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## NEW HYPOTHESIZED MUSICAL INSTRUMENTS OF THE EUROPEAN NEOLITHIC

*New finds from the Early Neolithic settlements in Austria and Hungary reconstructed as the first ceramic bells are published in the article. Modern copies of such bells were made and their sound was recorded.*

*Key words: Neolithic, Central Europe, musical instrument, clay bell, reconstruction.*

### Introduction

All living individuals are surrounded by different natural sounds, for example made by wind, weather, flowing water and additionally they create their own specific sounds like chirping, singing, roaring and etc. In addition, ancient people enriched this sounding world with their voices and the body percussion as well as with sounds of their working tools. Such acoustical environments are called «sound scapes». The sound of the vibrating strings of hunting bows was one of them. The Mesolithic and Neolithic hunting bows show a length range of 140–200 cm (Junkmanns 2013, p. 19). A string of 3.0 mm in diameter with a length of 169 cm produces a deep sound. A Neolithic hunter was buried with his hunting equipment near the first settlement of Brunn (Stadler 2017, p. 124–131). Any hunting bow could possibly be used as musical instruments: the greater the tension, the better the sound. The strings could have been made of twisted animal skin-strips, guts, plant fibres or hair. Various percussion instruments, such as sound stones, bars, bones, rattles made of either plant material, bones or claws, drums and whistles (Vitezovic 2017, p. 7–15), as well

as bullroarers made of bone or wood might have been known in the Mesolithic. Melodies using harmonics and rhythms could have easily been played.

The first farmers' way of life in the Neolithic changed the primarily «silent» soundscape and reached further. They were enlarged and shared with more creatures. Man changed and created it by including cultural sounds — produced by increasing numbers of people: sounds of working tools, domesticated animals — and musical instruments (Pomberger et al. 2018). The Neolithic epoch is characterized by some important innovations in a human life. One of them was a wide usage of clay in the Neolithic economy and cultic practice, where pottery, ceramic idols and amulets, as well as daub of building and ovens appeared. Due to wide-spreading of ceramics, new terracotta instruments were created by the Neolithic people. One of them is represented by some types of clay flutes, which were identified among the Neolithic materials of the Near East, Bulgaria, Macedonia, Hungary and Austria (Pomberger et al. 2018). In this article we consider the second musical instrument made of clay. However, probably there was also the earliest variant of clay bells. Fragments of them were found at Brunn 3 and Gellénháza in the same pits with clay flutes.

### Materials

Clay bells are defined in the collections of the Brunn 3 site in the Lower Austria and the Gellénháza site in western Hungary (Fig. 1).

The earliest examples were found at the Late Starčevo site of Gellénháza, Hungary (Fig. 3: 2–4). According to radiocarbon dating for a few sites, the Starčevo culture in Hungary is dated by 5800–5500 BC (Stadler, Kotova 2019, p. 223; Oross et al. 2020, p. 173), but parallels in pottery of the Formative phase of the Linear Pottery culture in Hungary with the Late Starčevo allow a partly synchronization of the sites of these cultures about 5500–5350 BC (Kotova, Stadler 2019, p. 425). Fragments

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Fig. 1. Location of the Brunn 3 and Gellénháza sites: 1 — Brunn 3; 2 — Gellénháza

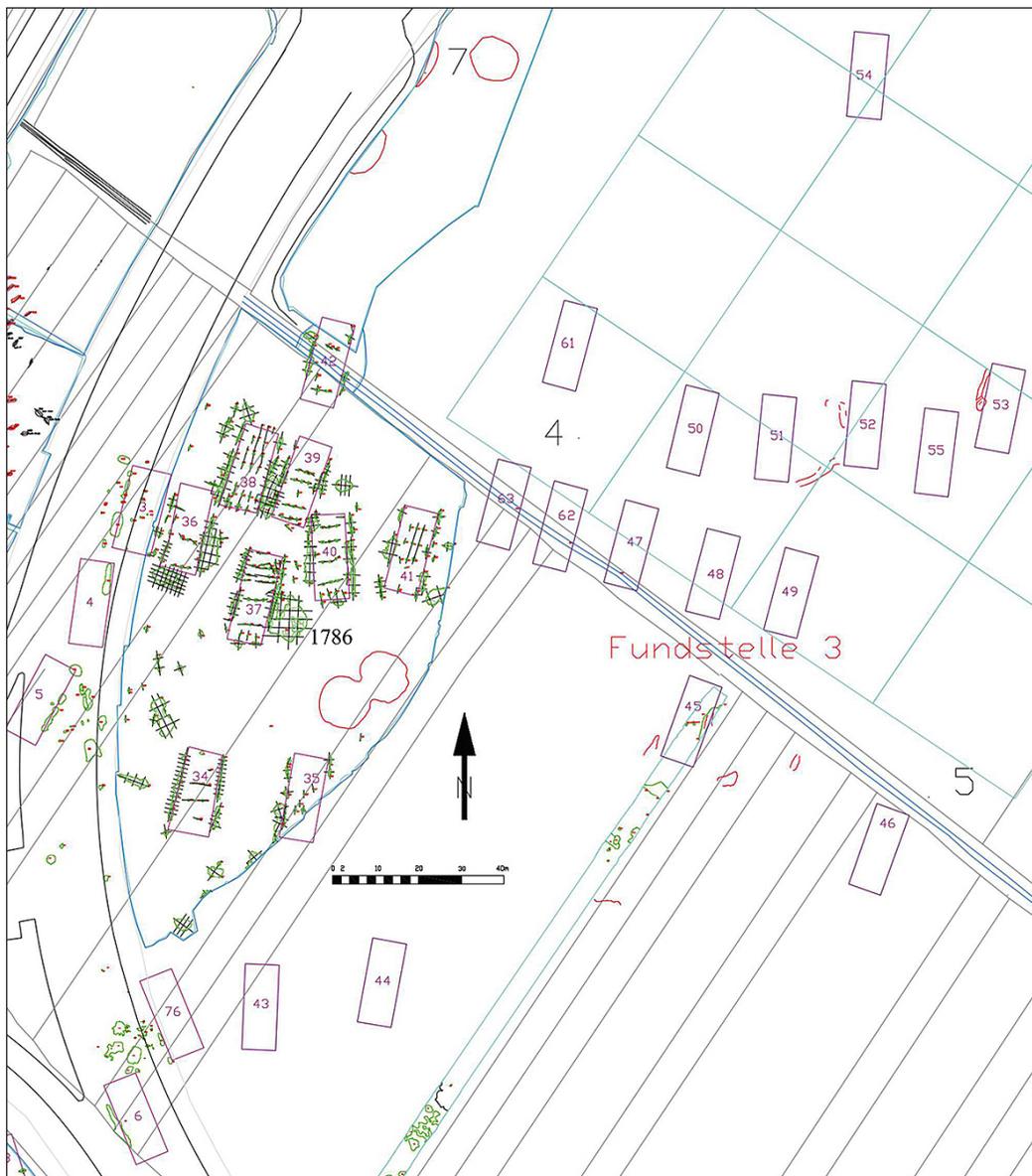
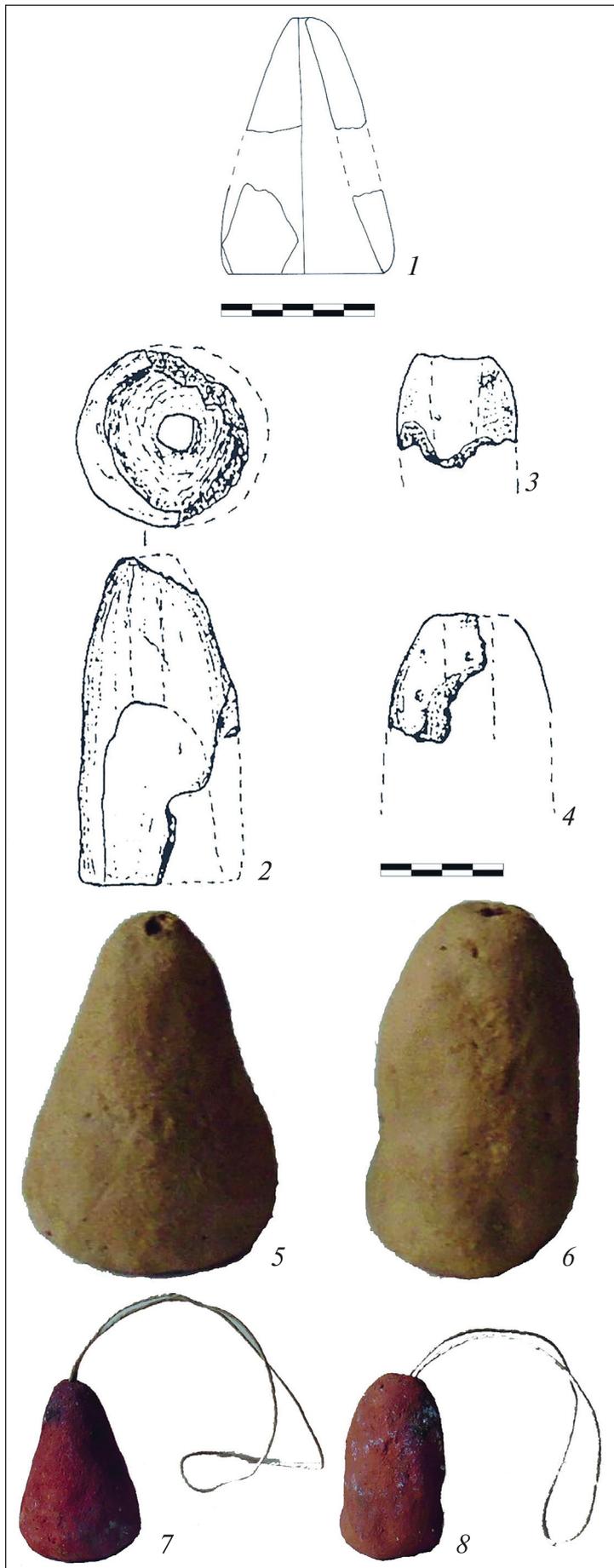


Fig. 2. Plan of the Brunn 3 site



of hypothetic bells from Gellénháza are interpreted as plummets (Simon 1996). The best-preserved object, shaped massive primordial, shows a crown with a hole of 5.0 mm in diameter (Fig. 3: 2). The whole bell is 64 mm height. The cavity measures 35 mm in its length and the wall thickness varies from 4.0 mm to 5.0 mm. The mouth is 31 mm in diameter. It was made of common clay with lots of organic admixture, a little bit of sand, mica, ochre, and white elements. The surface had a beige colour with orange inclusions.

The Brunn 3 was excavated in 1999 by Peter Stadler in outskirts of Vienna (Stadler, Kotova 2019). It belongs to the Milanovce phase of the Linear Pottery culture. It is dated by 5340–5265 cal BC (Stadler, Kotova 2019, tabl. 14.8, 14.9, p. 237, 239). There were studied 12 houses and about 20 houses were discovered with a magnetic survey (Fig. 2). Two fragments of a possible clay bell are detected in object No. 1786, which is near the dwelling 37.

One fragment is a part of the crown, measuring 30 mm, while the other is 23 mm long fragment that belongs to the mouth part (Fig. 3: 1). The drawn reconstruction shows a conic bell with a 2.0 mm hole in the crown. Its reconstructed height is 64 mm, the mouth diameter is 39 mm, and the thickness of the wall is 7.0–8.0 mm. It might be a preform of the bell, with or without a hammer.

### *The Development of Bells*

A vessel beaten with a stick arouses sounds and noises: a singing bowl. When turned upside down and hung from its base — either with forming two ears enwind with a string — it was discovered by ancient people that this singing bowl produces a more pronounced sound. It could swing freely: the bell was borne.

*Fig. 3. Clay bells: 1 — Singular bell from the Brunn site 3 (drawing after N. Kotova); 2 — three bells from Gellénháza (drawing after N. Kotova); 3 — Reconstructed bells before firing (reconstruction and photo after B. M. Pomberger); 4 — Reconstructed bells after firing (reconstruction and photo after B. M. Pomberger)*

These very early bells had no clapper, but were probably beaten with sticks of wood or long bones of animals. Bells are idiophones and create their sounds by vibrating resonant corpus. They belong to the percussion vessel group. The early clay bells of Central Europe can be classified as hanging bells without internal strikers (system No. 111.242.121 according to the classification of Hornbostel and Sachs: Hornbostel et al. 1914, p. 553–590).

Bells of this type are also known from the Early Neolithic: the Tisza Culture and the Epi-Lengyel (Pomberger 2016, p. 48–52).

### *Experimental Reconstruction of Clay Bells*

Coarse grained clay was used for the experimental copy of both bells. To start shaping the Brunn bell first the crown and the shoulders were formed from a lump of clay due to the reconstructed dimensions, followed by rolling to pieces of clay for the mouth and the lip. Then, the surface of the bell was

smoothened inside and outside. After a few minutes of drying a pierced hole of about 2.0 mm in diameter was pieced out through the crown with a stick. The reconstruction of the Gellénháza bell required another approach.

The used clay for the replica is a modern composition for pit-burning. The temper is dead-burned fireclay with sizes between 0–0.5 mm. The author is aware that this is not the same mixture like the original. Therefore, the object is a little bit heavier than the original. Furthermore, we know that the original sound of an idiophone hardly can be reconstructed, but approximate sounds and frequencies can be detected.

Natural organic mixture in clay makes the material more porous and therefore the sound is higher. However, at least we may say that the sounds of the idiophones from the Brunn Wolfholz, site 3 and Gellénháza were low-noise and sounded within the 7<sup>th</sup>–8<sup>th</sup> and maybe the 9<sup>th</sup> octaves. This means that the sounds of the bells perceived by the human ear are in the upper human hearing range of a man.

At first, a lump of clay was wrapped around a 5 mm diameter stick, and shaped into the slender long crown form of the original one. The crown shows a length of 29 mm and a diameter range between 29 mm and 10 mm. Then, with two rolls of clay the sides of the bell, the mouth and lip were shaped. The stick was removed after 30 minutes of drying. The shaping of each bell lasted only 10 minutes. The objects dried for three days, and afterwards were fired in an open flame for three hours and left in the ashes till they cooled down.

*Table 1. The stick used for beating the bells*

Stick	Wood	Diameter, mm
1	soft wood	4
2	soft wood	oval 5 × 7
3	bamboo, hollow	8
4	hardwood	10

*Table 2. Results of sound level measurement*

Bell	Stick 1	Stick 2	Stick 3	Stick 4
Brunn site 3	55.4 dB	56.7 dB	65.1 dB	67.7 dB
Gellénháza	56.9 dB	60.8 dB	65.1 dB	69.6 dB

*Table 3. Pitches and harmonics of the bell from the Brunn 3 site*

Bell	Fundamental pitch	1. Harmonic	2. Harmonic	Most prominent and long sounding pitch
Stick No. 1	3700 Hz (A#7-16c)	7100 Hz	—	A#7-16 Cent
Stick No. 2	2959 Hz (F#7+9c)	4398 Hz	6890 Hz	F#7+9 Cent
Stick No. 3	2960 Hz (F#7+9c)	4355 Hz	7326 Hz	F#7+9 Cent
Stick No. 4	2871 Hz (F7+46c)	3797 Hz	6551 Hz	F7+46 Cent

*Table 4. Pitches and harmonics of the Gellénháza bell*

Bell from Gellénháza	Fundamental pitch	1. Harmonic	2. Harmonic	3. Harmonic	Most prominent and long sounding pitch
Stick No. 1	7519 Hz (A#8+13)	—	—	—	A#8+13
Stick No. 2	7516 Hz (A#8+13)	—	—	—	A#8+13
Stick No. 3	3017 Hz (F#7+33)	4425 Hz	5824 Hz	7194 Hz	D8-74 Cent
Stick No. 4	1732 Hz (A6-24 Cent)	2583 Hz	3805 Hz	7054 Hz	B7-34 Cent

*Table 5. Calculated ranges of an open sound field with 42 dB*

Bell	Stick No. 1	Range, m	Stick No. 2	Range, m	Stick No. 3	Range, m	Stick No. 4	Range, m
Brunn 3 site	55.4 dB	0.94	56.7 dB	1.09	65.1 dB	2.68	67.7 dB	3.69
Gellénháza	56.9 dB	1.11	60.8 dB	1.74	65.1 dB	2.68	69.6 dB	4.8

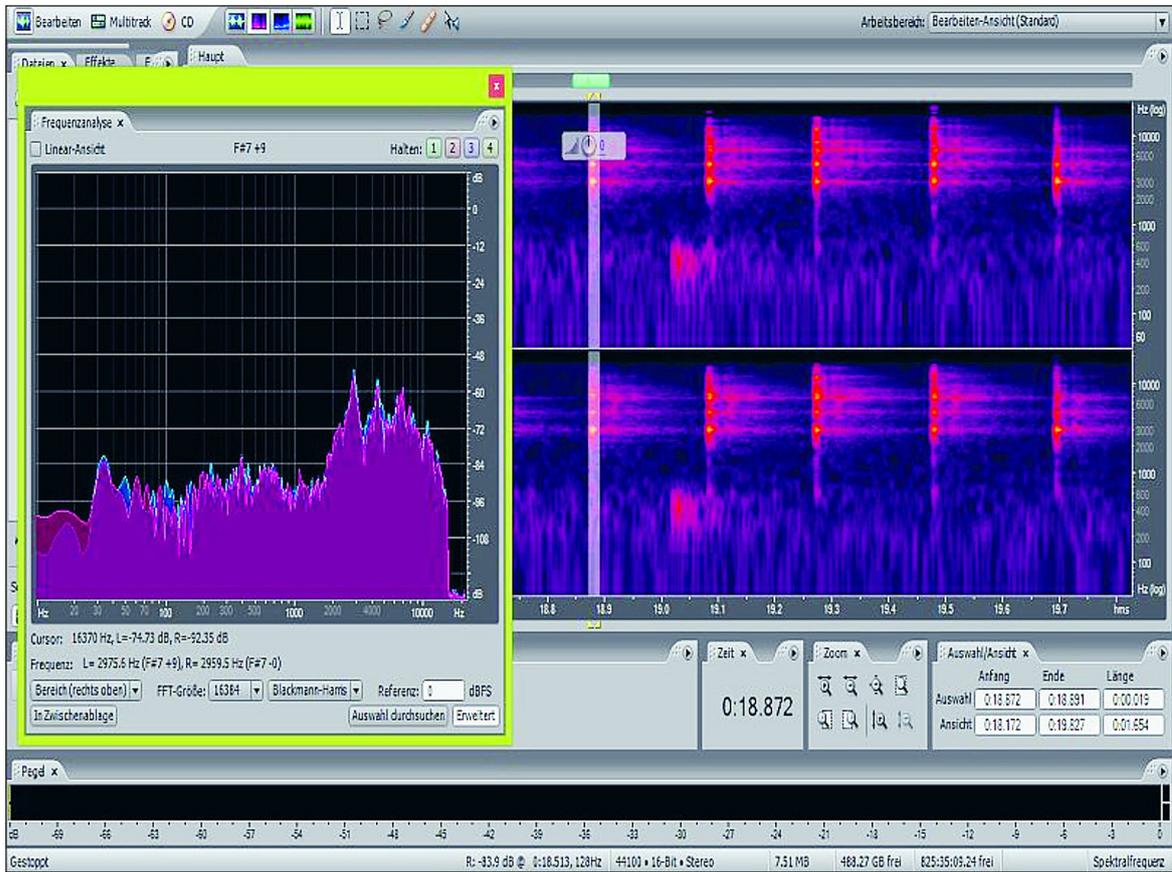


Fig. 4. Frequency analyses. Bell from the Brunn site 3 (after B. M. Pomberger)

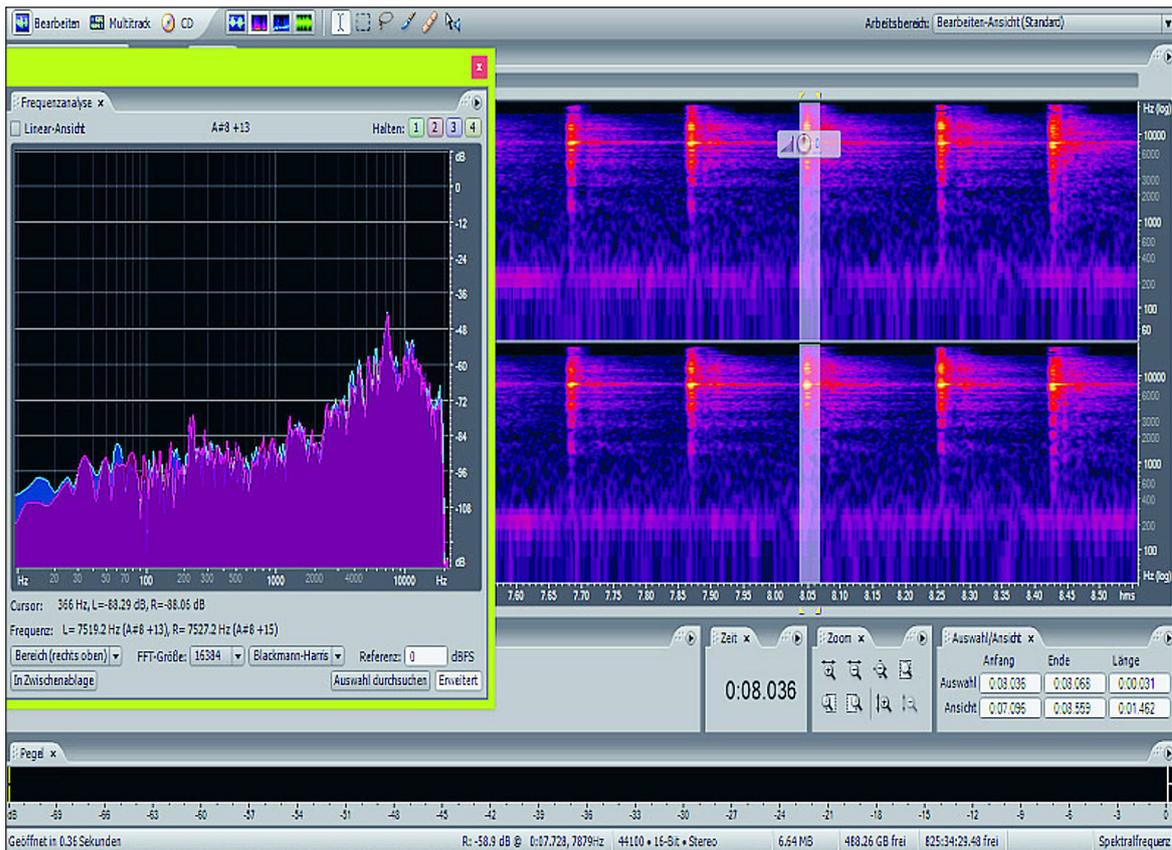


Fig. 5. Frequency analyses. Bell from the Gellénháza site (after B. M. Pomberger)

For the attachments of the bells hemp cords were used. They were twisted through the holes and the two ends were knotted.

### *Acoustics Analyses of the Reconstructed Bells*

Sound recordings were done and frequency analyses were made by using the program Adobe Audition 3.0. The concert pitch A4 was set at 440 Hz at a temperature of 20 degrees. Sound levels were measured with the sound level meter PCE-999, in a room full of textile. The weighted sound level dBA was used, which concentrates its attention on values between 2000 to 4000 Hz. The distance between the object and the measuring devices was 20 cm. And finally, the range was calculated by using the audio engineering calculator «sengpielaudio» (<http://sengpielaudio.com/Rechner-entfernung.htm>, 11.1.2019]. The sound level in the open sound field was set at 42 dB. Four sticks of different diameters and wooden materials served as hammers (see Table 1).

The measured sound levels of the Brunn bell vary between 58 dB and 65.7 dB. The Gellénháza bell shows values between 58.9 dB and 68.9 dB (see Table 2).

The results of the frequency analyses of the Brunn bell present a variation of fundamental pitch of about 2871 Hz (F7+46 cent] to 2959 Hz (F7+46 cent], when using sticks Nos. 2–4 as hammers. However, with the stick No. 4 the pitch showed 3700 Hz (A#7-16 cent]. Thus, we may say that the Brunn bell sounded within the 7<sup>th</sup> octave (Fig. 4).

The Gellénháza bell shows values of 7519 Hz (A#8+13c] for the fundamental pitch while using the sticks Nos. 1 and 2. The stick No. 3 produced 3017 Hz (F#7+33c] and the stick No. 4 — 1732 Hz (A6-24c]. The original bell would have sounded within the 8<sup>th</sup> octave (Table 4, Fig. 5).

Regarding the calculation of the ranges, the reconstructed Brunn bell shows ranges of 0.94 m to 3.69 m, and the reconstructed Gellénháza bell — 1.11 m to 4.80 m (Table 5).

Both bells presumably did not serve as musical instruments, because their sounds are too quiet and weak. This probably could be the reason why they were destroyed and thrown away into the pits.

### *Conclusions*

We hope that our first attempt to separate the remains of clay bells, like earlier clay flutes (Pombberger et al. 2018), among the numerous fragments of ceramics of ancient settlements will help researchers to see and study extraordinary ceramic ware, including musical instruments. The Brunn sites give information for reconstruction of dwelling position with extraordinary items, which include bells, flutes, idols, amulets, amphorae. Very often they are concentrated in the same pits or in different pits, but near the same house. All idols on the Linear Pottery culture sites were destroyed. Lines of destruction are located in strong parts of figures. This fact assumes purposeful damage of them during ceremonies (Becker 2011, p. 98, 350). It is possible to assume that ceremonies with destructions of some extraordinary items were connected with constructions of some houses that belonged to the leader of a settlement community (Kotova, Stadler 2017). Fragments of destroyed idols, amphorae, and musical instruments were put in pits near the dwelling, than these pits were buried.

These ceremonies could be accompanied by the drinking of supposedly alcoholic beverages, which required a special container — amphorae. In everyday life, amphorae, apparently, were not used, since their finds are rare. The remains of flutes and bells can testify to the musical accompaniment of the ceremonies. Exactly in the houses with extraordinary objects, fragments of imported vessels are concentrated. They are identical with pottery from the Hungarian early Neolithic sites of the Starčevo and Hungarian variant of the Early Linear Pottery culture. Some amphorae are also present among import vessels. Tools from Hungarian radiolarite are dominated among the stone items at the Brunn 2 and 3 sites and testified closed contacts of the ancient population of the Lower Austria and Western Hungary, including the Gellénháza site with finds of clay flutes and bells. Presence of imported vessels in the pits with extraordinary items allows assuming that members of friendly groups of population, with whom the Brunn settlers had close contacts, were invited to take part in some ceremonies.

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## НОВІ ГІПОТЕТИЧНІ МУЗИЧНІ ІНСТРУМЕНТИ НЕОЛІТУ ЄВРОПИ

Статтю присвячено знахідкам виробів, реконструйованих як глиняні дзвіночки. Артефакти знайдено на ранньо-неолітичних поселеннях Брунн 3 у Нижній Австрії (культура лінійно-стрічкової кераміки, 5340—5265 рр. до н. е.) та Гелленхаза в Західній Угорщині (старчевська культура, 5800—5500 рр. до н. е.). Ці керамічні вироби мають пірамідальну форму, висоту близько 6,5 см і отвір у верхній частині. Автор розкопок Гелленхази вважає ці предмети тягарцями, однак в археологічних об'єктах їх зафіксовано разом із глиняними флейтами, що дозволяє запропонувати іншу інтерпретацію. Глиняні моделі дзвіночків, виготовлені за зразками з обох поселень, уможливили вивчення їхнього звучання. Воно було доволі глухим. Це, мабуть, і зумовило той факт, що вироби розбили й викинули. На поселеннях культури лінійно-стрічкової кераміки Брунн 2 та Брунн 3 досліджено будинки, де в ямах концентрувалися неординарні предмети: дзвіночки, флейти, статуетки, амулети, амфори, імпортований посуд. Усі статуетки були умисно розбиті, очевидно, під час церемоній, які, ймовірно, були пов'язані зі спорудженням будинків. Такі обряди могли супроводжуватися споживанням напоїв із амфор, які в побуті практично не використовувалися, зважаючи на рідкість відповідних знахідок. Про музичний супровід церемоній свідчать і залишки флейт та дзвонів. Саме у будинках із незвичайними предметами й зосереджені уламки імпортованих посудин, ідентичних кераміці з угорських неолітичних стоянок культури Старчево та угорського варіанту культури ранньої лінійно-стрічкової кераміки. Імовірно, для участі у певних церемоніях запрошували сусідні дружні групи населення, передовсім неолітичних мешканців Західної Угорщини.

*Ключові слова: неоліт, Центральна Європа, музичні інструменти, глиняні дзвіночки, реконструкція.*

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## НОВЫЕ ПРЕДПОЛАГАЕМЫЕ МУЗЫКАЛЬНЫЕ ИНСТРУМЕНТЫ НЕОЛИТА ЕВРОПЫ

Статья посвящена находкам глиняных изделий, которые реконструированы как глиняные колокольчики. Они найдены на раннеолитических поселениях Брунн 3 в Нижней Австрии (5340—5265 гг. до н. э., культура линейно-ленточной керамики) и Гелленхаза в Западной Венгрии (5800—5500 гг. до н. э., старчевская культура). Рассматриваемые керамические изделия имеют пирамидальную форму, высоту около 6,5 см и отверстие в верхней части. Автор раскопок Гелленхаза считает их грузиками, однако они найдены в археологических объектах вместе с глиняными флейтами, что позволяет предложить иную их интерпретацию. Глиняные модели колокольчиков, изготовленные по образцам из обоих поселений, позволили изучить их звучание. Оно было довольно глухим, что, видимо, и стало причиной того, что изделия были разбиты и выброшены. На поселениях культуры линейно-ленточной керамики Брунн 3 и 2 в некоторых домах размещались ямы, в которых концентрировались неординарные предметы: колокольчики, флейты, статуэтки, амулеты, амфоры, импортная посуда. Все статуэтки были целенаправленно разбиты, скорее всего, во время церемоний, которые, видимо, были связаны со строительством этих домов, принадлежавших лидерам общин. Эти обряды могли сопровождаться распитием напитков из амфор, которые в быту практически не использовались, так как их находки редки. О музыкальном сопровождении церемоний свидетельствуют остатки флейт и колокольчиков. Именно в домах с необычными предметами сосредоточены обломки импортных сосудов, идентичных керамике из венгерских неолитических стоянок культуры Старчево и венгерского варианта культуры ранней линейно-ленточной керамики. Вероятно, для участия в некоторых церемониях приглашались соседние дружественные группы населения, и, в первую очередь, неолитические обитатели западной Венгрии.

*Ключевые слова: неолит, Центральная Европа, музыкальные инструменты, глиняные колокольчики, реконструкция.*

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