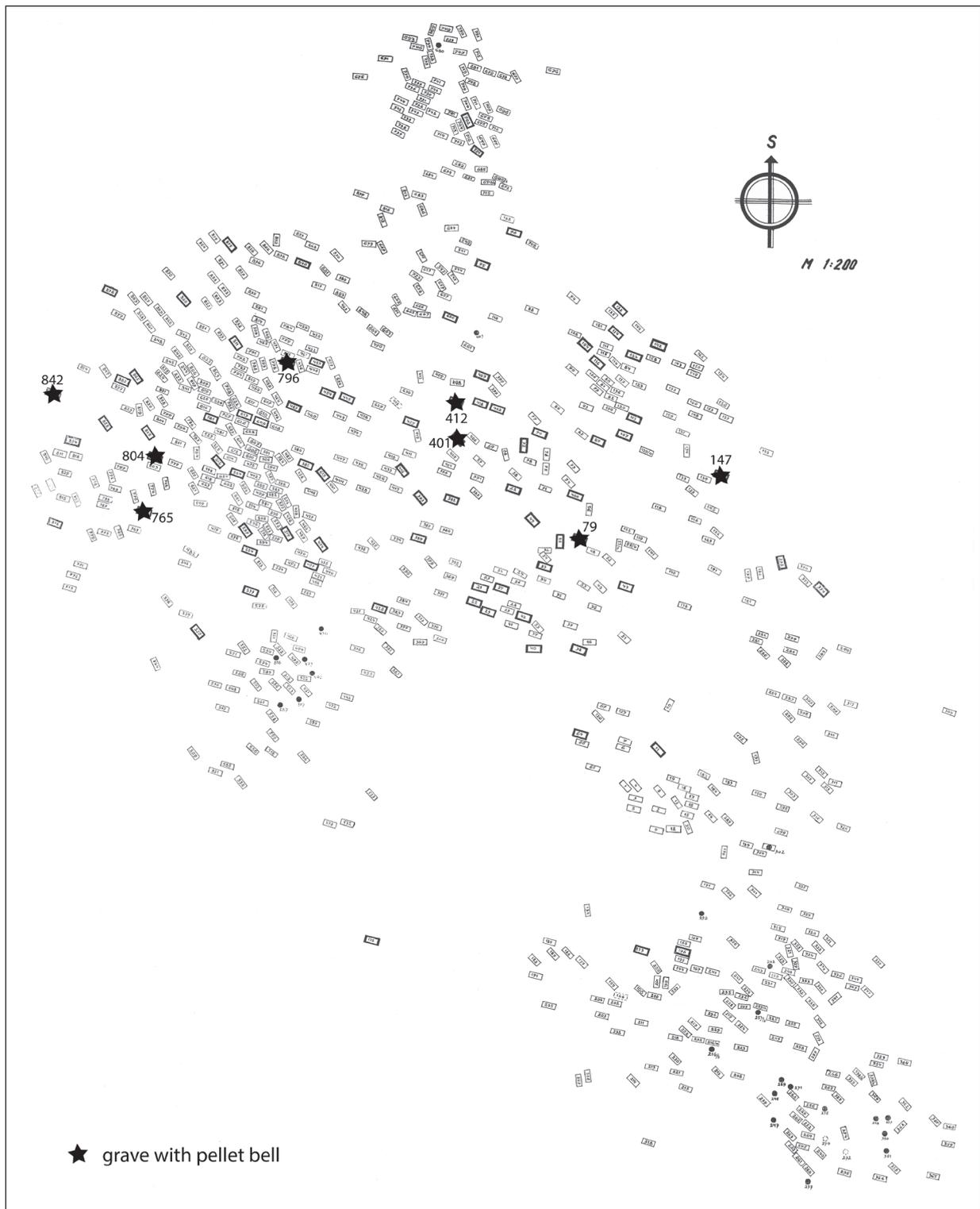
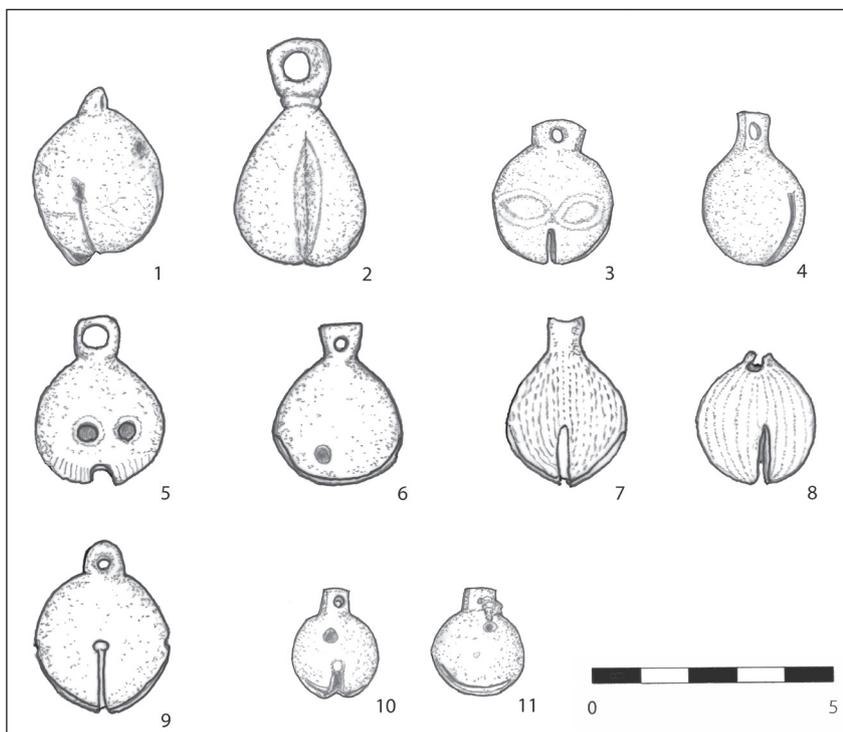


Fig. 2a. Devínska Nová Ves (cemetery I) with marked graves with pellet bells. (map according to *Eisner 1952*; graphic: B. M. Pomberger).

Obr. 2a. Devínska Nová Ves (pohrebisko I) s vyznačenými hrobmi s rolničkami. (mapa podľa *Eisner 1952*; grafika: B. M. Pomberger).

Fig. 2b. Devínska Nová Ves (cemetery I). Pellet bells: 1 – AP000123, 2 – AP000124, both grave 79; 3 – AP000273, 4 – AP000272, both grave 147; 5 – AP000482, grave 401; 6 – AP000501, grave 412; 7 – AP000926, grave 765; 8 – AP000968, grave 796; 9 – AP000982, grave 804; 10 – AP001056, 11 – AP001057, both grave 842 (according: Eisner 1952; graphic: B. M. Pomberger).

Obr. 2b. Devínska Nová Ves (pohrebisko I). Rolničky: 1 – AP000123, 2 – AP000124, oba z hrobu 79; 3 – AP000273, 4 – AP000272, oba z hrobu 147; 5 – AP000482, hrob 401; 6 – AP000501, hrob 412; 7 – AP000926, hrob 765; 8 – AP000968, hrob 796; 9 – AP000982, hrob 804; 10 – AP001056, 11 – AP001057, oba z hrobu 842 (podľa Eisner 1952; grafika: B. M. Pomberger).



2. THE SITES AND THE DATING

2.1 ROMAN PERIOD

Little is known about the find situation of the Roman period bells. One bell (Cat. 17) originates from cemetery II of the Roman fort *Gerulata* in the district Rusovce, Bratislava V (Pichlerová 1981, 199, Tab. CLXXXII: 2). This equestrian fort was founded by the Romans during the 1st century AD and held until the 4th century AD. Another deformed bell (Cat. 18) was discovered in Jarovce, in the South of Bratislava (e.g. Bazovský 2008, 24, Fig. 3). From Vištuk, district Pezinok, located north-east of Bratislava, one bell is known (Cat. 19). Vištuk was a Germanic settlement and dates in the late antiquity period. Two bells were detected in Komárno (Cat. 20, Cat. 21). One probably in historic time dating bell (Cat. 23) originates from the Židovská ulica in Bratislava, probably from a settlement. One bell (Cat. 22) which could be from the Roman period was found in Streda nad Bodrogom, in the south-east of Slovakia. Unfortunately, there are no further information about the find situation of all these bells (Fig. 1).

2.2 AVAR PERIOD

The Avar period cemetery I of Bratislava-Devínska Nová Ves, which consists of 862 graves in total, contains only 11 pellet bells. They originate from eight burials, namely 79, 147, 401, 412, 765, 796, 804 and 842 (see Fig. 2). The middle-late Avar period cemetery is dated from the third decade of the 7th century to the end of the 8th century AD (Eisner 1952, 407; Zábojník 2009, 81). According to the current state of research the pellet bells in MAP II (Csuthy 2019; Pomberger/Stadler 2018), which is proved by grave 79 of Devínska Nová Ves I. The cemetery of Bratislava-Záhorská Bystrica was occupied from the second half of the 7th century until the 8th century. The original number of relatively modestly furnished tombs was estimated at 400, but only 262 were excavated. Three pellet bells are known from three graves (graves: 83, 208, 166; Fig. 3; Kraskovská 1972; Zábojník 2009, 86). In Bratislava-Rusovce (site: Pri cintoríne) was one grave, a double burial (grave 34), where two small pellet bells were found. The grave dates into the 8th century (Fig. 4; Pichlerová/Stloukal 1978, 126; Zábojník 2009, 85). Furthermore, the archaeological collection of the Slovak National

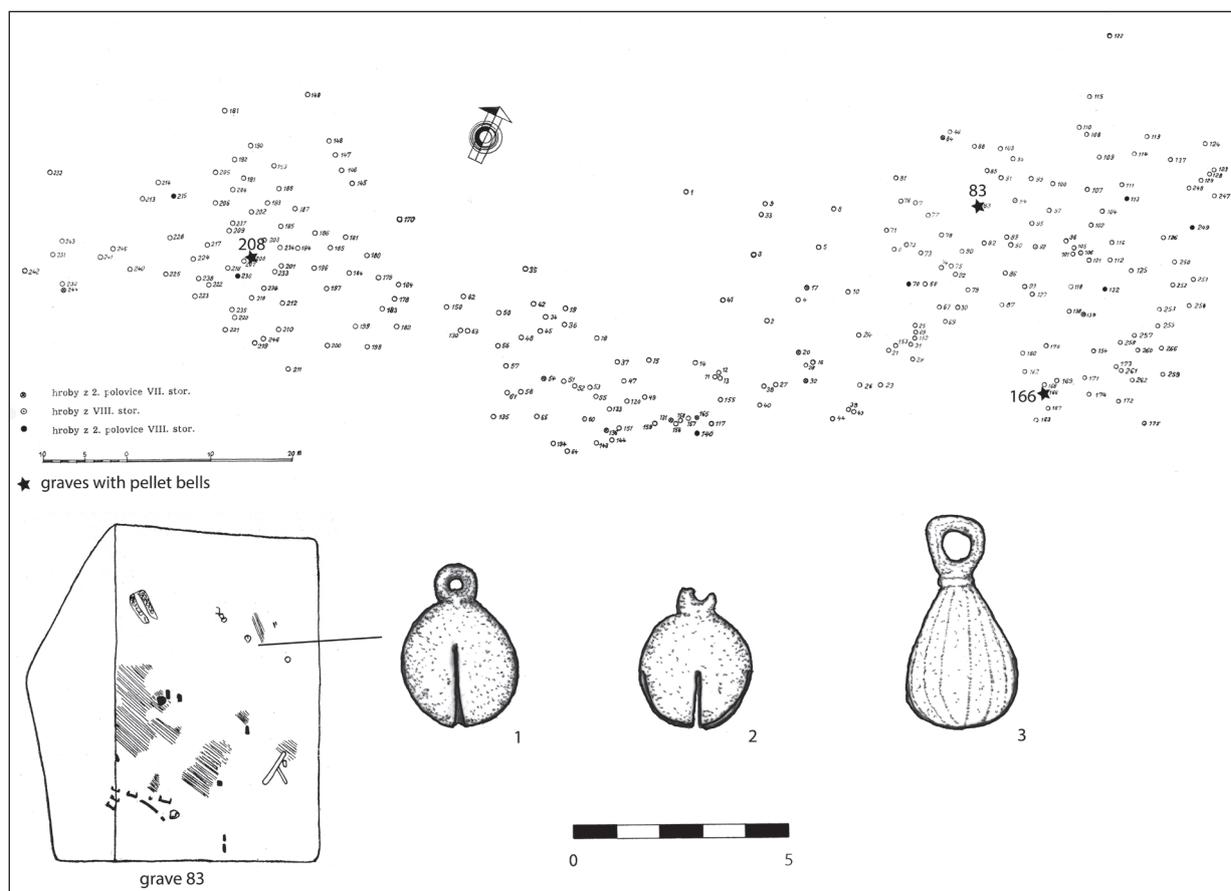


Fig. 3. Cemetery of Záhorská Bystrica with marked graves and pellet bells. 1 – AP012073, grave 83; 2 – AP012438, grave 166; 3 – AP014098, grave 208 (map according to *Kraskovská 1972*, Fig. 2; graphic: B. M. Pomberger).

Obr. 3. Pohrebisko v Záhorskej Bystrici s vyznačenými hrobmi a rolničkami. 1 – AP012073, hrob 83; 2 – AP012438, hrob 166; 3 – AP014098, hrob 208 (mapa podľa *Kraskovská 1972*, obr. 2; grafika: B. M. Pomberger).

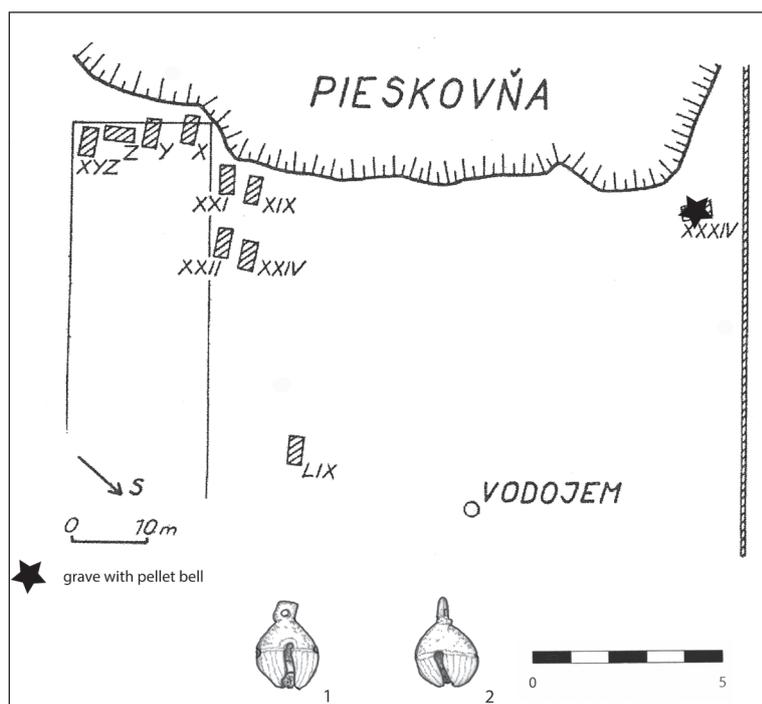


Fig. 4. Bratislava-Rusovce (site: Pri cintoríne) with marked graves and pellet bells. 1 – AP021001, 2 – AP2021002, both from grave 34 (map according to *Pichlerová/Stloukal 1978*, Fig. 1b; graphic: B. M. Pomberger).

Obr. 4. Pohrebisko v Bratislave-Rusovciach (poloha: Pri cintoríne) s vyznačenými hrobmi a rolničkami. 1 – AP021001, 2 – AP2021002, oba z hrobu 34 (mapa podľa *Pichlerová/Stloukal 1978*, obr. 1b; grafika: B. M. Pomberger).

Museum – Archaeological Museum in Bratislava houses some bells from later historic periods. They originate from Radzovce, Košice, Hronský Beňadik and Devín. They are dealt with in this article only in passing.

3. THE GRAVES WITH PELLET BELLS AND THE FIND POSITION

All eleven pellet bells from the Bratislava-Devínska Nová Ves (cemetery I) were found in graves of riders with horses. The pellet bells lay in the area of the horse skulls or forelegs and belonged to the animals' harness. The horses from graves 79, 147

and 842 each had two bells near the horse skull (Cat.: 1–4, 10–11). The pellet bell from grave 412 lay near the forelegs of the horse (Cat. 6). Each one bell was found near the horse skull in the burials 765 (Cat. 7), 796 (Cat. 8) and 804 (Cat. 9). Unfortunately, there is no information about the exact find position of the pellet bell from grave 401 (Cat. 5; Fig. 2; *Eisner 1952*, 24, 25, 47, 48, 91, 92, 94, 95, 161, 168, 181–183, pl. 3, 12, 21, 45, 47, 81, 84, 89, 94). For all pellet bells found near the skull we would propose, that they were fixed on the headstall. The one bell located near the forelegs might have been fixed on a sternum strap.

The find situation on the graves with pellet bells from the cemetery of Záhorská Bystrica is different. We know three bells, each from one burial, but the skeletons nearly passed away. Grave 83, burial of a rider and his horse, was disturbed and the pellet bells probably belonged to the horse gear (Cat. 12). The skeleton of the deceased in grave 208 (a woman?) passed away, but the idio- phone belonged to the deceased (Cat. 13). In the child's burial, grave 166, the pellet bell was found



Fig. 5. Share of burials with pellet bells (graphic: B. M. Pomberger).

Obr. 5. Podiel hrobov s roľničkami (grafika: B. M. Pomberger).

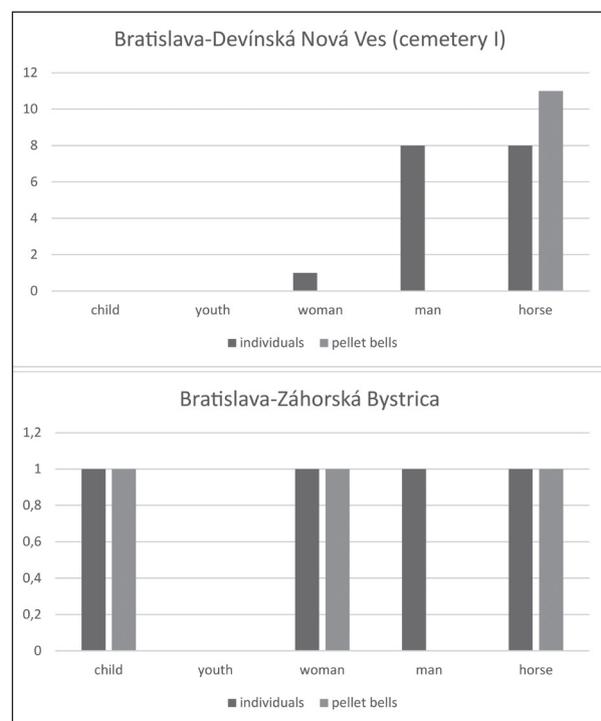


Fig. 6. Distribution of pellet bells in burials (author: B. M. Pomberger).

Obr. 6. Zastúpenie roľničiek v hroboch (autor: B. M. Pomberger).

in the middle of the grave pit, whereas the skeleton passed away (Cat. 14; Fig. 3; *Kraskovská 1972*, 22–25, 35, 36, 40, pl. 24, 37, 42). The child kept the idiophone somewhere on a ribbon or belt.

Very clear is the find situation in grave 34 a-b in Bratislava-Rusovce (site: Pri cintoríne). In this double burial the female skeleton (burial b) lay above the child's burial (burial a). The two pellet bells were found in the middle of the 30–40 years old woman's skeleton (Cat.: 15–16, Fig. 4) (*Pichlerová/Stloukal 1978*, 129, Figs. 3, 4).

Figure 5 shows very small amount of burials with pellet bells in the cemeteries of Bratislava-Devínska Nová Ves (cemetery I) und Bratislava-Záhorská Bystrica. The Slavic-Avarian burial ground of Bratislava-Rusovce (site: Pri cintoríne) consists of only two burials, one of which contained pellet bells. In the cemetery (I) of Bratislava-Devínska Nová Ves only horses were equipped with pellet bells. The cemetery of Bratislava-Záhorská Bystrica shows another situation. Here children, women and horses had pellet bells, but no single man (Fig. 6).

4. MORPHOLOGICAL ANALYSIS, DECORATIONS AND MEASUREMENTS

4.1 SHAPES OF PELLET BELLS

The pellet bells are all cast in lost wax technique and can be classified into four basic shapes (Fig. 7; *Pomberger 2020*). Shape I is presented by nine pellet bells (Cat.: 1, 3, 7, 8, 10–12, 14, 15), shape II by two pellet bells, (Cat.: 4, 6), shape IV by two items (Cat.: 5, 16) and shape VIII also by two pellet (Cat.: 2, 13). The drop shaped pellet bells originate from Devínska Nová Ves – grave 79 and Záhorská Bystrica – grave 208. A related shaped pellet bell is known from the Avar period cemetery at Szebeny I (Hungary) – grave 30 (*Garam 1975*, 77, pl. 4: 30/3). All pellet bells are cast in lost wax technique. They show simple sound and cruciform sound slots. The sound holes are arranged in three different ways: four sound holes at the ends of a cruciform sound slot, two opposite sound holes in the middle of the sound body and two pairs of sound holes opposite arranged un-

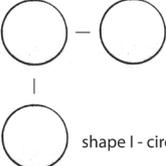
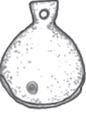
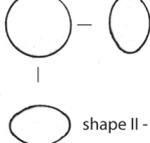
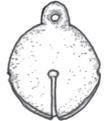
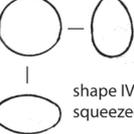
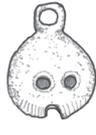
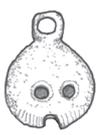
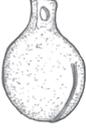
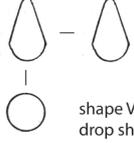
basic shapes	production	sound slot	sound holes and position	decoration
 <p>shape I - circular</p>	 <p>cast</p>	 <p>simple</p>	 <p>2 opposite sound holes</p>	 <p>eyes</p>  <p>sound holes like eyes</p>
 <p>shape II - oval</p>		 <p>cruciform</p>	 <p>four soundholes at the end of the sound slots</p>	 <p>vertical grooves</p>
 <p>shape IV - oval squeezed</p>			 <p>pair of opposite sound holes</p>	 <p>grooves near sound slot</p>  <p>none</p>
 <p>shape VIII - drop shaped</p>				

Fig. 7. Shapes of pellet bells (graphic: B. M. Pomberger).

Obr. 7. Tvary rolničiek (grafika: B. M. Pomberger).

der the belly center. Nearly related exemplars are known from the Great Migration Period collection of the Hungarian National Museum in Budapest, from unknown sites. In the Great Migration Period collection of the Rippl-Ronai Museum in Kaposvár (Hungary) pellet bells are kept from the Avar cemetery of Zamardi-Retiföldek, graves: 792 (Bárdos/Garam 2009, pl. 97: 792/4), 1711, 1885, 2019, 2088, 2099, 2308 (Bárdos/Garam 2014, pl. 187:1711/9; 198: 1885/4; 220: 2091/5; 221: 2099/4; 241: 2308/8). The pellet bells also show different decorations on the surfaces. There are two pair of eyes arranged opposite, two pair of sound holes like eyes arranged opposite, vertical grooves either over the whole sound body or the below halve, a ribbon of small vertical grooves near the sound slot – or simply a smooth surface (Fig. 7). The sizes of the pellet bells range from 2.3 cm to 4.8 cm. The wall thickness is between 0.5 mm and 2 mm and the weight ranges between 7 g and 33 g. As rattle bodies pebbles could be determined in rattle bodies (Cat.: 1, 7, 8, 14, 15). One pellet bell (Cat. 5) has a bronze ball inside as rattle body. The rattle bodies from the other pellet bells are lost or cannot be determined.

4.2 TYPES OF ROMAN BELLS

All Roman bells are cast in copper alloys and are classified into two types (Fig. 8, Pomberger 2018).

Type 1 with rectangular base appears in two variants. Variant B is presented by four bells (Cat.: 17, 19, 20, 22) and variant C by one bell (Cat. 18). The oval based type 2/variant A is presented by one bell (Cat. 21). All these bells show no decoration on the surface. Bell HF 23165 (Cat. 23) has a circular base and two circular grooves as decoration. The bells' sizes range between 4.1 cm and 7.4 cm and the wall thickness is between 1 mm to 3 mm. Their weight ranges between 31 g and 71 g. The clappers are all lost or corroded, because they were forged from iron.

5. CHEMICAL ANALYSES

Ten pellet bells and six bells were investigated by X-ray fluorescence method by Ján Tirpák, (Gemological Institute at Constantine the Philosopher University in Nitra) with regard to their chemical components. The analyses were carried out with using a handheld X-ray fluorescence spectrometer DELTA CLASSIC+ from Olympus from the USA, which is intended for non-destructive quantitative analyses of archaeological objects. This spectrometer measures only the composition of surface layer of the objects at the measured place and cannot guarantee the homogeneity of the material measured in its whole volume. J. Tirpák found out, that two pellet bells were made of bronze with rather small amounts of lead (Cat.:

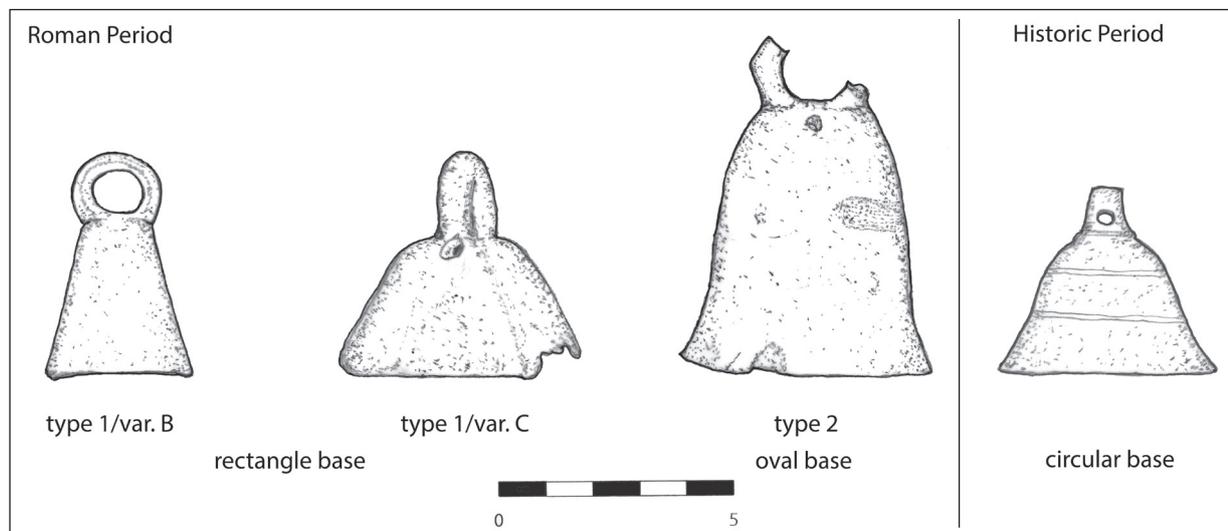


Fig. 8. Types of bells (graphic: B. M. Pomberger).
Obr. 8. Typy zvončekov (grafika: B. M. Pomberger).

Cat. Nr.	Idiophone	SNM – AM Inv. Nr.	Fe	Cu	Zn	As	Ag	Sn	Pb	Ni	Bi	Ga	Sb	Result
5	pellet bell	AP000482	0.24	86.55	1.56		0.32	8.3	2.93	0.1				bronze with a small amount of lead
6	pellet bell	AP000501	0.98	81.97	0.83		0.45	8.08	7.69					leaded bronze
7	pellet bell	AP000926		76.8	1.63		0.5	16.4	4.67					bronze with a small amount of lead
8	pellet bell	AP000968		27.01				13.09	56.5			3.4		leaded bronze
9	pellet bell	AP000982	0.43	85.35	0.93		0.39	5.75	7.17					leaded bronze
12	pellet bell	AP012073	1.03	45.37	0.96		1.75	31.16	17.32			1.6		leaded bronze
13	pellet bell	AP014098		55.82	0.96		0.41	32.56	10.24					leaded bronze
14	pellet bell	AP012438		49.55			0.48	31.16	17.32			1.49		leaded bronze
15	pellet bell	AP021002		69.6	1.41	1.24	1.43	12.72	12.4			1.05		leaded bronze
16	pellet bell	AP021001		63.4	2.4		1.86	15.22	15.78			1.35		leaded bronze/gunmetal
17	bell	AP009445	0.89	78.8	1.28			12.96	6.06					leaded bronze
19	bell	AP76204	1.06	67.42	12.23			11.24	7.92	0.12				gunmetal
20	bell	AP13771		82.25	1.35			9.48	6.92					gunmetal
21	bell	AP13772	0.29	73.45	0.66			4.59	19.42			1.6		leaded bronze
22	bell	AP 32157	0.58	75.8	4.6			5.03	12.93			1.06		gunmetal
23	bell	HF23165	0.23	68.87	20.61			9.91	0.25	0.12				brass with tin
Radzovce 1	bell	HF26051	0.24	79.94	13.71				5.03	0.48	0.61			brass with lead
Radzovce 2	bell with iron clapper	HF26052	0.9	74.61	1.76	0.61		18.57	2.36	0.2			0.98	bronze with a small amount of lead
Košice–Krásna 1	bell	AP32107	0.79	76.76	5.04			14.74	2.57	0.11				bronze with a mixture of zinc and lead
Hronský Beňadik 1	bell fragment	AH57416	0.95	67.22	0.67	3.27		2.08	12.2			1.29	12.31	bronze with antimony and lead
Bratislava–Devín 1	bell	InvNr. 1812	98.51	1.49										iron

Tab. 1. Chemical XRF analyses of bells and pellet bells (author: J. Tirpák, graphic: B. M. Pomberger).

Tabela 1. Chemické XRF analýzy zvončekov a rolničiek (autor: J. Tirpák, grafika: B. M. Pomberger).

5, 7), seven consist of leaded bronze (Cat.: 6, 8, 9, 12–14), and one of gunmetal (Cat. 16).

Three of the Roman bells were cast in gunmetal (Cat. 19, 20, 22) and two in leaded bronze (Cat.: 17, 21) and one bell showed a composition of copper, tin and zinc (Cat. 23; tab. 1; Tirpák, unpublished).

Beside these bells, J. Tirpák also investigated bells from the historical period. A brass bell and a bronze bell each from Radzovce (HF26051, HF26052), one bronze bell from Košice–Krásna (AP32107), one bronze bell fragment of Hronský Beňadik (AH57416) and an iron bell from Bratislava–Devín (Inv. Nr. 1812; tab. 1).

6. TEXTILES

The pellet bell from tomb 804 in Devínska Nová Ves I (Cat. 9) had textile remains adhering to its surface, which were analysed using a Dino-Lite digital microscope that allows magnifications between x30 and x250. The corresponding software enables a more detailed determination of a textile's technical data. Unfortunately, the mineralised textile on the bronze pellet bell (Fig. 9: a) was badly preserved and hardly visible. We were able to determine that it was a very fine textile, probably tabby woven, with a thread diameter of only 0.1–0.15 mm and an approximate weave density of 40 threads per

cm. This would place the fragment among the finest known textiles of the Avar period with comparable thread diameters deriving from the cemetery of Zwölfaxing Burstyn-Kaserne (Lower Austria; Grömer 2015, 194). The exact original position of the pellet bell is unknown but was probably on the horse's head, since it was found near a phalera at its jaw (Eisner 1952, 170, 171), suggesting that the pellet bell might have been attached to the bridle. The function of the textile cannot be determined with certainty, possibly it was part of the bridle – a fabric covering the leather straps, creating a fine appearance. Additionally, two loose hairs on the textile (Fig. 9: b) and the negative impression of fur were identified on the pellet bell. Due to the context and the hairs having a diameter of around 0.14 mm and a length of approximately 3 mm, comparable to the fur of a modern horse we analysed (Fig. 9: c), they most likely derive from the horse's fur itself, though the length of the fur is quite variable depending on the season and body part.

7. ACOUSTIC AND PSYCHOACOUSTIC

Bells and pellet bells are both idiophones, but even though they have a lot in common from an acoustic point of view, they are still quite clear-

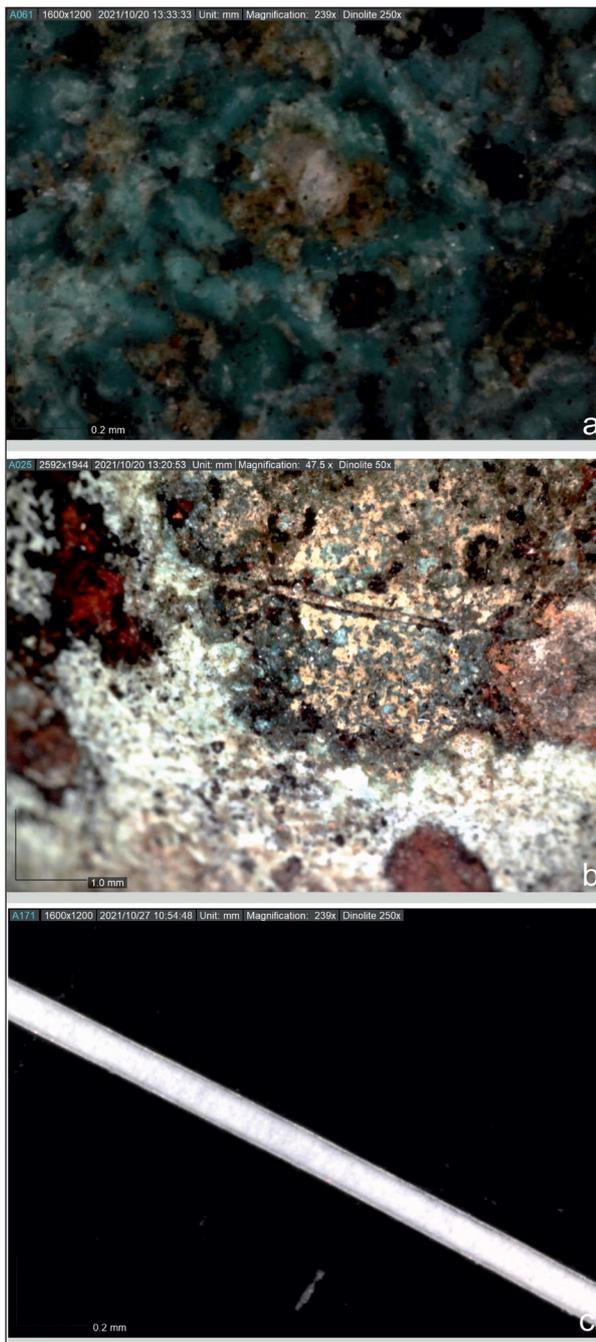


Fig. 9. Cat. 9 textiles: a – textile magnification x 250, b – textile and hairs, c – horse hair (photos: K. Saunderson).
Obr. 9. Textiláa kat. č. 9: a – zväčšenie textílu x 250, b – textil a vlasy, c – koňská srst' (photos: K. Saunderson).

ly distinguishable by their timbre. Since they are sound objects, acoustic and psychoacoustic analyses help us to gain some insight into the possible use of the objects and understand how they might have fit into the “soundscape” of their time.

Acoustics as part of classical physics is a field of research that deals mainly with the objective

parameters of sound and vibration like spectral and temporal features. Psychoacoustics on the other hand is part of psychophysics and seeks to understand the connection between the objective features and the human perception of sound. Thirteen objects in total could be recorded and analysed for this paper, 7 pellet bells (Cat. 5–9 and 14–16) and 5 bells (Cat.: 17, 19, 20, 22, 23). Single hits and constant ringing of the objects are analysed, since the lowest partials are well above 1,5 kHz, a high pass filter (Bessel, 5th order) with a cut off-frequency of 500 Hz has been applied to all recordings.

7.1 ACOUSTICS OF (PELLET) BELLS

The excitation of the objects is impulsive and happens when another solid object hits the inner wall of the structure. When rung by hand, worn as jewellery or attached to clothing, the objects are constantly hit either by a pellet, that is jumping around freely on the inside, or the clapper, which is attached to top part (crown) of the bell. In both cases, the typical ringing sound consists of a number of single hits, for bells about 5–10 per second (because of more inertia) and for the pellet bells up to 50 per second. Figure 10 show the waveforms of two typical bell and pellet bells, where the single hits can be seen. Each hit excites a variety of natural modes on the surface of the body, that influence each other like a spring-mass-system (*Hall 1980*, 148–152). The more complex those modes are, the higher the partials frequency. Lower modes usually are dampened less than higher modes, and the combination of all that creates the spectral and temporal properties of each sound.

The more pronounced single hits from the bells clapper result in some decay time, while the more frequently jumping and rolling pellet not only hardly creates strong oscillations but also dampening them when while having contact with the surface, resulting in almost no measurable decay time. Cat 6, 14 and 15 have at least a little decay of up to 50 milliseconds. Most bells have decay times for single hits of about 400–500 milliseconds with the exception of Cat. 19, where up to 1.2 seconds could be measured.

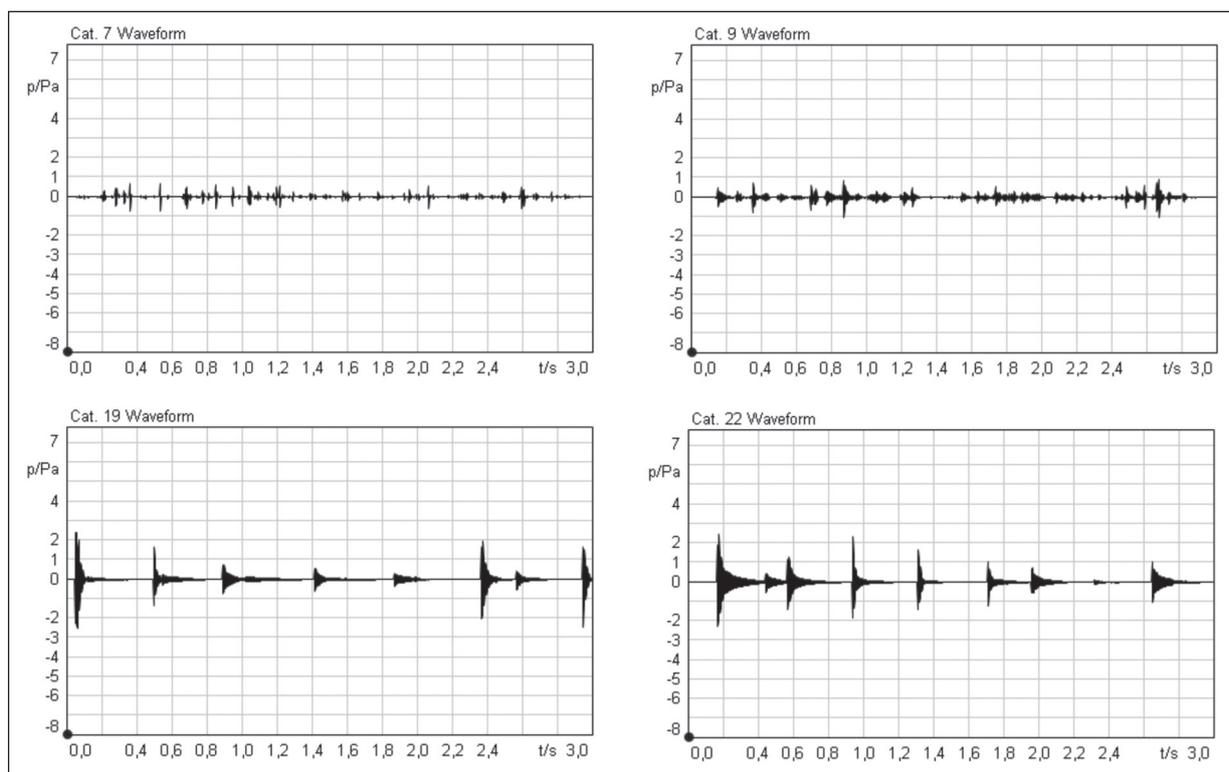


Fig. 10. Waveform of pellet bells for 3 seconds Cat. 7 and 9 and bells Cat. 19 and 22 (author: J. Mühlhans).
Obr. 10. Priebeh troj-sekundového signálu rolničiek kat. č. 7 a 9 a zvončekov kat. č. 19 a 22 (autor: J. Mühlhans).

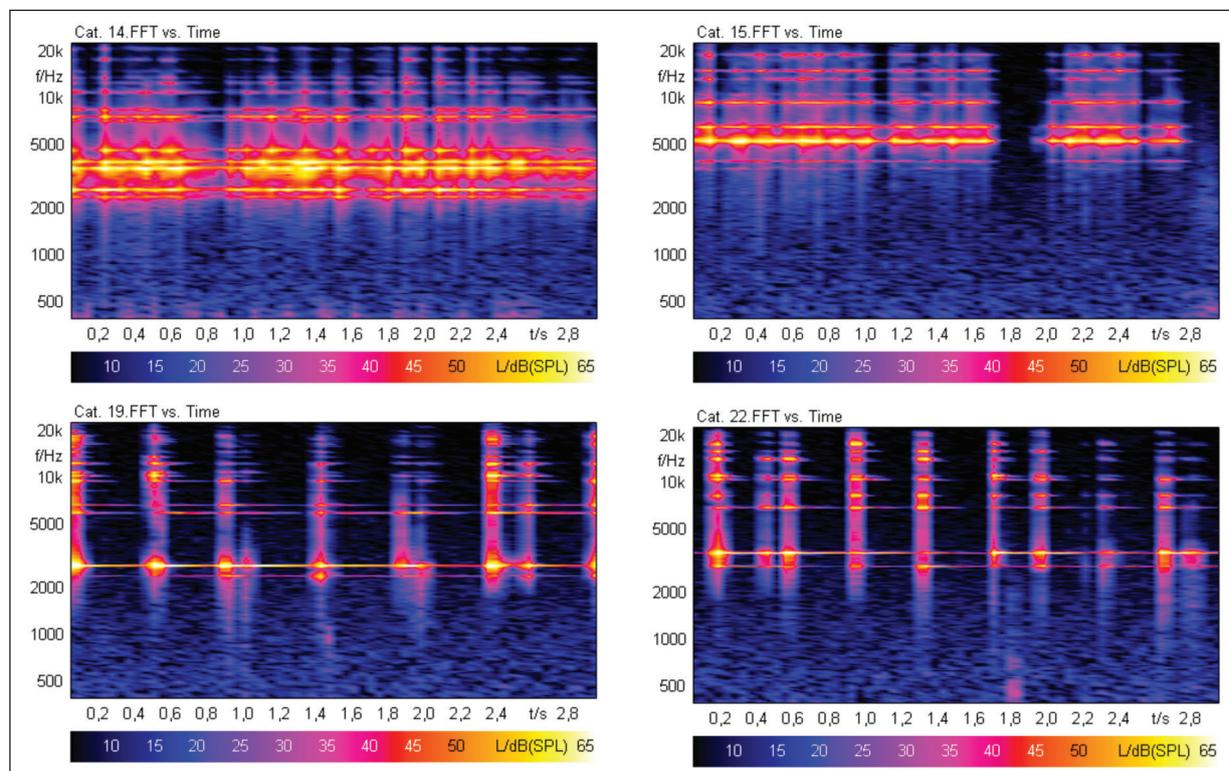


Fig. 11. Spectrograms for pellet bells Cat. 14 and 15 with at least some decay time and bells Cat. 19 and 22 with typically longer decay times (author: J. Mühlhans).
Obr. 11. Spektrogramy rolničiek kat. č. 14 a 15 s aspoň nejakou dobou znenia a zvončekov kat. č. 19 a 22 s typicky dlhšou dobou znenia (autor: J. Mühlhans).

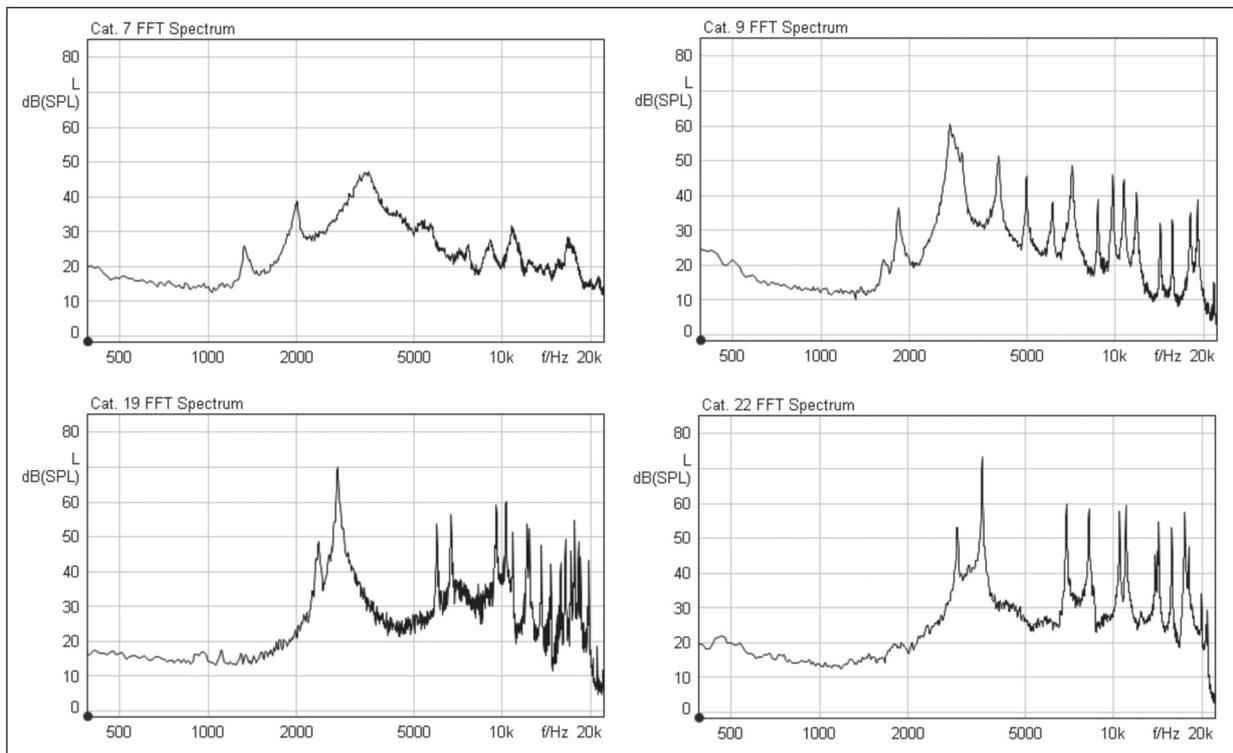


Fig. 12. Spectra of pellet bell Cat. 7 and 9 and bell Cat.19 and 22 (author: J. Mühlhans).

Obř. 12. Spektrogramy rolničiek kat. č. 7 a 9 a zvončekov kat. č. 19 a 22 (autor: J. Mühlhans).

7.2 SPECTRAL FEATURES

In contrast to aerophones and chordophones, the sound of idiophones is not harmonic, i.e. partials are not integer multiples of one single fundamental frequency but results from many vibrational modes. Depending on shape, material and wall thickness, there can be more or less partials in the spectrum, some weaker than others and because of the impact at excitation also a certain amount of broadband noise. Bells usually have more partials than pellet bells and they are also stronger in amplitude, which affects timbre. Partially can be visualised with a spectrum, a graphic representation of the frequency content that is created using the Fourier transformation. Each spike in the graph shows one discrete partial with its frequency (X-axis) and amplitude (Y-axis).

Overall, partials in both bells and pellet bells range from 1.3–20 kHz with the highest peaks and the main spectral energy somewhere between 2–6 kHz, with one exception, Cat. 23, which also is very high in brightness.

7.3 PITCH PERCEPTION AND THE PITCH OF BELLS

Pitch is a subjective human perception and a property of (musical) sounds that is used to order them on a scale from low to high (*Plack et al. 2005*, 1, 2). The sensation can be quite clear, as in most aero- or chordophones, or rather weak, as for most membrano- and many idiophones. However, it must not be mistaken with (fundamental) frequency. Number and amplitudes of partials greatly influence pitch perception. Just by looking at the spectra of Cat. 19 and 22 and its well-established partials, we can estimate much clearer pitch perception as in Cat. 7, where hardly any partials can be seen. But Cat. 9 shows that also pellet bells can produce clear partials (Fig. 12).

7.4 AUDIBILITY AND AUDIBLE RANGE OF THE OBJECTS

The maximum distance a sounding object can be heard at is defined by sound pressure level, frequency range and of course background noise. To

evaluate the probability of a signalling function, the maximum audible distance is estimated. The human ear is insensitive to low and very high frequencies but extremely sensitive in the 2–5 kHz range, where the threshold of hearing is close to or even below 0 dB SPL re p_0 ¹ (*DIN ISO 226 2006*). Since most of the frequency content lies in this range, the objects can be heard quite well, even though they are not high in sound pressure level.

Sound pressure levels decrease by 6 dB when the distance to the source is doubled (*Attenborough 2014*, 119). When level of the background noise is reached, the sound of the object gets masked by it, which means we cannot hear it anymore. Since the sound pressure level of the recordings was calibrated and the recording distance is known, we can roughly estimate the maximum audible distance.

At a distance of 1 m the pellet bells range from 40–55 dB SPL and the bells from 55–65 dB SPL. Since the objects are corroded to a certain extent, they could have been higher in SPL in the time they were used. Also, it is difficult to estimate background levels for different eras since all measurements reported in literature are done from the 20th century onward. The “wilderness” odder forest is given at about 22 dB in the day-night-average and rural but populated areas at about 50 dB (*Fidell 2008*, 1007). In silent areas pellet bells might have been heard up to a distance of about 10–20 meters while in populated areas probably only the person wearing them may be heard them. Bells were probably audible at about 50 meters in silent and 5–10 meters in populated areas. Note: this is a very vague estimation since background levels thus audible distance can change quickly when there is wind, people working or any kind of social interaction present.

7.5 PSYCHOACOUSTIC

Psychoacoustical parameters are used to estimate human perception of sounds with computer models, especially for loudness, brightness, sharpness, roughness or tonality.

Loudness is the subjective sensation of intensity of a sound, not to be mistaken with its level, but depending on it. Additionally, the sensitivity of the human ear is taken into consideration here. Loudness is measured in *phon* (linear scale, +10 phon is twice as loud) or *sone* (interval scale, value x 2 = twice as loud). Loudness is defined as 40 dB SPL at 1 kHz equals 40 *phon* or 1 *sone* (*Fastl/Zwicker 2007*, 203f).

Brightness represents sensations like “high-low” or “bright-dark” in sounds and is simply calculated with the *spectral centroid* (SC) – a frequency that divides the total spectral energy in equal parts and correlates well with the subjective impression (*Schubert/Wolfe/Tarnopolsky 2004*, 656).

Sharpness depends on spectral shape and density and is highly connected with the impression of pleasantness. It is measured in *acum*, a linear scaled value (*Fastl/Zwicker 2007*, 241).

Roughness is connected to the temporal fluctuations in amplitude and peaks at an amplitude modulation of 70 Hz, which is defined as 1 *asper*, which is the maximal roughness (*Fastl/Zwicker 2007*, 257).

There are still many different ways to calculate **Tonality**, which generally represents the TNR (tone-noise-ratio). Tonal components (partials) are compared to the amount of noise, values are given in dB (*Becker/Sottek/Lobato 2019*, 5820).

The psychoacoustic measurements, in contrast to the level measurements, show values for a distance of 10 cm, in simple terms as if you were ringing the object next to your ear. Pellet bells are between 8–20 *sone*, only „Cat. 14“ shows a significantly higher value of 28 *sone*, which means it is about 4 times as loud as the most silent one. The bells are between 20–36 *sone*, with the exception of Cat. 23, which is even lower than most bells at 12 *sone*. In brightness, all objects range between a SC of 3.3 to 6.2 kHz, with the bells averaging about 300 Hz lower than the pellet bells. The only prominent exception is again Cat. 23 with an exceptional high SC of 12.2 kHz. Sharpness is about the same for all objects, between 3.2

¹ A common misconception is that 0 dB is no sound pressure but 0 dB always refers to the reference SPL p_0 , which is 0.00002 Pascal sound pressure. Humans can hear as low as -3 dB, a sound pressure of about 0.000014 Pa.

and 5.3 acum there is not much deviation. The highest value comes from a pellet bell with high spectral energy in the 2–5 kHz band and the lowest value from a bell with rather strong partials in the lower frequency range. As we observed in many previous studies (*Pomberger et al. 2020; 2021; in preparation*) roughness values are low, in most cases <0.1 – which again shows that (pellet) bells are generally not perceived as rough. Unsurprisingly, pellet bells, with an average value of 14 dB, are less tonal than bells, which average at 22 dB. Cat. 7 and 8 stand out with particularly low values of about 2 dB, i.e. the noise component is almost as large as the tonal component, which can already be assumed from the spectrum (Fig. 10: Cat. 19).

In summary, it can again be stated that bells are somewhat louder and more tonal than pellet bells, due to their size also somewhat lower in frequency, but both types are equally sharp but hardly rough.

Cat. Nr.	SNM – AM Inv. Nr.	Idiophone	Frequency range (kHz)
5	AP000482	pellet bell	2–15.4
6	AP000501	pellet bell	2.7–15.1
7	AP000926	pellet bell	1.3–10.8
8	AP000968	pellet bell	4.3
9	AP000982	pellet bell	4.4–18
14	AP012438	pellet bell	2.4–17.7
15	AP021002	pellet bell	4–18.8
16	AP021001	pellet bell	2.9–11.8
17	AP009445	bell	2.5–16.7
19	AP76204	bell	2.4–19.5
20	AP13771	bell	1.4–17.2
22	AP 32157	bell	2.9–18.1
23	HF23165	bell	1.8–20.7

Tab. 2. Acoustic ranges of bells and pellet bells (author: B. M. Pomberger).

Tabela 2. Akustický rozsah zvončekov a rolničiek (autor: B. M. Pomberger).

Cat. Nr.	SPL 10cm L dB(SPL)	SPL 1m L dB(SPL)	Loudness vs. Time N5 soneGF	Sharpness vs. Time S acum	Roughness (Hearing Model) vs. Time R asper	Impulsiveness (Hearing Model) vs. Time I iu	Tonality DIN45681 TNR db	Specific Impulsiveness (Hearing Model) I iu	Brightness SC Praat Hz
5	64.7	44.7	12.9	3.25	0.119	4.34	11.43	4.77	5377
6	66.79	46.79	13.4	4.47	0.0701	2.19	20.88	2.28	5894
7	63.21	43.21	10.8	3.5	0.151	2.91	2.56	3.18	4251
8	61.12	41.12	8.66	3.39	0.168	2.94	2.08	3.17	4368
9	70.37	50.37	16.9	3.9	0.0867	2.27	23.52	2.46	3601
14	76.19	56.19	28.0	4.83	0.0695	2.2	20.71	2.21	3899
15	75.08	55.08	19.4	5.35	0.0413	1.4	19.57	1.51	5765
16	66.29	46.29	12.1	4.41	0.0624	2.3	17.22	2.52	6271
17	82.58	62.58	34.5	3.91	0.0743	3.05	18.57	2.82	3304
19	76.13	56.13	19.9	3.95	0.0324	1.57	23.36	1.55	5343
20	83.55	63.55	36.2	3.23	0.0768	3.69	18.15	3.85	3492
22	76.54	56.54	25.7	4.29	0.0282	1.79	23.48	1.88	6291
23	66.61	46.61	12.2	3.49	0.0443	2.24	26.88	2.38	12201

Tab. 3. Psychoacoustic data of pellet bells and bells (author: J. Mühlhans).

Tabela 3. Psychoakustické údaje rolničiek a zvončekov (autor: J. Mühlhans).

8. FUNCTION OF PELLET BELLS AND BELLS

Pellet bells and bells first and foremost are signaling instruments. Pellet bells belong according to Hornbostel’s and Sachs’ classification of musical

instruments to the group of vessel rattles (system number 112.13). Bells are classified to the group of directly struck idiophones (system number 111.242.122; *MIMO 2011*, 5, 6; *Hornbostel/Sachs 1914*, 565, 566). Cast or forged from metal, a material which is laboriously wrested from the

depths of the earth and which by fire undergoes a transforming process into a cultural object, these idiophones still are associated with various magic-religious ideas and popular beliefs (*Eliade* 1972, 149, 150, 153; *Hasanov* 2016, 195, 198–202; *Kramer* 2015, 13–82; *Sartori* 1932, 32–44, 78; *Vilting* 2002).

8.1 THE BELLS' MULTIFUNCTION'S DURING THE ROMAN PERIOD

Usually bells are found in houses, pits, gardens, courts, workshops, moats and trenches, depots, on roads and pavements, in sanctuaries and cemeteries. Bells served as signal instruments of watchmen, regulated the times in town life, in markets and baths. They were attached to animals in daily life situations and as ornaments. They sounded at meals and feasts and were fastened on statues of gods and temples. Bells very often served as apotropaic instrument, which were worn on necklaces, bracelets or bundled together as windchimes. They were parts of dresses to underline rhythmically and per sound the movements of dancers. Bells also played certain roles in war and executions. Numerous ancient written as well as iconographic sources bear witness to their functions (*Pomberger et al. in print a; in preparation*²).

8.2 PELLET BELLS AS PARTS OF HORSE BRIDLE DURING THE AVAR PERIOD

Pellet bells, be it a single piece or several, were discovered at horse skeletons. Mostly they lay near the skull. Less often, they were found on the backbone, in the chest area and by the forelegs. Avar riders attached bells to the bridle of their horses, either for decorative purposes, to spread sound or to protect their precious animals from evil. Pellet bells were also fixed on the saddle or on the breast strap (*Pomberger et al. 2021*, Fig. 13). Examples of pellet bells as parts of horse gear are listed up in table 4. They date from Middle Avar period II until the end of the very Late Avar

period. The specific role of horses in Avar society is associated with the nomadic cultures of the Eurasian steppes and "... can only be determined by relating it to the part it played in the late Avar cultural system..." (*Bede* 2012, 47). And furthermore, horses were one the efficient "mobility devices".

Occasionally there are rare evidences of bells as parts of horse harnesses from the Roman Period and the Migration Period in Europe: a five-year-old gelding with a bell was excavated in burial 1 from Großörner, Mansfeld-Südharz in Thuringia (Germany).³ Horses from Thuringia were famous during the early Middle ages and sometimes were buried in own graves. One bronze bell, found in the Roman military camp of Vindobona, is supposed to be part of a military horse harness (*Kronberger* 2012, 43), but it could as well belong to a mule. Mules were the pack animals in the Roman army. A skeleton of a mule, found in Kalkrise (Germany), had a bell fastened around its neck (*Rost/Wilbers-Rost* 2010, 117–136). According to Martynov the Scythes sometimes decorated the breast girth of their horses with bells (*Martynov* 2005, 447). The rock relief from Taq-e Bostan (Iran) shows the Sassanide Emperor Khosroe II (590–628 AD) in full Cataphract armour, sitting on a strong horse. Bells are fixed on the horse harness (*Koshrow II*). A look at contemporary Asia – China, Korea and Japan – shows us that bells and pellet bells were occasionally used as horse ornaments here too. A Xianbei burial (grave 154) dating to the early- or mid-fourth century AD, was discovered in Xiaomin near Anyang (China) and dates to the first half of the 4th century AD. It contains parts of a horse harness and bells. And a figurine of a horse with bells was unearthed in a Xianbei tomb near Hohhot (*Dien* 1986, 33, 34, 44). The Xianbei were a nomadic group in Inner Mongolia. Several Shang horse-and-chariot pits from the Bronze Age Shang Period in China were excavated. Already here the horses wore one tiny bronze bell around their necks. To the drivers' equipment's bow-shaped devices, gongxing qi (弓形器), belonged, with two crotales (pel-

² B. M. Pomberger/M. Hackl/W. Wegner/J. Mühlhans: Well, it's just a bell! – Ancient Bells from Ovilava/Wels. In preparation.

³ Landesmuseum Sachsen-Anhalt, Halle an der Saale. Text of the show case.

Site	Grave Nr.	Relative dating	Rider sex	Horse sex	Number of pellet bells	Pellet bells find position
Komárno (cemetery IX)	36	LAP IIIb	M	stallion	2	near horseskull, disturbed
	79	LAP IIIb	M	stallion	2	horse skull
	101	LAP IIIa	M	?	1	horse skull, disturbed
	107	LAP I	M	?	4	backbones of horse, disturbed
	121	LAP IIIb	M	?	2	horse skull, disturbed
	149	LAP IIIa	M	?	2	horse skull
	153	LAP IIIa	M	?	1	backbones of horse, disturbed
Bratislava-Devínska Nová Ves (cemetery I)	79	MAP II	M	?	2	horsegear
	147	LAP	M	?	2	horsegear
	401	LAP I	M	?	1	horsegear?
	412	LAP I/II	M	?	1	forelegs of horse
	765	LAP ?	M + F	?	1 ?	horseskull
	796	LAP ?	M	?	1	horseskull
	804	LAP II/IIIa	M	?	1	horseskull
	842	LAP IIIa	M	?	2	horsegear?
Radvaň nad Dunajom / Žitava I	10	LAP IIIb	M	?	14	horsegear, disturbed
	31	LAP IIIb	M	?	4	horsegear, disturbed
Zamárdi-Réti földek	1653	LAP	no information	?	3	neck
	1900	LAP ?	no information	?	5	disturbed
Valalíky-Všechsvätých	16/60	LAP	M	?	1	disturbed
	42/61	LAP IIIa?	M	?	1	horsegear
	98/84	LAP II/III	M	?	3	horseskull
Wien-Liesing	3	LAP	M	?	1	breast of horse
	8	LAP	M?	?	1	on croup of horse
Wien – Csokorgasse	650	LAP	?	?	1	head of horse (gear?)
Vösendorf / Laxenburgerstraße	525	LAP	M	?	1	?

Tab. 4. Examples of pellet bells as parts of horse gear and the relative chronological dating (author: B. M. Pomberger).

Tabela 4. Príklady roľníčiek tvoriacich súčast' jazdeckej výbavy a ich relatívna chronológia (autor: B. M. Pomberger).

let bells) at the end of the arms (*Barbieri-Low 2000*, Figs. 12, 15; *Wan 2013*, 36). Korea adopted horses and horse harness with their possible bells from China during the Han Dynasty (206 BC–220 AD). Jeju was the center for breeding the Korean horses. "... *Horse-related bronze objects or those made in the shape of a horse, including bronze horses, horse-shaped belt buckles and components from horse-drawn carriages, were used to demonstrate the power of their owners, and hence were likely possessed by only an extremely limited number of individuals holding high social status... The development of full horse tack was completed between the fourth and the fifth centuries, during the Three Kingdoms Period (Silla)...*" (57 BC–935 AD; *Korean horses*). A collection of small bronze bells, which decorated the girth of horses and a horse rider-shaped clay vessel clay figure with pendants and pellet

bells on the breast girth of the horse are housed in the Jeju National Museum (*Korean Horses*). Japan adopted from South Korea horses and harness during the fourth century AD for warfare. Like in South Korea bells and pellet bells were fixed on the horses' breast girth. In Japan only, a few high-ranking persons used pellet bells for their horses (*Wieczorek/Steinhaus/Sahara 2005*, 225, 235, 249, 333, 337–342). The upper class of the Cham people in today Vietnam decorated their horses with pellet bells, which were worn fixed on a neck strap (*Wade 2009*, pl. 43). The pellet bells and bells served as amulet and decoration at the same time. The question of whether pellet bells were newly invented in the Avar Khaganate or whether this idea was introduced from abroad, maybe from Asia via the silk road, cannot yet be answered according to the current state of research.⁴

⁴ N. Profantová informed me, that the oldest pellet bells from Moravia and Bohemia date to the 8th century and originate from Dolní Dunajovice.

8.3 PELLET BELLS WORN BY PERSONS

Among the collection of pellet bells from the Avar period there are four rattles, which belong to the deceased persons. They were detected in the middle of the skeletons, which means that they lay near the hands, the pelvis or the thighs. The woman of grave 34b from Bratislava-Rusovce (site: Pri cintoríne) wore the pellet bells fastened on a belt or ribbon, which kept the tunic together. The child from burial 166 of Záhorská Bystrica kept the idiophone also somewhere on a ribbon or belt. We know similar finds from the Komárno – cemeteries IV and IX (*Pomberger et al. 2021*) and from cemeteries in Hungary (*Pomberger et al. in print b*). Pellet bells may have several functions, for example as amulets, jewellery and toys. They are used for practical and ornamental as well as for animist-religious purposes. On the one hand, they could have been carried during life, on the other hand, a person probably with a magico-religious function in the community could have given these sound objects to the deceased to take to the grave. The bells were supposed to protect the person, but also to ease their way into the afterlife (*Pomberger et al. in print b*).

8.4 PELLET BELLS WITH FACES AND EYES – “THE EVIL EYE”

Two pellet bells show eye like patterns. One, from burial 147, has two big eyes gazing at the looker. The other one from burial 410 shows two sound holes arranged like eyes. Objects with eyes often could have been worn as amulet and should protect against the evil eye, which was feared during the Middle Ages as well as in later popular belief. “...*The magic power of the eye, sends out poisoned arrows that sicken other living beings and damage inanimate things...*”. Stares, like those of predators or snakes when they focus on prey, are perceived as discomfoting. The same can be said of piercing, penetrating glances from people (*Bächtold-Stäubli/Hoffmann-Krayer 1987, 679–703*). Glances as threatening stares belong to the „repertoire of aggressive behaviour“ in humans and animals. It is known, that people sometimes can read other people’s thoughts or intentions in their facial expressions. Psychologists found out,

that persons with the borderline personality disorder “...*are highly vigilant to social stimuli, maybe because they resonate intuitively with mental states of others...*” (*Frick et al. 2012, 1–8*).

9. CATALOGUE

L legend: th. = total height, hwl. = height without handle, l. = length, w. = width, dm. = diameter, wth. = wall thickness, cw. = conserved weight, InvNr. = inventory number, Literature = Literature used

Avar Period:

Site: Bratislava-Devínska Nová Ves (cemetery I)

Feature function: cemetery

Date: MAP-LAP, ca. 625–8th. Cent. AD.

Finds: 11 pellet bells

Figure: Fig. 2

Literature: *Eisner 1952, 24, 25, 47, 48, 91, 92, 94, 95, 161, 168, 181–183, pl. 3, 12, 21, 45, 47, 81, 84, 89, 94.*

Cat. 1: pellet bell AP000123

Context: grave 79, horseman and horse, pellet bells near horse skull

Date: MAP II, 7th cent. AD

Conservation status: complete (?), cruciform soundslot, 4 sound holes (?), pebble as rattle body

Base shape: shape I

Handle: round

Decoration: none, smooth

Measurements: h. 37 mm

Material: copper alloy

Frequency range: no recording, no frequency analyses

Figure: Fig. 2

Cat. 2: pellet bell AP000124

Context: grave 79, horseman and horse, pellet bells near horse skull

Date: MAP II, 7th cent. AD

Conservation status: complete, cruciform sound slot, pebble as rattle body (?)

Base shape: shape VIII

Handle: rectangle

Decoration: none, smooth

Measurements: h. 48 mm

Material: copper alloy

Frequency range: no recording, no frequency analyses

Figure: Fig. 2

Cat. 3: pellet bell AP000273

Context: grave 147, horseman and horse, pellet bells belong to horse gear
 Date: LAP II, 8th cent. AD
 Conservation status: complete, cruciform sound slot, pebble as rattle body (?)
 Base shape: shape I
 Handle: round-trapezoidal
 Decoration: pair of eyes
 Measurements: h. 30 mm
 Material: copper alloy
 Frequency range: no recording, no frequency analyses
 Figure: Fig. 2

Cat. 4: pellet bell AP000272

Context: grave 147, horseman and horse, pellet bell belong to horse gear
 Date: LAP II, 8th cent. AD
 Conservation status: complete, rattle body lost, cruciform sound slot
 Base shape: shape II
 Handle: rectangle
 Decoration: non-decoration, smooth
 Measurements: 32 mm
 Material: copper alloy?
 Frequency range: no recording, no frequency analyses
 Figure: Fig. 2

Cat. 5: pellet bell AP000482

Context: grave 401, horseman and horse, no information about position of pellet bell, probably belonging to horse gear (?)
 Date: LAP I, 7th cent. AD
 Conservation status: complete, cruciform sound slot, 4 sound holes like eyes, bronze ball as rattle body
 Base shape: shape IV
 Handle: rectangle
 Decoration: smooth, vertical groove framing the sound slot, 4 facetlike sound hole
 Measurements: th. 34 mm, dm. 27,5 x 26,5 mm, wth. 1–2 mm, cw. 26 g
 Material: leaded bronze
 Frequency range: 2–15,4 kHz
 Figure: Fig. 2

Cat. 6: pellet bell AP000501

Context: grave 412, horseman and horse, pellet bell near forelegs of horse

Date: LAP I/II, 7th cent. AD

Conservation status: complete, simple sound slot, pebble as rattle body?
 Base shape: shape II
 Handle: rectangle-trapezoidal
 Decoration: no decoration, smooth
 Measurements: th. 34 mm, dm. 26 x 22 mm, wth. 1 mm, cw. 17 g
 Material: leaded bronze
 Frequency range: 2.7–15.1 kHz
 Figure: Fig. 2

Cat. 7: pellet bell AP000926

Context: grave 765, man and woman and horse, pellet bells above horse skull
 Date: LAP, 7th–8th cent. AD
 Conservation status: complete, handle, broken cruciform sound slot, pebble as rattle body
 Base shape: shape I
 Handle: rectangle (?)
 Decoration: vertical grooves,
 Measurements: th. 36 mm, dm. 26 x 25 mm, wth. 1 mm, cw. 16 g
 Material: bronze with lead
 Frequency range: 1.3–10.8 kHz
 Figure: Fig. 2

Cat. 8: pellet bell AP000968

Context: grave 796, horseman and horse, pellet bells near horse skull
 Date: LAP, 7th–8th cent. AD
 Conservation status: nearly complete, handle broken, pebble as rattle body
 Base shape: shape I
 Handle: broken
 Decoration: vertical grooves, cruciform sound slot
 Measurements: cons. h. 27 mm, dm. 24 x 22 mm, wth. 1–2 mm, cw. 13 g
 Material: leaded bronze
 Frequency range: 4.3 kHz
 Figure: Fig. 2

Cat. 9: pellet bell AP000982

Context: grave 804, horseman and horse, pellet bell near horse skull
 Date: LAP II/III, 8th cent. AD
 Conservation status: complete, cruciform sound slot, 4 sound holes, pebble as rattle body?, textile rest

Base shape: shape I
 Handle: round
 Decoration: smooth
 Measurements: th. 36 mm, dm. 29 x 29 mm, wth. 1–2 mm, cw. 32 g
 Material: leaded bronze
 Frequency range: 4.4–18 kHz
 Figure: Fig. 2

Cat. 10: pellet bell AP0001056

Context: grave 842, horseman and horse, pellet bells belonging to horse gear – headstall?
 Date: LAP III, end of 8th cent. AD
 Conservation status: complete, cruciform sound slot, 2 sound holes
 Base shape: shape I (?)
 Handle: rectangle
 Decoration: smooth
 Measurements: th. 23 mm
 Material: copper alloy
 Frequency range: no recording, no frequency analyses
 Figure: Fig. 2

Cat. 11: pellet bell AP001057

Context: grave 842, horseman and horse, pellet bells belonging to horse gear – headstall?
 Date: LAP III, 8th cent. AD
 Conservation status: complete, simple sound slot, 2 sound holes
 Base shape: shape I (?)
 Handle: rectangle
 Decoration: smooth
 Measurements: th. 22 mm
 Material: copper alloy
 Frequency range: no recording, no frequency analyses
 Figure: Fig. 2

Site: Bratislava-Záhorská Bystrica

Feature function: cemetery
 Date: LAP, second half 7th–8th cent. AD
 Finds: 3 pellet bells
 Figure: Fig. 3
 Literature: *Kraskovská 1967; 1972, 22–25, 35, 36, 40, pl. 24, pl. 37, pl. 42, map.*

Cat. 12: pellet bell AP012073

Context: grave 83, horseman and horse, grave disturbed, skeletons nearly passed away, pellet bell belonging pro-

bably to horse gear
 Date: LAP III, end of 8th cent. AD
 Conservation status: complete, 1 hole in mantle, cruciform sound slot, rattle body conserved (pebble or cinder)
 Base shape: shape I
 Handle: round
 Decoration: smooth
 Measurements: th. 38 mm, dm. 27 x 27 mm, wth. 1–2 mm, cw. 23 g,
 Material: leaded bronze
 Frequency range: no recording, no frequency analyses
 Fig: Fig. 3

Cat. 13: pellet bell AP014098

Context: grave 208, woman?, skeleton passed away
 Date: LAP, second half 7th–8th cent. AD
 Conservation status: one hole in mantle, simple sound slot, mouth of sound slot broken out a little bit
 Base shape: shape VIII
 Handle: rectangular
 Decoration: vertical cannelure
 Measurements: th. 47.5 mm, dm. 26 x 26 mm, wth. 0.5–1 mm, cw. 30 g
 Material: leaded bronze
 Frequency range: no recording, no frequency analyses
 Figure: Fig. 3

Cat. 14: pellet bell AP012438

Context: grave 166, child, pellet bell in the middle of the grave pit, skeleton passed away
 Date: LAP, second half 7th–8th cent. AD
 Conservation status: mantle complete, handle broken, cruciform sound slot, pebble as rattle body
 Base shape: shape I
 Handle: round, broken
 Decoration: smooth
 Measurements: th. 32 mm, dm. 27 x 25 mm, wth. 1–1.5 mm, cw. 33 g
 Material: leaded bronze
 Frequency range: 2.4–17.7 kHz
 Figure: Fig. 3

Site: Bratislava-Rusovce (Pri cintoríne)

Feature function: cemetery
 Date: LAP, 8th cent.
 Finds: 2 pellet bells
 Fig: Fig. 4
 Literature: *Pichlerová/Stloukal 1978, 129, 139, Figs. 3, 4*

Cat. 15: pellet bell AP021002

Context: grave 34 a-b, double burial with superposition, woman (burial b) lay above child (burial a), pellet bells were in the middle of the female skeleton, woman's age 30–40 years

Date: LAP, 8th cent. AD

Conservation status: complete, cruciform sound slot, 4 sound holes, pebble as rattle body

Base shape: shape I

Handle: round

Decoration: grooves on the lower half

Measurements: th. 26 mm, dm. 18 x 18 mm, wth. 0.5 mm, cw. 7 g

Material: leaded bronze

Frequency range: 4–18.8 kHz

Figure: Fig. 4

Cat. 16: pellet bell AP021001

Context: grave 34 a-b, double burial with superposition, woman (burial b) lay above child (burial a), pellet bells were in the middle of the female skeleton, woman's age 30–40 years

Date: LAP, 8th cent. AD

Conservation status: complete, cruciform sound slot, 4 sound holes, pebble as rattle body

Base shape: shape IV

Handle: round

Decoration: grooves on the lower half

Measurements: th. 23 mm, dm. 18 x 17 mm, wth. 1 mm, cw. 7 g

Material: leaded bronze

Frequency range: 2.9–11.8 kHz

Figure: Fig. 4

Roman Period:

Site: Bratislava-Rusovce (Roman Gerulata)

Feature function: settlement, cemetery

Date: 1st–4th cent. AD

Finds: 1 bell

Figure: Fig. 1

Literature: *Pichlerová 1981, 199, tab. CLXXXII.*

Cat. 17: bell AP009445

Context: stray find, cemetery II, excavation/found 1949

Date: Roman period

Conservation status: mantle complete, clapper lost, rests of eyelet

Type: type 1/Var. B

Handle: trapezoidal

Decoration: smooth

Measurements: th. 47 mm, l. 39 mm, w. 31 mm, wth. 3 mm, cw. 46 g

Material: bronze with lead

Frequency range: 2.5–16.7 kHz

Figure: Fig. 1

Site: Bratislava-Jarovce

Feature function: stray find

Date: no information – no date

Finds: 1 bell

Literature: *Bazovský 2008, 24, obr. 3*

Cat. 18: bell AP 52172

Context: stray find

Date: Roman Period?

Conservation status: mantle deformed, 1 crack probably with a hole near vertex, 1 hole near vertex on the other side, both holes probably to fix a clapper, clapper lost

Type: type 1/Var. C

Handle: trapezoidal

Decoration: smooth

Measurements: th. 44 mm, l. 35 mm, w. 30 mm, wth. 2 mm, cw. 38 g

Material: copper alloy

Frequency range: no recordings, no frequency analyses

Figure: Fig. 1

Site: Vištuk

Feature function: Germanic settlement

Date: late antiquity

Finds: 1 bell

Literature: unpublished

Cat. 19: bell AP76204

Context: stray find

Date: Roman period?

Conservation status: one small hole in mantle, clapper lost, fragments of eyelet

Type: type 1/Var. B

Handle: round

Decoration: smooth

Measurements: th. 52 mm, l. 40 mm, w. 32,5 mm, wth. 2 mm, cw. 45 g

Material: gunmetal

Frequency range: 2.4–19.5 kHz

Figure: Fig. 1

Site: Komárno

Feature function: stray find, Roman settlement/area?

Date: Roman period

Finds: 2 bells

Figure: Fig. 1

Literature: *Kraskovská 1986*, 114, obr. 1: 3, 4

Cat. 20: bell AP13771

Context: unknown circumstances

Date: Roman period?

Conservation status: mantle complete, clapper lost

Type: type 1/Var. B

Handle: round

Decoration: smooth

Measurements: th. 63 mm, l. 46 mm, w. 33 mm, with. 2 mm, cw. 71 g

Material: bronze with lead

Frequency range: 1.4–17.2 kHz

Figure: Fig. 1

Cat. 21: bell AP13772

Context: unknown circumstance

Date: Roman period?

Conservation status: 80 % conserved, mantle deformed, handle broken, clapper lost

Type: type II

Handle: broken

Decoration: smooth

Measurements: cons. h. 74 mm, cons. dm. 59 mm, cw. 67 g

Material: leaded bronze

Frequency range: no recordings, no frequency analyses

Figure: Fig. 1

Site: Streda nad Bodrogom – Hradištná

Feature function: settlement?

Date: Roman Period?

Finds: 1 bell

Figure: Fig. 1

Literature: unpublished, excavation B. Polla, without further information

Cat. 22: bell AP 32157

Context: no information

Date: Roman period?

Conservation status: mantle complete, clapper lost, bell often used which could be seen because the handle is very thin above

Type: type 1/Var. B

Handle: round

Decoration: smooth

Measurements: th. 47 mm, l. 32 mm, w. 27 mm, with. 2 mm, cw. 32 g

Material: leaded bronze with some tin

Frequency range: 2.9–18.1 kHz

Figure: Fig. 1

Historic Period (?)

Site: Bratislava – Židovská ulica

Feature function: settlement?

Date: historic period?

Find: 1 bell

Literature: unpublished, excavation B. Polla 1969

Cat. 23: bell HF23165

Context: no further information

Date: historic period

Conservation status: complete, clapper lost

Type: base circular

Handle: rectangle

Decoration: circular grooves, inside grooves,

Measurements: th. 41 mm, dm 46 mm, with. 1–2 mm, cw. 31 g

Material: brass

Frequency range: 1.8–20.7 kHz

Figure: Fig. 1

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RANO-HISTORICKÉ KOVOVÉ IDIOFÓNY Z ARCHEOLOGICKEJ ZBIERKY SLOVENSKEHO NÁRODNÉHO MÚZEA V BRATISLAVE

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V rámci projektu „Metallic idiophones between 800 BC and 800 AD in Central Europe“ sme skúmali rímske zvončeky a avarske rolničky zo zbierky Slovenského národného múzea – Archeologického múzea v Bratislave (SNM – AM).

Sedem zvončekov pochádza z lokalít: Bratislava-Rusovce (Gerulata), Bratislava-Jarovce, Židovská ulica v Bratislave, Vištuk, Komárno a Streda nad Bodrogom.

Jedenásť rolničiek je známych z avarskeho pohrebiska v Bratislave-Devínskej Novej Vsi, kde sa našli hroby jazdcov s výzbrojou a s konským postrojom. Troje rolničky sa našli v Bratislave-Záhorskej Bystrici a dvojce v Bratislave-Rusovciach (poloha: Pri cintoríne). Datované sú do 7. a 8. storočia. Rolničky z pohrebiska v Bratislave-Devínskej Novej Vsi ležali blízko lebiiek a len v jednom prípade blízko predných nôh, ako súčasť konského postroja. Tieto predmety boli zrejme upevnené na ohlávku, resp. jeden z nich na pás okolo hrude. Ďalší nález pochádza z pohrebiska v lokalite Bratislava-Záhorská Bystrica. Tu sa rolničky nachádzali v hrobe jazdca ako súčasť konského postroja. Okrem toho sa našli dvojce rolničky, ktoré patrili žene a dieťaťu. V hrobe 34b na pohrebisku v Bratislave-Rusovciach mala jedna žena dvojce malé rolničky. V tomto prípade sa nosili na opasku, zvyčajne viseli na bočnom remeni, alebo vo vačku. Vzhľadom na ich nevelký počet je zrejme, že v slovansko-avarskom prostredí neboli rolničky bežné. Podľa súčasného stavu výskumu vieme, že sa vyskytovali počas neskorej strednej doby avarskej I a prvý raz sa objavujú v hrobe 79 v Bratislave-Devínskej Novej Vsi (pohrebisko I).

Všetky rolničky sú odliate metódou strateného vosku a môžu byť klasifikované do základných tvarov I, II, IV a VIII. Ich veľkosť je v rozmedzí 2,3–4,8 cm a vážia od 7 do 33 g. Ako srdcia rolničiek slúžili malé okruhliaky a bronzová guľka.

Rímske zvončeky spadajú pod typ 1 s variantmi B a C, resp. pod typ 2/variant A. Ich veľkosť je

v rozmedzí 4,1–7,4 cm a zachovaná váha 31 až 71 g. Srdcia zvončekov podľahli korózii.

Z chemických rozborov pomocou röntgenovej fluorescenčnej metódy (XRF) vyplýva, že zvončeky boli odliate zo zvonoviny, olovnateho bronzu, zliatiny medi s cínom a zinkom, a takisto z mosadze. V chemickom zložení rolničiek nachádzame bronz s pomerne malým množstvom olova, olovnatý bronz a zvonovinu. Pri rolničkách z hrobu 804 z Bratislavy-Devínskej Novej Vsi (pohrebisko I) bola zistená prítomnosť jemnej mineralizovanej textilie a dvoch konských vlasov.

Zvončeky a rolničky netvorí podľa vibračných módov harmonické zvuky. U zvončekov ho tvorí viac harmonických frekvencií než u rolničiek. Vo všeobecnosti sú u zvončekov a rolničiek v rozsahu 1,3 až 20 kHz, pričom najvyššie vrcholy a hlavná spektrálna energia dosahujú hodnoty medzi 2 až 6 kHz. Pokiaľ ide o hladinu akustického tlaku, pri vzdialenosti 1 m rolničky vykazujú hodnotu 40–55 dB a zvončeky 55–65 dB. Nakoľko sú artefakty do istej miery skorodované, je možné, že hladina ich akustického tlaku bola v čase používania vyššia.

Psychoakustické parametre slúžia na analýzu ľudského vnímania zvukov prostredníctvom počítačových modelov, najmä pokiaľ ide o hlasitosť, frekvenčné spektrum, ostrosť, drsnosť a tonalitu. Z hľadiska merania majú rolničky 8 až 20 son, s výnimkou kat. č. 14, pri ktorom evidujeme 28 son. Zvončeky majú 20 až 30 son, s výnimkou kat. č. 23, ktoré má len 12 son. Frekvenčné spektrum všetkých idiofónov je 3,3 až 6,2 kHz, pričom u zvončekov je v priemere o 300 Hz nižšia než u rolničiek. Kat. č. 23 vykazuje vysokú hodnotu SC 12,2 Hz. Ostrosť zvuku je u všetkých artefaktov v rozsahu 3,2 až 5,3 acum. Rolničky s priemernou hodnotou 14 dB sú menej tonálne než zvončeky s priemerom 22 dB. Kat. č. 7 a 8 majú veľmi nízku hodnotu 2 dB.

Rolníčky a zvončky sú signalizačné nástroje. Odliate či kované, vytvorené sú z materiálu, ktorý sa pracne získava z hlbín zeme a pomocou ohňa transformuje na kultúrny artefakt. Ich význam sa spája s rôznymi magicko-náboženskými praktikami, či ľudovou vierou. Zvončky sa v rímskej dobe používali v každodennom živote na rôzne účely, ako aj vo vojne, pri popravách, či v magicko-sakrálnom kontexte. O ich funkciách svedčia mnohé písomné a ikonografické pramene.

Avarské rolníčky sa spočiatku objavujú na konských uzdách, ako ozdobné prvky, alebo amulety s apotropaickou funkciou. Demonštruje to postavenie, ktoré mali kone v avarskej spoločnosti, tvorenej najmä nomádmi chovajúcimi kone. Rolníčky na uzdách mali pravdepodobne bohatší či elitní jazdci. Súdobé porovnanie kon-

ských postrojov ukazujú, že len málo vysoko postavených osôb zo Sasánovskej ríše, Číny, Japonska, Kórey a z ríše Čamov vo Vietname mali rolníčky a zvončky upevnené na postroji. Rolníčky slúžili zároveň ako amulet aj ozdoba. Na základe súčasného stavu výskumu nie je možné povedať, či majú pôvod v Avarskom kaganáte, alebo v zahraničí, azda v Ázii, kde sa rozšírili po Hodvábnej ceste. Neskôr začali rolníčky nosiť aj ľudia, najmä deti a ženy. Mohli slúžiť ako amulety, ozdoby, či hračky. Používali sa na praktické a ozdobné účely, ako aj náboženské (animistické) praktiky. Na jednej strane ich nosili ľudia počas života, na druhej strane osoby s magicko-náboženskou úlohou v spoločnosti ich mohli uložiť zosnulým do hrobu. Zvončky tak chránili človeka a zároveň mu mali pomôcť v posmrtnej púti.

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